WHAT’S NEW IN LIGHTING?

Andy Kyker, LC, LEED GA
Specification Engineer
GE Lighting
Agenda

Lighting Legislation Update
LED Basics
LED Design Considerations
LED Modules
Zhaga
LED Applications
Fluorescent Ballasts
Lighting Legislation Update
Energy Policy & Conservation Act (EPCA)
Fluorescent Ballast
Energy Conservation Standards

Ballast Amendments Effective Nov 14, 2014
Summary

- Covers T8 and T5 ballasts in addition to T12 ballasts
- Includes previously exempt residential & sign ballasts
- Input voltage between 120V and 277V and 60 Hz.
- New rules create a new ballast efficiency metric Ballast Luminous Efficiency (BLE) and method of measurement
- Requires an efficiency improvement in a significant number of today’s fluorescent ballasts
- Exempted:
  - Dimming ballasts that dim to 50 percent or lower
  - T8 magnetic ballasts for use in EMI-sensitive apps
  - Programmed-start ballasts operating 4-ft. medium bi-pin lamps below 140 mA (0.71 ballast factor).
Ballast EPCA Standards

Summary

- New rules create a new ballast efficiency metric Ballast Luminous Efficiency (BLE) and method of measurement,
- Requires an efficiency improvement in a significant number of today’s fluorescent ballasts,
- Compliance and reporting requirements.
Ballast Luminous Efficiency (BLE)

Metric & Method of Measurement Advantages

- Efficiency is the Performance parameter for NEMA Premium ballast program
- Removes lamp and photometric measurement variations and inaccuracies
- Allows accurate evaluation of high performance ballasts
ANSI/IES/ASHRAE 90.1 2010
Whole Building Ltg. Power Densities

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Office Buildings</td>
<td>1.0</td>
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<td>Schools</td>
<td>1.2</td>
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<tr>
<td>Hospitals</td>
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<td>Warehouses</td>
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<td>Dormitories</td>
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# Legislation impact through 2014

<table>
<thead>
<tr>
<th>Effected Bulbs</th>
<th>Timing</th>
<th>Regulation</th>
<th>Primary Fixture</th>
<th>Example Eliminated Bulbs</th>
<th>Replacements Bulbs Available Now</th>
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</thead>
<tbody>
<tr>
<td>100-Watt Medium Base (includes 55W)</td>
<td>Can no longer manufacture 1/1/2012* inventory sellable until depleted</td>
<td>New efficiency standards for all 100-Watt general service bulbs: Maximum wattage: 72-Watts Minimum life: 1,000 hours Lumens (brightness): 1,490-2,600**</td>
<td>Lamp</td>
<td>Crystal clear 110 40W</td>
<td>More options coming in 2012</td>
</tr>
<tr>
<td>75-Watt Medium Base (includes 71W)</td>
<td>Can no longer manufacture 1/1/2013* inventory sellable until depleted</td>
<td>New efficiency standards for all 75-Watt general service bulbs: Maximum wattage: 53-Watts Minimum life: 1,000 hours Lumens (brightness): 1,050-1,489**</td>
<td>Lamp</td>
<td>Crystal clear 110 75W</td>
<td>More options coming in 2012</td>
</tr>
<tr>
<td>60-Watt Medium &amp; Intermediate Base (includes 57W)</td>
<td>Can no longer manufacture 1/1/2014* inventory sellable until depleted</td>
<td>New efficiency standards for all 60-Watt general service/deco bulbs: Maximum wattage: 43-Watts Minimum life: 1,000 hours Lumens (brightness): 750-1,049**</td>
<td>Lamp</td>
<td>Crystal clear 110 60W</td>
<td>More options coming in 2012</td>
</tr>
<tr>
<td>All PAR20</td>
<td>Can no longer manufacture 7/14/2012 inventory sellable until depleted</td>
<td>New lumen-per-Watt standards eliminate most F40 and F96 T12 bulbs and some F32 T8 lamps. Linear fluorescent lamps less than 4ft aren’t affected.</td>
<td>Lamp</td>
<td>Crystal clear 110 20W</td>
<td>More options coming in 2012</td>
</tr>
<tr>
<td>PAR30</td>
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<td></td>
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<tr>
<td>PAR38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;39-Watt</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>T12 F34</td>
<td>Can no longer manufacture 7/14/2012 inventory sellable until depleted</td>
<td>New lumen-per-Watt standards eliminate most F40 and F96 T12 bulbs and some F32 T8 lamps. Linear fluorescent lamps less than 4ft aren’t affected.</td>
<td></td>
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<tr>
<td>F40</td>
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<td></td>
</tr>
<tr>
<td>F96</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T8 F32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F96</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

* California will enact the new standards for general service bulbs 1 year earlier

** Lumen range is 25% lower for color-enhanced products like GE Reveal® light bulbs
Lighting Legislation

July 14, 2012* – Linear Fluorescent Regulations

- 4’ Fluorescent - T12, T8, T5
  - Exemptions for Plant, Cov-R-Guard, Colored, High CRI, etc....
- 8’ Slimline – T12, T8
- 8’ HO – 800 ma – T12, T8
  - Cold Temp. (CT) Exemption
  - (1500 ma NOT Regulated)
- U6, U3 – T12; U6, U-1/5/8 – T8

July 14, 2012* – Halogen PAR

- PAR38, PAR30, PAR20

*Last Date to Manufacture – Can Sell Inventory
CA – Same Date as Federal
## 2012 Standard – Linear Fluorescent Lamps

<table>
<thead>
<tr>
<th>LAMP TYPE</th>
<th>CCT</th>
<th>LPW STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>4’ Medium Bi-Pin ≥25W</td>
<td>≤ 4500K</td>
<td>89</td>
</tr>
<tr>
<td>4’ Medium Bi-Pin ≥25W</td>
<td>&gt; 4500K and ≤7000K</td>
<td>88</td>
</tr>
<tr>
<td>2’ U-Shaped ≥25W</td>
<td>≤ 4500K</td>
<td>84</td>
</tr>
<tr>
<td>2’ U-Shaped ≥25W</td>
<td>&gt; 4500K and ≤7000K</td>
<td>81</td>
</tr>
<tr>
<td>8’ Slimline ≥52W</td>
<td>≤ 4500K</td>
<td>97</td>
</tr>
<tr>
<td>8’ Slimline ≥52W</td>
<td>&gt; 4500K and ≤7000K</td>
<td>93</td>
</tr>
<tr>
<td>8’ High Output</td>
<td>≤ 4500K</td>
<td>92</td>
</tr>
<tr>
<td>8’ High Output</td>
<td>&gt; 4500K and ≤7000K</td>
<td>88</td>
</tr>
<tr>
<td>4’ Min Bi-Pin T5 ≥26W</td>
<td>≤ 4500K</td>
<td>86</td>
</tr>
<tr>
<td>4’ Min Bi-Pin T5 ≥26W</td>
<td>&gt; 4500K and ≤7000K</td>
<td>81</td>
</tr>
<tr>
<td>4’ T5 HO ≥49W</td>
<td>≤ 4500K</td>
<td>76</td>
</tr>
<tr>
<td>4’ T5 HO ≥49W</td>
<td>&gt; 4500K and ≤7000K</td>
<td>72</td>
</tr>
</tbody>
</table>
2012 Standard – Linear Fluorescent Lamps
Typical “4’” Lamp Types Covered

• F34T12, F40T12
• F28W/T5, F28/T5/WM, F54W/T5, F54/T5/WM
• F32T8, F32T8/HL, F32T8/WM, F28T8, F32T8/25W
• - 89 LPW
• - 32 Watts ➞ Min. 2850 Lumens
• - 30 Watts ➞ Min. 2679 Lumens
• - 28 Watts ➞ Min. 2500 Lumens
• - 25 Watts ➞ Min. 2225 Lumens

Note: 2’, 3’ and 5’ lamps not covered.
# High Lumen 8’ T12 High Output

<table>
<thead>
<tr>
<th>Primary Application...</th>
<th>Most Commercial Spaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Message...</td>
<td>Energy efficient 8’ T12 high output lamp design that meets the DOE minimum standards &amp; runs on existing T12 HO ballasts...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product Performance...</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Watts:</strong> 95W</td>
</tr>
<tr>
<td><strong>Initial Lumens:</strong> 8,850</td>
</tr>
<tr>
<td><strong>Mean Lumens:</strong> 7,920</td>
</tr>
<tr>
<td><strong>CCT:</strong> 3000K &amp; 4100K</td>
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<tr>
<td><strong>CRI:</strong> 77</td>
</tr>
<tr>
<td><strong>Rapid Start Life (3hrs):</strong> 12K</td>
</tr>
<tr>
<td><strong>System Warranty:</strong> None</td>
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</tbody>
</table>
High CRI 4’ T12

Primary Application... Most Commercial Spaces

Customer Message...
High CRI F34 T12 lamp design that complies with DOE requirements & runs on existing T12 ballasts...

Product Performance...

<table>
<thead>
<tr>
<th></th>
<th>CW/C</th>
<th>CX</th>
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<tbody>
<tr>
<td>Watts:</td>
<td>34W</td>
<td>34W</td>
</tr>
<tr>
<td>Initial Lumens:</td>
<td>1,800</td>
<td>2,500</td>
</tr>
<tr>
<td>Mean Lumens:</td>
<td>1,500</td>
<td>2,200</td>
</tr>
<tr>
<td>CCT:</td>
<td>4100K</td>
<td></td>
</tr>
<tr>
<td>CRI:</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>Rapid Start Life (3hrs):</td>
<td>15K</td>
<td>20K</td>
</tr>
<tr>
<td>System Warranty:</td>
<td>None</td>
<td></td>
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Rare Earth Phosphors Sources.

http://www.globalsecurity.org/military/world/china/rare-earth.htm
## 4’ T8 Options

<table>
<thead>
<tr>
<th>Description</th>
<th>IS (12hr/Start)</th>
<th>PS (12hr/Start)</th>
<th>Initial Lumens</th>
<th>Mean Lumens</th>
<th>Color Temp K</th>
<th>CRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>F32T8 SP(700)</td>
<td>~30,000</td>
<td>~36,000</td>
<td>~2700</td>
<td>~2440</td>
<td>3500K</td>
<td>75-78</td>
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<tr>
<td>F32T8 XL(XP) SP(700)</td>
<td>~36,000</td>
<td>~45,000</td>
<td>~2850</td>
<td>~2700</td>
<td>3500K</td>
<td>78</td>
</tr>
<tr>
<td>F32T8 SPP(800XV)</td>
<td>~30,000</td>
<td>~36,000</td>
<td>~2900</td>
<td>~2725</td>
<td>3500K</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>~40,000</td>
<td>~42,000</td>
<td>~2900</td>
<td>~2725</td>
<td>3500K</td>
<td>83</td>
</tr>
<tr>
<td>F32T8 SPX(800)</td>
<td>~30,000</td>
<td>~36,000</td>
<td>~2925</td>
<td>~2800</td>
<td>3500K</td>
<td>85</td>
</tr>
<tr>
<td>F32T8 XL(XP) SPX(800)</td>
<td>~40,000</td>
<td>~45,000</td>
<td>~2925</td>
<td>~2800</td>
<td>3500K</td>
<td>85</td>
</tr>
<tr>
<td>F32T8 SXL SPX(800)</td>
<td>~40,000</td>
<td>~60,000</td>
<td>~2850</td>
<td>~2700</td>
<td>3500K</td>
<td>83-85</td>
</tr>
</tbody>
</table>
4’ T8 Options

- Lamp Platforms:
  - F32T8 HL “Super T8”
  - F32T8 SP/700(78) & SPX/800(86)
  - F28T8 = 28W
  - F32/25T8 = 25W at 4’
Energy Saving 4’ T8 Fluorescent Lamps

- **F32T8 SPX**
  - Ar
  - Light Output: 100%
  - LPW: 92

- **F32T8/HL**
  - Ar
  - Light Output: 105%
  - LPW: 97

- **F30T8**
  - Ar
  - Light Output: 95%
  - LPW: 93

- **F28T8**
  - Ar
  - Light Output: 92%
  - LPW: 97

- **F32T8/25W**
  - Kr
  - Light Output: 89%
  - LPW: 100

Approximations:
- F32T8 SPX: Ar (~10%)
- F30T8: Ar (~10%)
- F28T8: Ar (~30%)
- F32T8/25W: Kr (~90%)
T5 Energy Savings...

Watts: 54W 51W 47W/49W
Light Output: 5,000 5,000 4,800
Life (3hrs/12hrs): 30K/36K 30K/36K 30K/36K

Assumptions: $.10 kwh, 30,000 hrs burn, Savings per one 54W T5 lamp
LED Basics
From DOE & NEMA

• In 2001, lighting ~765 TWh electricity consumption. Equal to 22% of U.S. total.
• In 2010, lighting ~700 TWh, 19% of total.
• In 2001, ~6,977 million permanent lamps in U.S.
• In 2010, ~8,203 million permanent lamps in U.S.

• LED lighting is expected to represent 36% of lumen-hour sales (general market) by 2020, and 74% by 2030
Benefits & Impacts

What are the benefits of LEDs?
LEDs offer a number of advantages over conventional light sources. LEDs...

**ENVIRONMENT**
- contain no mercury, lead, or glass
- offer significant energy savings, up to 90% compared to incandescent in traffic signals
- last for up to 50,000 hours

**DURABILITY**
- are highly resistant to shock and vibration
- have excellent cold weather performance

**CONTROL**
- are dimmable
- have a quick turn-on time

How can LEDs impact us?
By the year 2030, the US Department of Energy estimates LED lighting could save approximately 190 terawatt-hours of electricity per year, which is equivalent to:

- the annual output of 24 large power plants (1000 MW)
- enough electricity to power 95 million homes
- and at today's prices $15 billion in savings
While traditional lighting technologies are relatively mature and offer less potential for improvement, SSL is still at a comparatively early stage and continues to achieve dramatic advances in efficacy.

Source: DOE SSL R&D Multi-Year Program Plan
DOE Life-Cycle Assessment

Figure ES. 1 Life-Cycle Energy of Incandescent Lamps, CFLs, and LED Lamps

ENERGY STAR® Program
Start August 31, 2010

• EPA now in charge of LED ENERGY STAR® Program
  - DOE sign MOU Sept 30, 2009
  - Expand and enhance energy efficiency programs for products and buildings
  - Re-align roles to best utilize expertise of each agency

• DOE completed ENERGY STAR® LED specification
  - Formally communicated program on Dec 3rd
  - Goes in effect August 31, 2010

• EPA will manage changes going forward with technical support of DOE
## Energy Star Qualification Summary Highlights

<table>
<thead>
<tr>
<th></th>
<th>Omnidirectional</th>
<th>Decorative</th>
<th>Directional</th>
<th>Non-Standard</th>
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<tbody>
<tr>
<td><strong>Minimum Efficacy</strong></td>
<td></td>
<td>40 LPW</td>
<td>&lt;or= PAR20: 40 LPW</td>
<td>&lt; 10 watts: 50 LPW</td>
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<tr>
<td>Minimum Light Output</td>
<td></td>
<td>40 LPW</td>
<td>&lt;or= PAR20: 40 LPW</td>
<td>&lt; 10 watts: 50 LPW</td>
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<tr>
<td>If claiming it replaces:</td>
<td></td>
<td>If claiming it replaces:</td>
<td>BR, ER, K &amp; R: Luminous flux = target wattage of the replaced lamp X10</td>
<td>200 lumens</td>
</tr>
<tr>
<td>25W -&gt; 200 lumens</td>
<td></td>
<td>10W -&gt; 70 lumens</td>
<td>PAR and MR16 : see tool</td>
<td>200 lumens</td>
</tr>
<tr>
<td>40W -&gt; 400 lumens</td>
<td></td>
<td>25W -&gt; 150 lumens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60W -&gt; 800 lumens</td>
<td></td>
<td>40W -&gt; 300 lumens</td>
<td></td>
<td></td>
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<tr>
<td>See PDF for higher levels</td>
<td></td>
<td>60W -&gt; 500 lumens</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lumen Maintenance</strong></td>
<td>&gt;or = 70% (L70) at 25,000 hours</td>
<td>&gt;or = 70% (L70) at 15,000 hours</td>
<td>&gt;or = 70% (L70) at 25,000 hours</td>
<td>&gt;or = 70% (L70) at 25,000 hours</td>
</tr>
<tr>
<td>Warranty</td>
<td>All types: 3 year minimum</td>
<td>All types: 3 year minimum</td>
<td>All types: 3 year minimum</td>
<td>All types: 3 year minimum</td>
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<tr>
<td>Packaging</td>
<td>All types: Manufacturer must use the Lighting Facts label</td>
<td>All types: Manufacturer must use the Lighting Facts label</td>
<td>All types: Manufacturer must use the Lighting Facts label</td>
<td>All types: Manufacturer must use the Lighting Facts label</td>
</tr>
</tbody>
</table>
ENERGY STAR® qualified LED lamp website

Commercial Products:

Residential Products:
http://www.energystar.gov/index.cfm?fuseaction=iledl.display_products_excel
FTC Lighting Facts Label - Mandatory

Front ^
- Lumens
- Energy Cost per Year
Based on $11.4 / KW-Hr.

Back >

- Brightness: 820 lumens
- Estimated Energy Cost: $7.23 per year

Estimated Yearly Energy Cost: $7.49
Based on 3 hrs/day and 11.4 ¢/kWh.
Your cost will depend on your rates and use.

Life in Years
Based on 3 hrs/day.
1.4 yrs

Color Appearance
- Warm
- Cool

Energy Used: 60 watts

2700 K
CALiPER testing from the Pilot Round through Round 11 shows a steady increase in average and maximum efficacy of market-available SSL luminaires and replacement lamps. The minimum efficacy seen in Round 11 is higher than the overall average efficacy observed in 2007.

Source: Caliper Round 11 Summary Report
LED Life Ratings

Traditional Lamps rated at B50 - 50% Mortality

B50 Life rated when 50% of a population has failed
B50 = Avg rated life

LEDS rated at 70% Lumen Maintenance

L70 Life defined as lumen depreciation to a particular point
L70 = Rated life @ 30% depreciation
LED Design Considerations
Dimming Considerations
Incandescent / Halogen Dimmers

Line-voltage tungsten filament lamps, including line-voltage (120 V) halogen lamps. Resistive in nature.

Rated for cold filament inrush. The leading edge cut dimmer keeps voltage at zero until it turns on. Red Line.
Reverse Phase Control Electronic Low-Voltage (ELV)


Very smooth turn on following the sine wave. Red Line ramps up.
Reverse Phase Control / Trailing Edge Cut Dimmers

Complex Design

• Trailing dimmers are more complex and costly, but are easier on lamp filaments, as there is no sharp current step.

• Trailing cut dimmer are less likely to generate noise mechanical noise in the lamp filament or noise into the electrical system.

• Trailing edge cut dimmers turn on at zero crossing with each line cycle then turn off at the desired level.
Dimming Compatibility

Only bulbs designed as dimmable should be used on a dimmer. Otherwise life & performance will suffer.

Actual performance of any LED or other lamp family will vary from bulb type to bulb type and among different manufacturers.

Check the bulb, or package, or call the manufacturer.

PER UL Standard 1472, manufacturers must test each bulb to ensure its compatibility with the dimmers.
Incandescent/halogen bulbs will typically dim lower than CFL or LED bulbs. Most dimmable CFLs will dim down to 10% to 30% measured light output. Early versions of dimmable LEDs on the market have the ability to dim lower than CFLs and can reach levels as low as 5% to 15% measured light. The actual dimming range is dictated by the bulb’s circuitry.
### How to calculate wattage when mixing lamp types: (example only)

**Example 1:**
1. I have a single-gang dimmer and 3 CFL bulbs that are 16 W each, totaling 48 W.
2. Because I have 48 W of CFL bulbs installed, I can have up to 400 W of incandescent bulbs also controlled by this dimmer (6 incandescent bulbs that are 65 W each = 390 W)

(Please note this example applies to a single-gang dimmer only)

<table>
<thead>
<tr>
<th>Single-Gang</th>
<th>Total CFL/LED Wattage Installed</th>
<th>Maximum Allowable Incandescent/Halogen Wattage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 W</td>
<td>+ 600 W</td>
</tr>
<tr>
<td></td>
<td>1-25 W</td>
<td>+ 500 W</td>
</tr>
<tr>
<td></td>
<td>26-50 W</td>
<td>+ 400 W</td>
</tr>
<tr>
<td></td>
<td>51-75 W</td>
<td>+ 300 W</td>
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<tr>
<td></td>
<td>76-100 W</td>
<td>+ 200 W</td>
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<tr>
<td></td>
<td>101-125 W</td>
<td>+ 100 W</td>
</tr>
<tr>
<td></td>
<td>126-150 W</td>
<td>+ 0 W</td>
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<table>
<thead>
<tr>
<th>2-Gang</th>
<th>Total CFL/LED Wattage Installed</th>
<th>Maximum Allowable Incandescent/Halogen Wattage</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0 W</td>
<td>+ 500 W</td>
</tr>
<tr>
<td></td>
<td>1-25 W</td>
<td>+ 400 W</td>
</tr>
<tr>
<td></td>
<td>26-50 W</td>
<td>+ 300 W</td>
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<tr>
<td></td>
<td>51-75 W</td>
<td>+ 200 W</td>
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<td></td>
<td>76-100 W</td>
<td>+ 100 W</td>
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<tr>
<td></td>
<td>101-125 W</td>
<td>+ 50 W</td>
</tr>
<tr>
<td></td>
<td>126-150 W</td>
<td>+ 0 W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3-Gang</th>
<th>Total CFL/LED Wattage Installed</th>
<th>Maximum Allowable Incandescent/Halogen Wattage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 W</td>
<td>+ 400 W</td>
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<tr>
<td></td>
<td>1-25 W</td>
<td>+ 300 W</td>
</tr>
<tr>
<td></td>
<td>26-50 W</td>
<td>+ 200 W</td>
</tr>
<tr>
<td></td>
<td>51-75 W</td>
<td>+ 100 W</td>
</tr>
<tr>
<td></td>
<td>76-100 W</td>
<td>+ 50 W</td>
</tr>
<tr>
<td></td>
<td>101-125 W</td>
<td>+ 0 W</td>
</tr>
<tr>
<td></td>
<td>126-150 W</td>
<td>+ 0 W</td>
</tr>
</tbody>
</table>
In-Rush Current

Inrush current can be 10 times greater than steady-state current.
LED Modules
Infusion is a completely tool free, interchangeable modular system
Infusion Applications

Luminaire Flexibility

- Recessed
- Accent
- Pendant
- Multi-head
- Track
- Cylinder
# Competitive Comparison

<table>
<thead>
<tr>
<th>Parameter</th>
<th>GE Infusion Gen2</th>
<th>Xicato XSM</th>
<th>Philips Fortimo SLM</th>
<th>Philips Fortimo TDLM</th>
<th>Cree LMH2</th>
<th>Osram PrevaLED HD</th>
<th>Bridgelux Helion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Picture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Installation</strong></td>
<td><strong>Twist-in</strong></td>
<td>Screw down</td>
<td>Screw down</td>
<td><strong>Twist-in</strong></td>
<td>Screw down</td>
<td>Screw down</td>
<td><strong>Twist-in</strong></td>
</tr>
<tr>
<td><strong>Lumens</strong></td>
<td>Up to 3,500</td>
<td>Up to 2,000</td>
<td>Up to 3,000</td>
<td>Up to 2,000</td>
<td>Up to 1,250</td>
<td>Up to 3,000</td>
<td>Up to 1,200</td>
</tr>
<tr>
<td><strong>Lm per watt</strong></td>
<td>Up to 70</td>
<td>Up to 64</td>
<td>Up to 85 * @ 500 mA</td>
<td>Up to 62</td>
<td>Up to 80</td>
<td>Up to 84</td>
<td>Up to 59</td>
</tr>
<tr>
<td><strong>Color Temps</strong></td>
<td>27 / 30 / 40</td>
<td>27/30/35/40</td>
<td>27/30/35/40</td>
<td>27 / 30 / 40</td>
<td>27/30/35/40</td>
<td>27/30/35/40</td>
<td>30 / 41</td>
</tr>
<tr>
<td><strong>CRI</strong></td>
<td>Up to 87</td>
<td>Up to 95</td>
<td>Up to 95</td>
<td>Up to 80</td>
<td>90</td>
<td>Up to 90</td>
<td>Up to 82</td>
</tr>
<tr>
<td><strong>Color Consistency</strong></td>
<td>4 / 2-step</td>
<td>2-step</td>
<td>4 / 3-step</td>
<td>5 / 6-step</td>
<td>3-step</td>
<td>3-step</td>
<td>3-step</td>
</tr>
<tr>
<td><strong>Size (dia.)</strong></td>
<td>70 mm</td>
<td>45 mm</td>
<td>50 mm</td>
<td>75 mm</td>
<td>88.2 mm</td>
<td>50 mm</td>
<td>80 mm</td>
</tr>
<tr>
<td><strong>L70 Life</strong></td>
<td>50,000 hrs</td>
<td>50,000 hrs</td>
<td>50,000 hrs</td>
<td>25,000 hrs</td>
<td>50,000 hrs</td>
<td>50,000 hrs</td>
<td>50,000 hrs</td>
</tr>
<tr>
<td><strong>Zhaga</strong></td>
<td>Book 5</td>
<td>No</td>
<td>Book 3</td>
<td>Book 2</td>
<td>No</td>
<td>Book 3</td>
<td>No</td>
</tr>
</tbody>
</table>

This information is based on data publicly available at the time of printing. GE and competitor product offerings may change at any time.
Zhaga

What is Zhaga?

• Zhaga is a consortium (group) of LED industry players, including: LED module manufacturers, LED luminaire manufacturers, and LED accessory component (i.e. heat sinks, optics) manufacturers.

Zhaga’s role:

• Zhaga promotes the interchangeability of LED modules by specifying their interfaces and enabling easy identification of Zhaga compliant products.
  • Mechanical, Photometrical, Thermal, Electrical

Zhaga’s purpose:

• Creates market confidence in LED lighting solutions which stimulates the growth of the application of LED’s
  • i.e. Speed up adoption and grow the market for LED modules quickly.
Zhaga is a cooperation between companies

- 167 members
  - 55 members with voting rights
  - From Asia, North America, Europe
  - Companies you recognize such as:
    - Acuity, Cooper, Zumtobel, Iguzini, Ideal, Leviton, BJB, Lutron, GE, Osram, Philips, Panasonic, Ideal, Nuventix, Cree

Meeting every 6-8 weeks
Zhaga

- Zhaga will create many light engine specifications
- Different lighting applications need different light engines
- Zhaga specifications are called “books”

<table>
<thead>
<tr>
<th>Book No.</th>
<th>Book 1</th>
<th>Book 2</th>
<th>Book 3</th>
<th>Book 4</th>
<th>Book 5</th>
<th>Book 6</th>
<th>Book 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Overview and Common Information</td>
<td>Socketable module with integrated driver</td>
<td>Screw-down module with separate driver</td>
<td>Street light module</td>
<td>Socketable module with separate driver</td>
<td>Large socketable module with integrated driver</td>
<td>Office module with separate driver</td>
</tr>
<tr>
<td>Status</td>
<td>Complete</td>
<td>Complete</td>
<td>Complete</td>
<td>In preparation</td>
<td>Complete</td>
<td>Complete</td>
<td>In preparation</td>
</tr>
<tr>
<td>Picture</td>
<td><img src="image1.png" alt="Picture" /></td>
<td><img src="image2.png" alt="Picture" /></td>
<td><img src="image3.png" alt="Picture" /></td>
<td><img src="image4.png" alt="Picture" /></td>
<td><img src="image5.png" alt="Picture" /></td>
<td><img src="image6.png" alt="Picture" /></td>
<td><img src="image7.png" alt="Picture" /></td>
</tr>
</tbody>
</table>
Defining an LED light engine

- An LED light engine is the combination of an LED module and its associated control gear (‘driver’)

Light Engine with Integrated Control Gear

Light Engine with Separate Control Gear
Stable interfaces – Rapid innovation

- Zhaga specifies *only* what is necessary to enable the *interchangeability* of light engines from different manufacturers.

- The design freedom inside the light engines and in the luminaires is maximized.

Zhaga treats the inside of a light engine as a ‘black box’
LED Applications
Fluorescent Ballasts
Fluorescent Ballast Products

- **Magnetic T12**
  - Old Technology
  - Low Efficiency
  - < 30% THD
  - Large Can Size
  - High Heat

- **Electronic T12 & T8, Dedicated Voltage**

- **MultiVoltage T12 & T8 Instant Start**
  - Reduce Stock
  - Reduce Labor

- **Premium Ballast**
  - High Efficiency
  - Multi-Voltage
  - Anti-Striation
  - Class CC Arc

- **Program Start**
  - T8 & T5 Premium
  - For Frequent Switching
  - >100,000 cycles
  - Multi-Voltage
  - Premium Efficiency
  - Parallel or Series?

Performance Features
Instant Start Ballast

- Parallel Wired, lamp goes out, the other stays on.
- One wire to Shunted sockets.
- 550 Volts Open Circuit Voltage
- Cathodes Not heated. High OCV to start lamps.
- Good for long cycles of starting 1-2 times per day.
Programmed Start Ballast

- Similar to Rapid Start, but Programmed Precise Control
- Cathodes heated without Arc Voltage
- Damaging “Glow Current” near Zero!
- Less damage during starting = Longer lamp life at short cycles
- Used with dimming technology
Options for Reducing Lighting Loads

Options:

1. **Switching**
   - Fixture Switching (rows)
   - Fixture Switching (checkerboard)
   - Tandem Wiring (inboard/outboard)

2. **Stepped Dimming ~50-60%**
   - 2 hot leads/2 switches, switching logic
   - 0-10V
   - Powerline Carrier

3. **Load Shed Dimming 100 to 60%**
   - 0-10V Analog
   - Powerline Carrier
   - DALI 0-16V Digital

4. **Full Range Dimming 100~3%**
   - 0-10V Analog
   - Powerline Carrier or Phase Cut
   - DALI 0-16V Digital
### T8 vs T5 Efficacy For Office Environment

<table>
<thead>
<tr>
<th>Luminaire</th>
<th># Lamps</th>
<th>Lumens</th>
<th>Lumens</th>
<th>BF</th>
<th>LLF</th>
<th>Watts</th>
<th># Fixtures</th>
<th>Required</th>
<th>Footcandles</th>
<th>Watts/Ft Sq</th>
<th>Lum/Watt</th>
</tr>
</thead>
<tbody>
<tr>
<td>T5 Perforated Basket</td>
<td>2-51W</td>
<td>5000</td>
<td>4600</td>
<td>1.00</td>
<td>0.76</td>
<td>107</td>
<td>10</td>
<td>53.6</td>
<td>1.34</td>
<td>85.98</td>
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<td>T5 Perforated Basket</td>
<td>2-28W</td>
<td>2900</td>
<td>2660</td>
<td>0.96</td>
<td>0.73</td>
<td>59</td>
<td>15</td>
<td>47.0</td>
<td>1.11</td>
<td>86.56</td>
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<tr>
<td>T8 Perforated Basket</td>
<td>3-32W</td>
<td>2950</td>
<td>2800</td>
<td>0.89</td>
<td>0.78</td>
<td>84</td>
<td>12</td>
<td>48.6</td>
<td>1.26</td>
<td>89.00</td>
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</tr>
<tr>
<td>T8 Perforated Basket</td>
<td>3-28W</td>
<td>2950</td>
<td>2800</td>
<td>1.15</td>
<td>1.00</td>
<td>108</td>
<td>10</td>
<td>53.0</td>
<td>1.35</td>
<td>89.44</td>
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<tr>
<td>T8 Perforated Basket</td>
<td>3-28W</td>
<td>2725</td>
<td>2562</td>
<td>1.10</td>
<td>0.96</td>
<td>91</td>
<td>12</td>
<td>55.2</td>
<td>1.37</td>
<td>92.91</td>
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</tr>
<tr>
<td>T8 Perforated Basket</td>
<td>3-28W</td>
<td>2725</td>
<td>2562</td>
<td>1.10</td>
<td>0.96</td>
<td>91</td>
<td>10</td>
<td>47.0</td>
<td>1.14</td>
<td>92.91</td>
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<tr>
<td>T8 Perforated Basket</td>
<td>3-32W</td>
<td>3100</td>
<td>2915</td>
<td>0.89</td>
<td>0.77</td>
<td>84</td>
<td>10</td>
<td>53.6</td>
<td>1.05</td>
<td>92.66</td>
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<tr>
<td>T8 Parabolic</td>
<td>3-32W</td>
<td>2950</td>
<td>2800</td>
<td>0.89</td>
<td>0.78</td>
<td>84</td>
<td>10</td>
<td>58.3</td>
<td>1.05</td>
<td>89.00</td>
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<tr>
<td>T8 Parabolic</td>
<td>3-32W</td>
<td>3100</td>
<td>2915</td>
<td>0.89</td>
<td>0.77</td>
<td>84</td>
<td>8</td>
<td>49.0</td>
<td>0.84</td>
<td>92.66</td>
<td></td>
</tr>
</tbody>
</table>

Design based on the number of fixtures required to provide 50 footcandles at a 2.5' workplan. Room dimensions 40' x 20' x 9'.

Based on ambient temperature of 77 deg.

**The Most Efficacious System?** Typically the T8 lamp is more efficient but it does depend on the lamp/ballast system.

As can be seen, the 3100 lumen 32W T8 and the 28W T8 are more efficient than the 2950 lumen 32W T8 and the 51W T5. The 28W T5 does very well but requires more luminaires.

If you consider the T8 in a parabolic luminare, the 3100 lumen 32W T8 really stands out.

**Note 1:** Many people simply look at the lumens/watt figure. I prefer to calculate the watts/ft sq because this really shows you how much energy is going to be required to get the desired results.

**2:** GE has a 51W T5 that has the same lumens as everyone's 54W lamp. This actually helps the T5 come closer to the T8.
THANK YOU!

QUESTIONS?