



**focus on energy**<sup>sm</sup>

Partnering with Wisconsin utilities

# **Industrial Lighting Best Practices**

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**US Lamp, Inc.**

# Industrial Lighting Efficiency



# Agenda

- **Introduction**
- **Lighting Basics**
- **Lighting Best Practices**
- **Getting Your Project Started**
- **Summary**



# Lighting Basics



# Lighting Efficiency Benefits

- **Energy savings = \$ savings**
- **Reduced maintenance = time and cost savings**
- **Better light quality:**
  - **Increased productivity**
  - **Improved safety and performance**
  - **Comfort**

# Basic Definitions

- **Lamp – light bulb of any type**



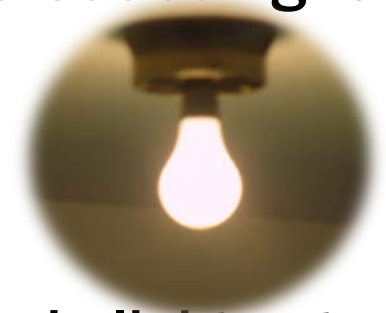
- **Luminaire – complete lighting fixture including:**

<b>Housing</b>	<b>Lens or shade</b>
<b>Reflectors</b>	<b>Lamps</b>
<b>Wiring</b>	<b>Ballast</b>
<b>Trim</b>	<b>Lamp holders</b>



# Lighting Types – Incandescent

- Filament heated by electric current to produce light
  - Incandescent
  - Halogen – advanced incandescent
- Inefficient
  - <10% energy consumed actually results in light output  
(6%-7% per GE Lighting)
  - >90% energy lost as heat
  - Legislation to ban these in U.S. by 2012 (2011 in CA)
- Short lived – filament burns up or breaks



# Lighting Types – Fluorescent

**Luminescence – excited electrons cause phosphors in lamp to glow:**

- **Fluorescent lamps use phosphor coating to emit white light**
- **Linear light source provides even illumination**
- **Can be temperature sensitive**
- **Very wide offering of products**





# Lighting Types - HID

## High Intensity Discharge

- Excited gasses discharge light
- Point source is easily controlled – aimed accurately
- Not temperature sensitive (cold or warm)



# Lighting Types – HID (continued)

## Types:

- Metal halide – standard, P.S. – white light
- High pressure sodium – amber light
- Mercury vapor – bluish green white light
- Low pressure sodium – yellow colored light, monochromatic

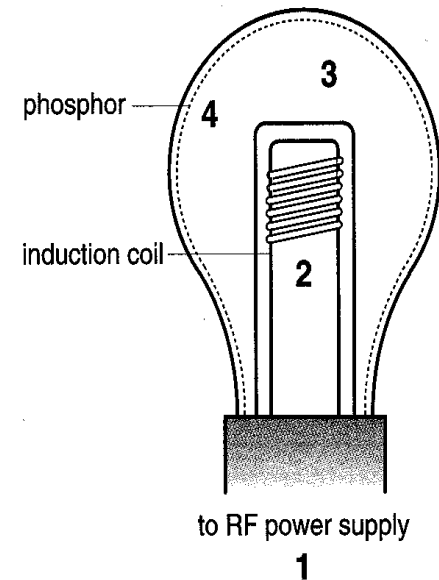
**For 24/7 MH operation, shut down each week for 15 minutes – safety concern!**

# Induction Lamps – Early 90's

Alternative to low wattage HID lamps:  
*(street lighting retro-fits)*

- Three system parts
  - High frequency generator (2.65mhz)
  - Power coupler
  - Discharge vessel (lamp)
- 55-400W
- Instant starting, 85 CRI
- 100,000 hours life, 65-70 LPW
- 3000°K, 3500°K, and 4100°K
- Excellent for difficult-to-access areas

***New technology?***



# Lighting Types – LED

## Light Emitting Diode

- Very long life – if heat is controlled, 50,000+ hours
- Efficiencies improving – 130 LPW at LED, 70-80 LPW from fixtures
- Good color rendition, 85-90 CRI
- No UV in beam – great for artwork, etc.
- Starting to work for exterior, low footcandle needed
- Coming of age in task lighting, downlights, etc.
- Still needs to improve for general indoor lighting

# LED Canopy Lighting 2008



**3 pump rows, 42 fixtures, 18 footcandles**

# LED Canopy Lighting 2009



**5 pump rows, 30 fixtures, 80 footcandles**

# DOE Testing

**4', T8 LED retrofit products not viable per DOE:**

**“Simply put, the 4' SSL linear replacement lamps do not provide sufficient light output or efficacy, have poorer color quality than fluorescent benchmarks, often require electrical rewiring of the troffer (to bypass the ballast), and do not represent wise use of SSL technology at this time.”**

# CRI – Color Rendering Index

How accurately a light source makes an object appear compared to natural or incandescent light.

Rated on 1-100 scale (100 closest to natural light):

- T12 fluorescent, 52 to 65
- T8, T5 and CFL, 70 to 95
- Standard MH, 55 to 65
- Pulse start MH, 70 to 80
- Ceramic PS MH, 80 to 94
- LED, 85 to 90
- HPS, 22
- LPS, 0



# Color Rendering Index

## *Color Accuracy*

Ability of a light source to show colors “realistically” compared to how an object would appear in incandescent or natural light.



CRI = 90



CRI = 70



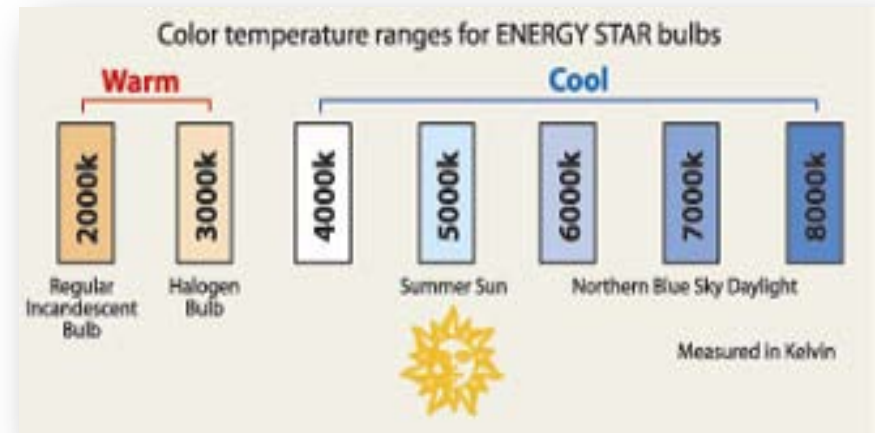
CRI = 50

# CCT – Correlated Color Temperature

## *Color Appearance*

Describes appearance of the light itself

- High pressure sodium 2200K
- Incandescent 2000-3000K
- Warm white fluorescent 2700K
- Neutral fluorescent 3500K
- Cool white fluorescent 4100K
- Metal halide 4200-5500K
- Average noon sunlight 4800K
- Daylight, fluorescent 5000K
- Uniform overcast skylight 7500K



Generally the higher the color temperature, the bluer the light appears.

# Ballast – What And Why

**Ballast – transformer to start/regulate fluorescent and discharge lamps**

## Fluorescent ballast types:

- **Magnetic (core, coil)**
  - Heavy, hot
  - May be required in areas with equipment sensitive to high frequency (60Hz)
- **Electronic**
  - Instant start –efficient, least expensive
  - Rapid and newer programmed start
    - PS uses less Watts
    - More gentle starting
    - Use with sensors, frequent (200,000) on/offs



# High Intensity Discharge Ballast Types

- **Standard probe start MH – old technology**
- **Pulse start**
  - Faster re-strike time
  - Better maintained light level
  - More lumens per watt
  - Better color rendition
- **Electronic – newer**
  - Even better LPW and maintenance-close to T8, T5HO
  - Pricing is coming down
  - Worth getting a quote to compare



# What Is Ballast Factor?

**BF can be used to customize light level of T8 fixtures – light output is proportional to specified BF– design to meet light level needed:**

Ultra low BF, less light and less energy	.60	3L = 67 w
Low BF, <i>under-drives</i> lamps for low light output	.77	4L = 98 w
Normal BF close to rated light output from lamps	.87	4L = 112 w
Medium BF cap a ballast lead for slight overdrive	1.0	3L = 94 w
High BF, <i>over-drives</i> lamps for high light output	1.18	3L = 111 w

(Based on 32w T8's - 30w, 28w, 25w also available)

# Calculating Electric Energy Consumption

**Watts** – units of instantaneous power

**1 kiloWatt (kW) = 1000 watts**

**To calculate electricity consumption:**

kWh of consumption =

$( (\# \text{ Fixtures} \times \text{*input watts}) / 1000 ) \times \text{hours of operation}$

**\*Find input watts in manufacturers' catalogs!**

# Lighting Measurement Terminology

- **Lumens – total light output from a lamp**
  - Listed by lamp manufacturers in catalog
  - Expressed as “initial lumens” or “mean lumens”
  - Lighting design targets “mean lumens”
- **Illuminance – light level at the task**
  - Measured in footcandles by light meter or calculated with photometric data from manufacturer spec sheet
- **Footcandles (fc) – light level at specific location**
  - Defined as a unit of illuminance equal to  $1 \text{ lm/ft}^2$
  - Measured at task level
  - Both horizontal and vertical are important!



# Recommended Light Levels

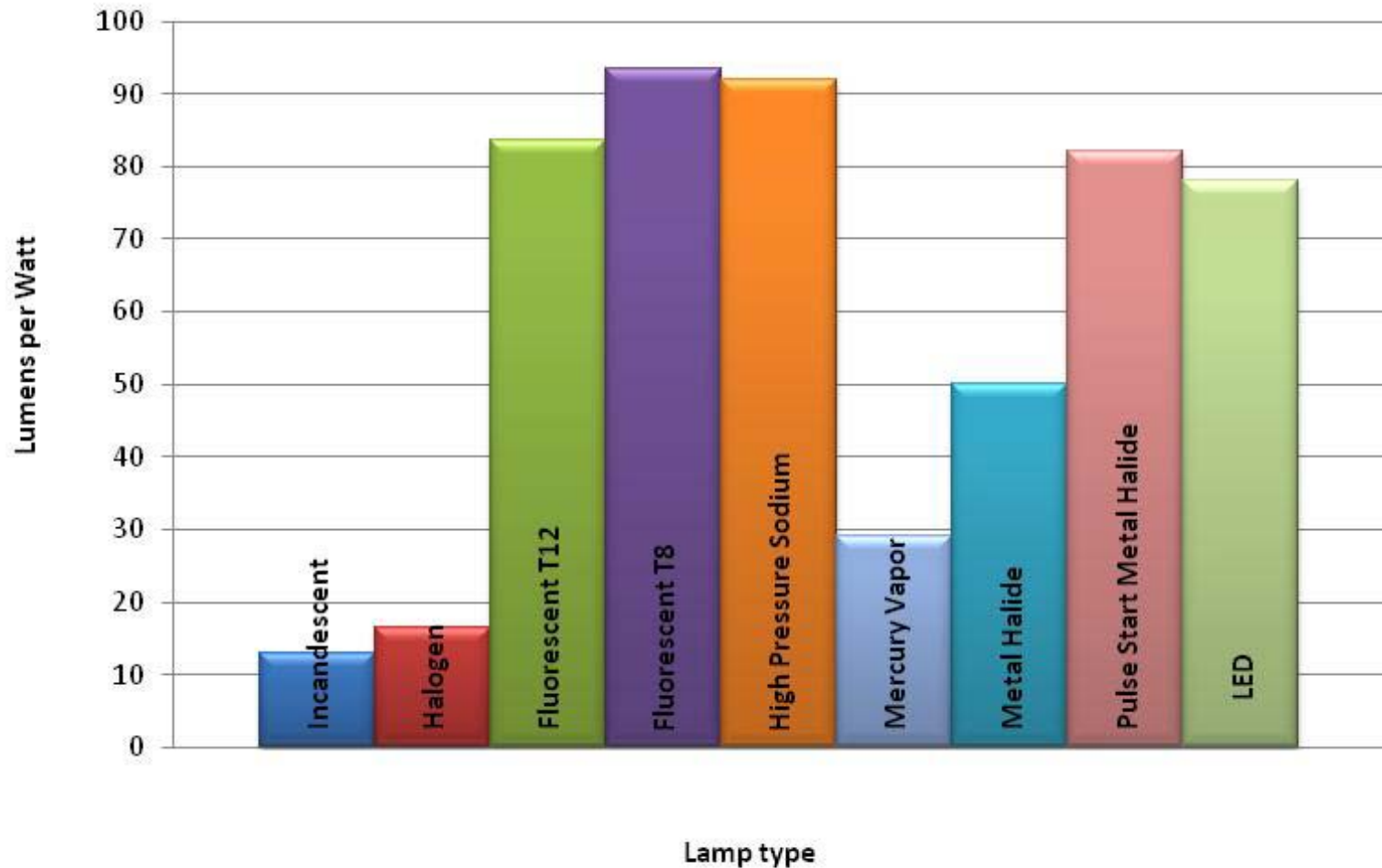
- **Illuminating Engineering Society of North America (IESNA) publishes guidelines (9<sup>th</sup> edition) based on 13 criteria – 10<sup>th</sup> edition released mid 2011**
  - Type of task being performed
  - Size of objects handled
  - Level of detail required
  - Average age of workers in that space
- **Recommended illuminance examples (IES RP7-01)**
  - Motor and equipment observation      30 fc
  - Medium bench or machine work      50 fc
  - Inspection (difficult)      100 fc
- **More light needed for smaller size and lower contrast**
  - Adjust for age of worker, contrast, size



# More Measurement Terminology

- **Efficacy – lumens per watt (LPW)**
  - Measures lamp efficiency (like a car's MPG)
  - Varies by lamp type – larger wattage is more efficacious
  - Good starting point, not only consideration – look at total system performance for proper lighting solution for **ambient temperature, fc required, dirt, glare, fixture optical performance**
- **Lamp lumen depreciation/lumen maintenance**
  - As lamps age they give off less light
  - Follows a specific curve – published for light sources by mfg.
  - Lumen depreciation differs by light source type

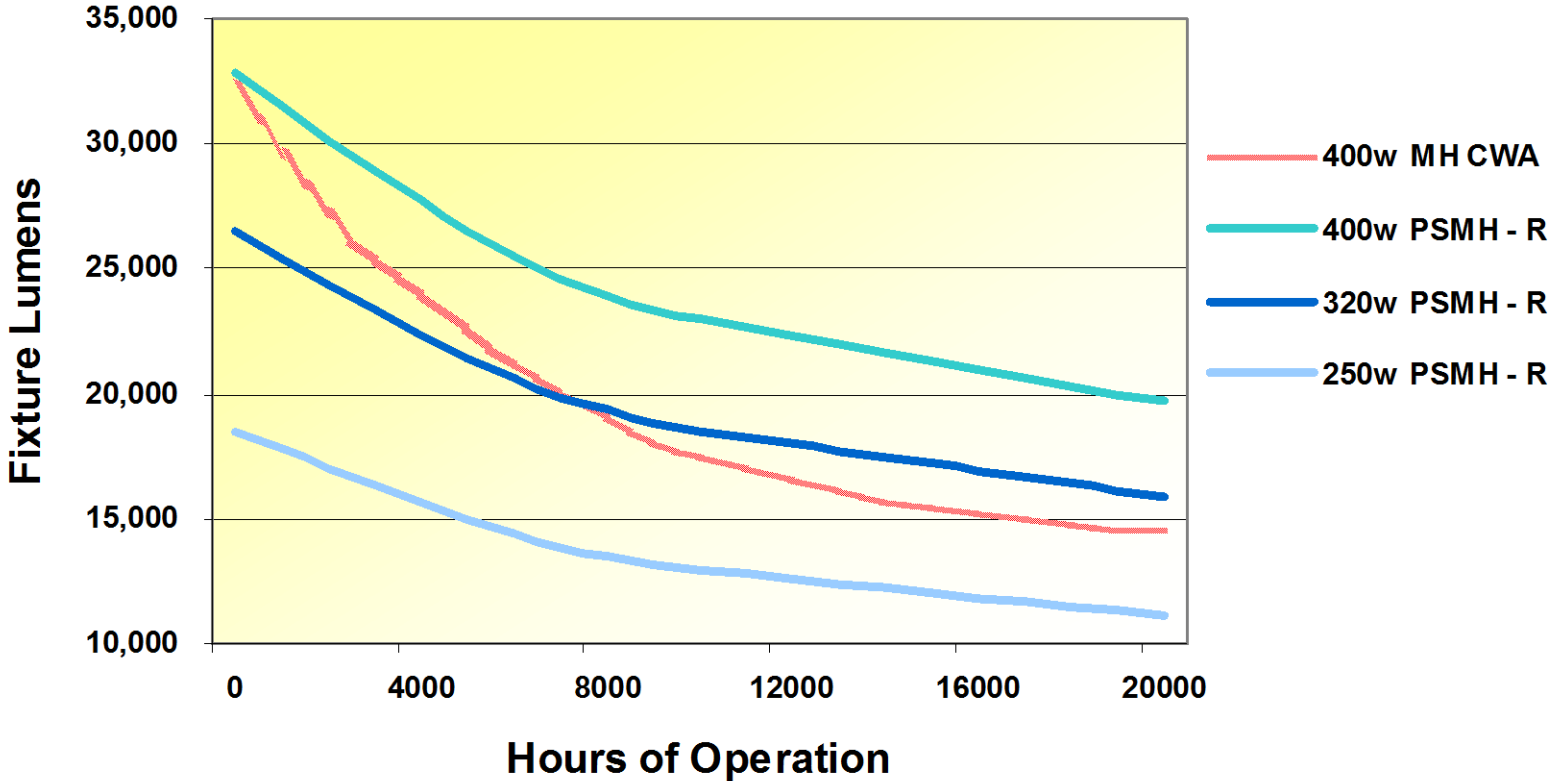
# Efficacy of Various Lamp Types



Picture used with permission from various lighting manufacturers and sources, including GE, Osram/Sylvania, IES, BOC., and others.

# Fixture Lumen Maintenance

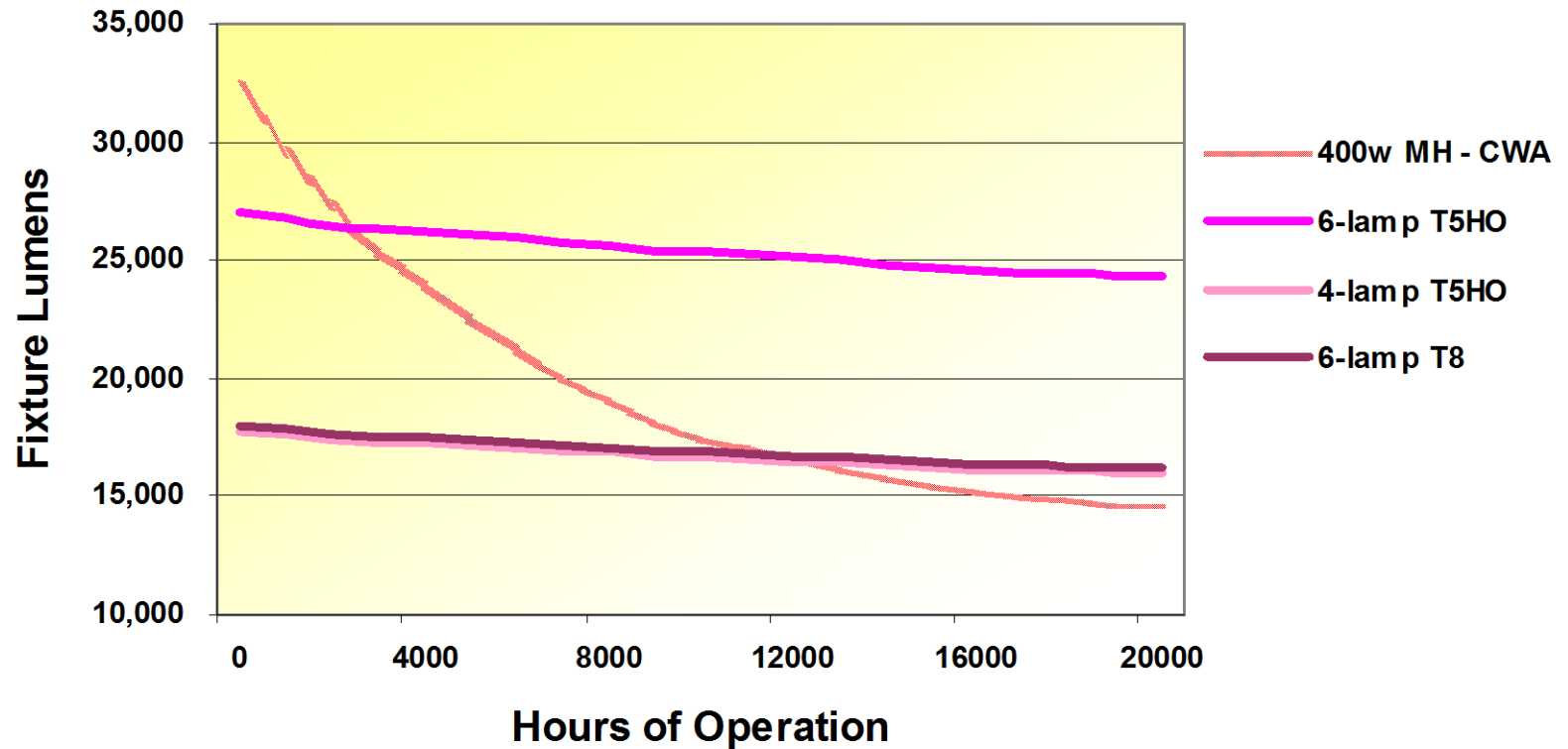
## Pulse start versus standard 400W MH



Graph and information courtesy of Ruud Lighting

# Fixture Lumen Maintenance

## Linear fluorescent



# Lamp Nomenclature

- **Varies by manufacturer**
- **Example – F32T8/835**

**F = fluorescent**

**32 = lamp watts, sometimes length (i.e. F96T8 = 96”)**

**T = tubular shape**

**8 = diameter in eighths of an inch (T8 = 1” diameter)**

**Usually followed by description of CRI & CCT**

- **CW = cool white (4100K)**
- **SPX35, 835 = 85 CRI and 3500K**

**Sometimes followed by additional efficiency description**

- **WM = *Watt Miser*; SS = *Super Saver*; EW = *Econo-Watt***

# Best Practices

# Facility Lighting Level Standards

1. Identify current lighting equipment.
2. Interview workers in each area about light levels and effectiveness.
3. Determine existing light levels with light meter.
4. Establish standards using in-house information and industry standards – IES.
5. Evaluate data for areas of potential lighting reduction/increase.
6. Use the standards when changing lighting, verify levels with light meter afterward.
7. Monitor light levels regularly to assess any degradation in levels.

**Establish then verify/maintain**

# Lighting Level Standards (continued)

- **Resources available from IESNA**
  - **RP-7, Recommended Practices for Lighting Industrial Facilities (\$40)** <http://www.iesna.org/shop/item-detail.cfm?ID=RP-7-01&storeid=1>
  - **AEDG-4-08, Advanced Energy Design Guide for Warehouses** <http://www.iesna.org/shop/item-detail.cfm?ID=AEDG-4-08&storeid=1>
- **Advanced Lighting Guidelines online subscription**
  - Download at <http://www.algonline.org/>
- **National Lighting Bureau (NLB) Guide to Industrial Lighting**
  - Download FREE .pdf at <http://www.nlb.org/pubs/>



# Properly Maintain Your Lighting System

- **Clean fixtures, lamps, lenses**
  - Dirt buildup traps light inside fixture
  - Same energy consumption, less light
  - Can lose 10-30%+
- **Inspect fixture components**
- **Institute group relamping program**
  - Replace lamps at 60-80% of rated life
- **New IES/NALMCO publication available**  
– *RP-36-03 Planned Indoor Lighting Maintenance*



<http://webstore.ansi.org/RecordDetail.aspx?sku=IESNA/NALMCO+RP-36-03>

# High Bay Fixtures

**Use with high efficiency T8 or T5 lamps, electronic ballasts, where appropriate**

- **40-45% more efficient than T12 with magnetic ballasts, have higher quality light**
- **T12 4' and most 8' delisted on 7-14-12**
- **Up to 50% more efficient than old HID – but be careful!**
- **Payback in  $\leq 3$  years in long burn applications**
- **May not be appropriate for:**
  - **Unheated spaces, cold warehouse, pools (caustic)**
  - **Extremely dirty, solvent, oily, dusty locations**



# High Bay Fluorescent Can Work In...

...cold temperature environments

35°F room temperature



Before



After

# High Bay Fluorescent Can Work In...

...swimming pools



Before



After

# High Bay Fluorescent Can Work In...

...warehousing



Before



After

# Pulse Start Metal Halide

Use pulse start metal halide where high bay fluorescent is not feasible.

## Advantages over probe start MH:

- Greater efficacy
- Better lumen maintenance
- Longer lamp life
- Better color rendition
- Faster warm up
- Quicker restrike
- Start in colder temps. vs. fluorescent
- **Can save up to 80W+ per fixture, large variety of wattages, sizes. 400W to 320W, etc.**



# Pulse Start Metal Halide Example

## Power plant



Before



After

# Install Automated Controls

- Ideal for areas where lighting might be left on when not in use
- Occupancy sensors can save up to 80%+ in energy costs
- Infrared, ultrasonic, dual technology, microphonic
- Dimming/daylighting controls can reduce energy costs, extend lamp life





# Maximize Efficient Task Lighting

- When upgrading lighting, maximize task lighting and minimize ambient or overhead – put light where needed.
- Combination of area lighting and independently switched task lighting saves up to 20%.



# Getting Your Project Started

# Project Support

- Program Ally listing on Focus on Energy website, [www.focusonenergy.com](http://www.focusonenergy.com)
- Vendors for lighting, HVAC, motors, etc.
- Energy Advisors – Focus on Energy has advisors available to assist with projects, [800-762-7077](tel:800-762-7077)

# Energy Advisor Support

- Facility surveys – identify technologies
- Savings estimates
- Project study support – verify vendor proposal(s) accuracy
- Project incentive support
- Assist selling your project to management
- **Specific Vendor Support** – picks up from Focus on Energy estimates to develop formal design/proposal

# Selling Your Project Upstream

- **Simple payback analysis – basic approach**
  - **Capital cost**
  - **Energy savings**
- **Lifecycle cost benefit analysis – comprehensive approach addressing all project benefits**
  - **Capital cost**
  - **Energy savings**
  - **Correcting, improving light levels**
  - **Maintenance cost**
  - **Depreciation**
  - **Other cost, savings streams**
  - **Tax deduction opportunities – EAct 2005**

# EPAAct 2005

- **Energy Policy Act of 2005**
- **Signed into federal law August, 2005**
- **Effective 1-1-05 through 12-31-13**
- **Numerous provisions for energy efficiency**
- **Higher standard for lighting, HVAC and building envelope technologies**
- **Tax deductions for implementation – includes language for tax exempts to benefit**

# Tax Deduction Financial Impact

**Based on ASHRAE 2001 standard:**

- **Full building envelope measures can generate up to \$1.80/ sq. ft. tax deduction.**
- **Interim lighting rules allow for \$.30-.60/sq. ft. tax deduction based on 25%-40% improved efficiency.**
- **200,000 sq. ft. lighting project can generate up to \$120,000 lighting tax deduction.**

# Focus on Energy Lighting Incentives

- Provide cash back *incentives* for eligible customers and projects –  
[www.focusonenergy.com/financialincentives](http://www.focusonenergy.com/financialincentives)
- Primarily granted on a per fixture basis (prescriptive)
- Custom grants available for new construction projects, “cutting edge” technology:
  - Energy saving projects that don’t fit prescriptive
  - Requires pre-approval by program management



# Typical Incentives\*

<b>Existing Equipment</b>	<b>Installed Measure</b>	<b>Incentive/ Unit</b>
HID (400W)	High bay 6T8 or 4T5H0	\$50
HID (400W)	High bay T8 or T5 w/sensor controls	\$65
HID (400W)	Pulse start MH 320W w/electronic ballast	\$50
2 lamp T12 HO or 2 lamp T12 VHO	4 lamp HPT8 components	\$20 \$40

\* through March 31, 2012

# Practical Energy Management (PEM)<sup>©</sup>

- Understand how your facility uses energy
- Develop skills necessary to manage energy usage, cost
- Half-day training dates
- For future Industrial Practical Energy Management training dates, check the Focus website at [www.focusonenergy.com/training](http://www.focusonenergy.com/training)

# Building Operator Certification

- Understand how your facility systems interact
- Develop the skills necessary to manage energy usage, identify upgrade opportunities
- Level II – advanced equipment troubleshooting and diagnostics plus facilities management training
- Level II offered March 1, 2012
- 7 – full day training sessions, once per month
- Offered at 4 videoconference locations – Chippewa Falls, Green Bay, Madison, Mequon
- Covers facility preventive maintenance and troubleshooting, advanced electrical diagnostics, HVAC troubleshooting and maintenance, HVAC controls and optimization, introduction to building commissioning, and enhanced automation and demand reduction
- Check the Focus on Energy for upcoming series dates

# Get Your Project Started!

Contact your **Energy Advisor** or **Program Ally**; ask about technical support and incentives for eligible projects.

Don't have an Energy Advisor?

Contact Focus on Energy, [800-762-7077](tel:800-762-7077), for more information.

# Summary

- **Understand lighting technology, terminology**
- **Implement lighting best practices to maximize return on your investment**
- **Work with Focus on Energy and qualified Program Allies to make your energy efficiency projects happen**

# Additional Resources

- Lightsearch.com: useful formulas, economics, etc.  
[www.lightsearch.com/resources/lightguides/index.html](http://www.lightsearch.com/resources/lightguides/index.html)
- IESNA website: [www.iesna.org](http://www.iesna.org)
- Lighting Design Lab: [www.lightingdesignlab.com](http://www.lightingdesignlab.com)
- Federal Energy Management Program (FEMP):  
[www1.eere.energy.gov/femp/](http://www1.eere.energy.gov/femp/) and  
[www1.eere.energy.gov/industry/bestpractices/](http://www1.eere.energy.gov/industry/bestpractices/)
- National Lighting Product Information Program:  
[www.lrc.rpi.edu/programs/NLPIP/publications.asp](http://www.lrc.rpi.edu/programs/NLPIP/publications.asp)

# Additional Resources (continued)

- Designlights Consortium:

[www.designlights.org/downloads/highbay\\_guide.pdf](http://www.designlights.org/downloads/highbay_guide.pdf)

- NEMA tax incentive information:

[www.lightingtaxdeduction.org/](http://www.lightingtaxdeduction.org/)

- Focus on Energy fact sheets

[www.focusonenergy.com/Information-Center/](http://www.focusonenergy.com/Information-Center/)

# Another Resource

**Randy Johnson, LC, President**

**US Lamp, Inc.**

**920-434-3636**

**rjohnson@uslamp.com**



# Thanks for participating!

## Focus on Energy Industrial Program

*Thank you to the following companies for the use of their photos:*

*GE Lighting, Philips Lighting, Osram/Sylvania Lighting, US Lamp, Inc., TCP, Seagull Lighting, Orion Lighting, Lithonia, Grainger, Ruud Lighting, Holophane, Hubbell Lighting, Lutron, WattStopper, Maxlite, Joseph Coates, and Energy Star*