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· August 15-18, 2010 · Dallas, Texas ·
· Dallas Convention Center ·

O & M: Lighting

Michael Davenport
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MACTEC

BIO

- Binh Nguyen

  Career

  – BSEE -University of Florida, Gainesville, FL 2004

  – Certified Energy Manager – AEE

  – Harris Lighting 2005-2008

  – MACTEC Engineering 2008- Present

  Hobbies

  – Cars

  – Sports

OUTLINE

- Lighting Terminology and Theory
- Lighting Costs
- Lighting Controls
- Lighting Technologies

LIGHTING TERMINOLOGY

Lumen (lm) – SI unit of luminous flux

- ✓Basically the measure of the power of light perceived by the human eye
- ✓Lamps are rated by their lumen output

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- ✓1 fc = 1 lumen per square foot
- ✓1 lux = 1 lumen per square meter

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GE Marketing Device, circa 1960

LIGHTING TERMINOLOGY

Lamp – the replaceable component of a lighting fixture

- ✓Often referred to as a “bulb”

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Bulbs are planted in your garden

LIGHTING TERMINOLOGY

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- ✓Often referred to as a “bulb”

Bulbs are planted in your garden

Lamps provide light in your facility

LIGHTING TERMINOLOGY

CRI – Color Rendering Index

- ✓The ability of a light source to render color in comparison to natural light
- ✓Measured on a scale of 1-100 (Incandescent Lamp = 100)

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CCT- Correlated Color Temperature

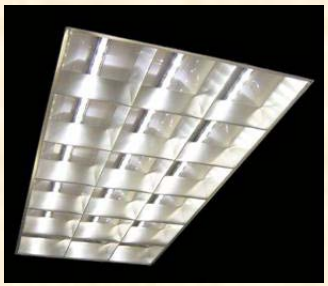
- ✓Numerical Scale used to describe the color of light in kelvin (K) units
  - •2700K – Incandescent lamps
  - •3500K – Household Compact Fluorescent Lamps (CFL)
  - •4100K – Common T8 lamp found in your office
  - •6500K – Natural sun light

LIGHTING TERMINOLOGY

CRI & CCT EXAMPLES

Candle 1700K – 100 CRI

High Pressure Sodium – 2100K - 25 CRI



T8 Lamps – 4100K - 85 CRI

LIGHTING TERMINOLOGY

CRI & CCT EXAMPLES

LIGHTING TERMINOLOGY

Photopic Lumens – Type of light measured by common light meters

- ✓Part of the human eyes perception of brightness
- ✓Measure of the physical lumens output without accounting for quality factors like CRI or CCT

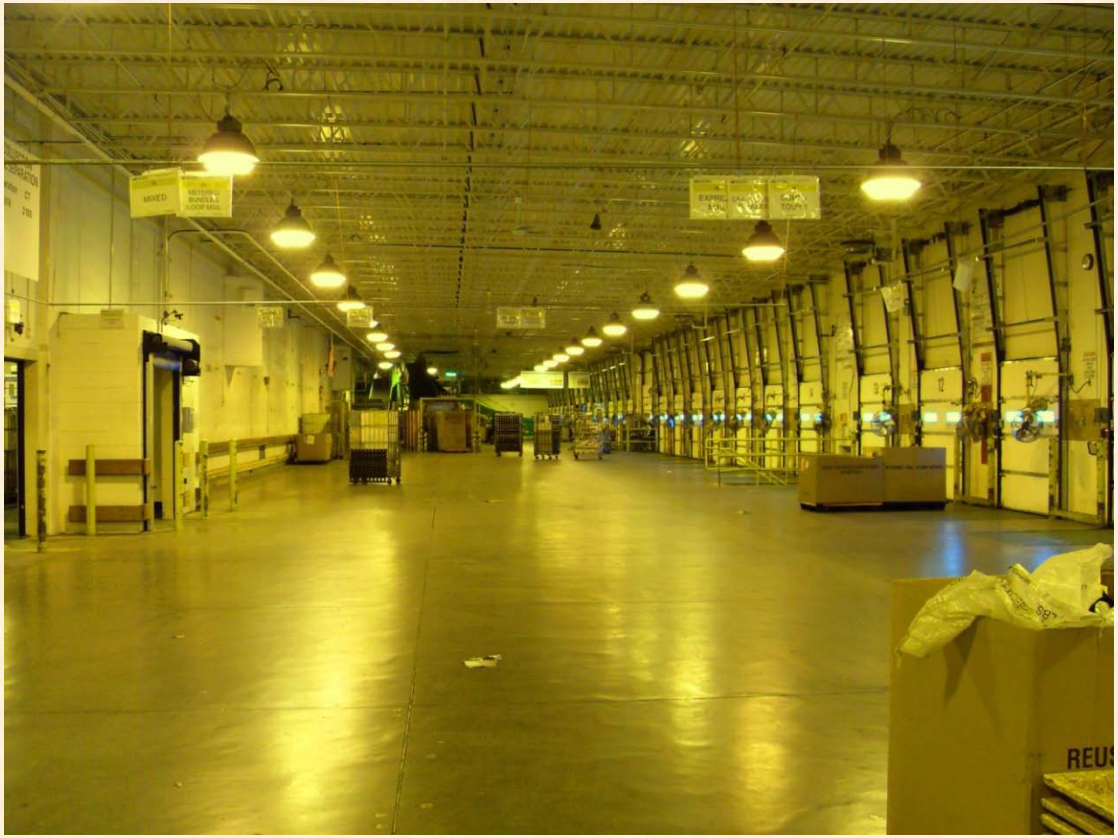
Scotopic Lumens – Type of light NOT measured by common light meters

- ✓Other Part of the human eyes perception of brightness
- ✓Accounts for quality of light from higher CRI and CCT
- ✓Physical lumen output and fc might be lower but the space appears brighter because the quality of light is better

LIGHTING TERMINOLOGY

Photopic Lumens vs. Scotopic Lumens

400W High Pressure Sodium (464W with Magnetic Ballast)



Average Light Level: 50 fc

LIGHTING TERMINOLOGY

Photopic Lumens vs. Scotopic Lumens

145W 4-Lamp T8 High Output with High Lumen “Super” T8 Lamps

1 for 1 replacement with 319W per fixture savings

Average Light Level: 25 fc

LIGHTING TERMINOLOGY

Efficacy– The measure of lumens per watt to express the optical efficiency of a lamp/ballast system or light fixture

- ✓Lighting term NOT to be confused with EFFICIENCY

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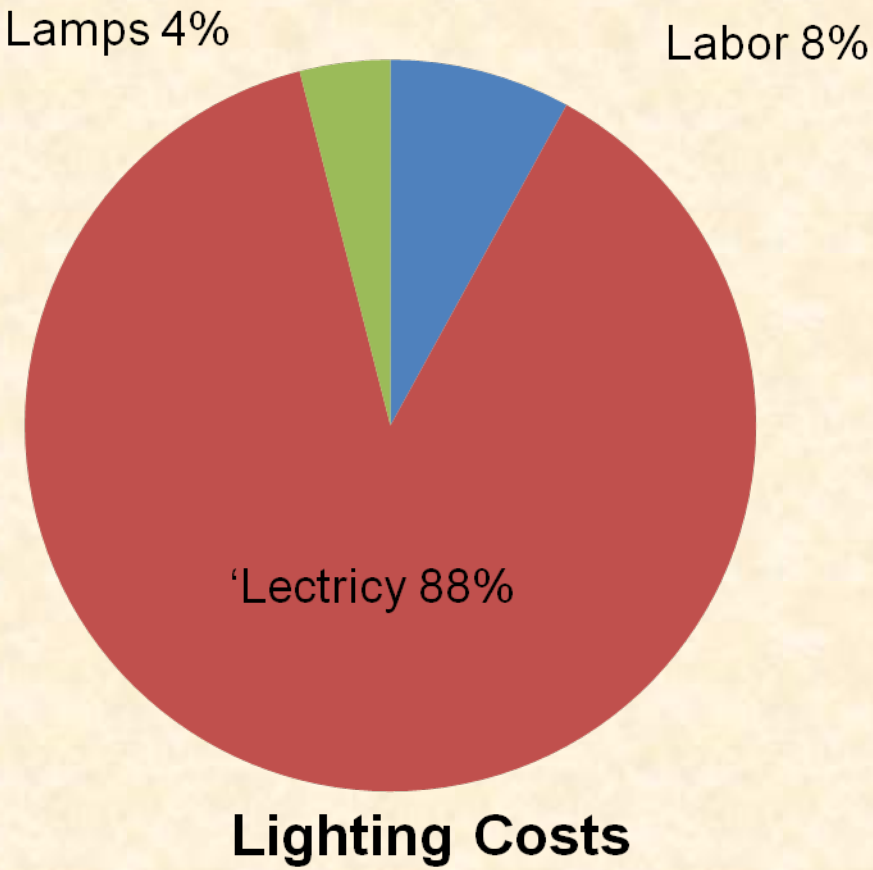
Common Efficacy of Lighting

•60W incandescent lamp	15 lm/W
•13W CFL	60 lm/W
•400W Metal Halide	78 lm/W (initial) 51 lm/W (mean)
•400W HPS	107 lm/W (initial) 96 lm/W (mean)
•Standard 4’ -34W T12	68 lm/W
•Normal Output Standard T8	95 lm/W (high efficiency ballast)
•High Output Super T8	97 lm/W (high efficiency ballast)
•High Output T5	93 lm/W (watt-miser lamps)

LIGHTING COSTS

The 3 L's of Lighting



LIGHTING COSTS

Office Example

4-Lamp Recessed Fluorescent T12 Fixture

144-Watts per Fixture

60 Hours per week Usage

52 Weeks a Year

200 Fixtures

$0.12 kWh Energy Rate

144W/1000 = 0.144kW x (60hrs/wk x 52 wks) = 449kWh per year

449kWh x 200 fixtures = 89,856 kWh per office space

LIGHTING COSTS

Office Example

4-Lamp Recessed Fluorescent T12 Fixture

144-Watts per Fixture

60 Hours per week Usage

52 Weeks a Year

200 Fixtures

$0.12 kWh Energy Rate

144W/1000 = 0.144kW x (60hrs/wk x 52 wks) = 449kWh per year

449kWh x 200 fixtures = 89,856 kWh per office space

Energy Costs

$10,782 per year to light the Office

LIGHTING COSTS

Warehouse Example

400W High Pressure Sodium Fixture

465-Watts per Fixture

24 Hour Operation

500 Fixtures

$0.12 kWh Energy Rate

465W/1000 = 0.465kW x (24hrs x 365days) = 4,073 kWh per year

4,073 kWh x 500 fixtures = 2,036,500 kWh per warehouse

LIGHTING COSTS

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Energy Costs

$244,380 per year to light the Warehouse

LIGHTING COSTS

EXIT Sign Example

Incandescent EXIT sign

30-Watts per Fixture

24 Hour Operation

50 Fixtures

$0.12 kWh Energy Rate

30W/1000 = 0.03kW x (24hrs x 365days) = 263 kWh per year

263 kWh x 50 fixtures = 13,150 kWh per building

LIGHTING COSTS

EXIT Sign Example

Incandescent EXIT sign

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Energy Costs

$1,578 per year to for EXIT signs for Building

LIGHTING CONTROLS

The most energy efficient light is one that is off

- Wall-mounted or ceiling-mounted occupancy sensor
- Fixture-mounted occupancy sensor
- Wall-mounted Timer
- Timeclock
- Network controls system

LIGHTING CONTROLS

Common Controls Mistakes

- Using incorrect ballast can shorten lamp life
  - ✓Program Start ballast is recommended for controls
- Sensors that allow “ON” override
- Poorly positioned sensor
  - ✓Wallswitch behind bookcase or desk
  - ✓Ceiling Sensor blocked by partitions
- System not programmed or commissioned properly
- Not using the system

LIGHTING TECHNOLOGY

COMMON LIGHTING FOUND IN FACILITIES

Fluorescent 2x4 Troffers – Lens and Parabolic

Fluorescent Wrap Around Fixtures

Recessed Can and Track Lights

CFL or Incandescent EXIT signs

Fluorescent Industrial Strip Fixtures

High Intensity Discharge (HID)

LIGHTING TECHNOLOGY

FLUORESCENT

T12 – 12/8th of an inch or 1.5 inch diameter
Typical 4'- 4-lamp 34W system uses 144W- 9,120 lm
CRI = 60

T8 – 8/8th of an inch or 1 inch diameter
Same length and pin configuration as a T12
Typical 4'- 2-lamp 32W T8 system uses 57W – 5,016 lm
CRI = 85

LIGHTING TECHNOLOGY

FLUORESCENT

T5HO – 5/8th of an inch or 0.625 inch diameter
Typical 4'- 2-lamp 54W system uses 121W – 10,000 lm
CRI = 85

T5 lamps are shorter and have different pin configurations compared to T12/T8

T5HO – High Output generally recommended for high-bay applications 40' and above

T5-28W Standard Output generally used in office applications

Many new indirect volumetric fixtures use T5-28W

LIGHTING TECHNOLOGY

FLUORESCENT

National Electrical Manufacturers Association (NEMA) & US Census

2009 US Lamps Sales Breakdown

Linear Fluorescent	26%
Incandescent	23%
CFL	25%
HID	15%
Halogen	11%

LIGHTING TECHNOLOGY

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Linear Fluorescent	26%	→	T12	T8	T5
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31% of Linear Fluorescents out there are wasting energy and people are still buying replacement lamps!!!!

LIGHTING TECHNOLOGY

FLUORESCENT

US D.O.E. Legislation – June 14, 2009

Lamp Type	CCT	Efficacy Requirement (lm/W)
4-ft (T8-T12) Medium Bi-pin >25W	<4,500K	89
	>4,500K and <7,000K	88
U-Lamps (T8-T12) Medium Bi-pin >25W	<4,500K	84
	>4,500K and <7,000K	81
8-ft (T8-T12) Slimline >52W	<4,500K	97
	>4,500K and <7,000K	93
8-ft (T8-T12) High Output	<4,500K	92
	>4,500K and <7,000K	88
4-ft (T5) Miniture Bi-pin Standard>26W	<4,500K	86
	>4,500K and <7,000K	81
4-ft (T5) Miniture Bi-pin HO>49W	<4,500K	76
	>4,500K and <7,000K	72

****Effective July 14, 2012**

LIGHTING TECHNOLOGY

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→ Effectively eliminates 8-ft lamps of any kind

LIGHTING TECHNOLOGY

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****Effective July 14, 2012**

Earlier Legislation:

- 2000 – Magnetic Ballast Ban by April 05
- Loop-hole with Energy Saving Lamps
- 2005 – EPAct 2005 Closed Loop-hole
- **Magnetic Ballast Banned for Sale in the U.S. on July 1, 2010**

→ Effectively eliminates 8-ft lamps of any kind

LIGHTING TECHNOLOGY

FLUORESCENT 2X4 TROFFERS and WRAPS

LIGHTING TECHNOLOGY

FLUORESCENT 2X4 TROFFERS and WRAPS

Energy Saving Retrofit – Delamp and reuse existing fixtures by changing out the lamp/ballast and bracket and add a new “kit” that includes a high efficiency T8 ballast with reflector and brackets.

Up to 40%-60% Energy Savings

ENERGY SAVING RETROFIT

Office Relight Example

Currently Lighting Energy $10,782 per year

New 2-Lamp T8 Retrofit with Reflector

75-Watts per Fixture High Output

75W/1000 = 0.075kW x (60hr/wk x 52 wks) = 234kWh per year

234kWh x 200 fixtures = 46,800 kWh per office space

New Energy Costs

$5,616 per year to light the Office – 48% savings vs 4-lamp T12

Other Instant Benefits

Improved Light Quality and Quantity

Reduced number of lamps to maintain

LIGHTING TECHNOLOGY

INCANDESCENT CAN AND TRACK LIGHTS

LIGHTING TECHNOLOGY

INCANDESCENT CAN AND TRACK LIGHTS

Energy Saving Retrofit – Simply change these screw-in 65W- 85W incandescent lamps to 23W reflectorized CFL or 15W LEDs.

Up to 65%-83% Energy Savings

LIGHTING TECHNOLOGY

EXIT SIGNS

LIGHTING TECHNOLOGY

EXIT SIGNS

Energy Saving Retrofit – Simply change the screw-in 7W-15W CFL or incandescent lamps to 3W LEDs. Or replace with new 3W LED sign.

Up to 235 kWh per year per sign plus maintenance costs

ENERGY SAVING RETROFIT

LED Sign Replacement Example

LED Sign Replacement

3-Watts per Sign

3W/1000 = 0.003kW x (24hrs x 365 days) = 27kWh per year

27kWh x 50 signs = 1,350 kWh per building

New Energy Costs

$162 per year to light the Office – 90% savings vs incandescent sign

Other Instant Benefits

Reduced Maintenance Costs from replacing lamps

LIGHTING TECHNOLOGY

FLUORESCENT INDUSTRIAL STRIPS

LIGHTING TECHNOLOGY

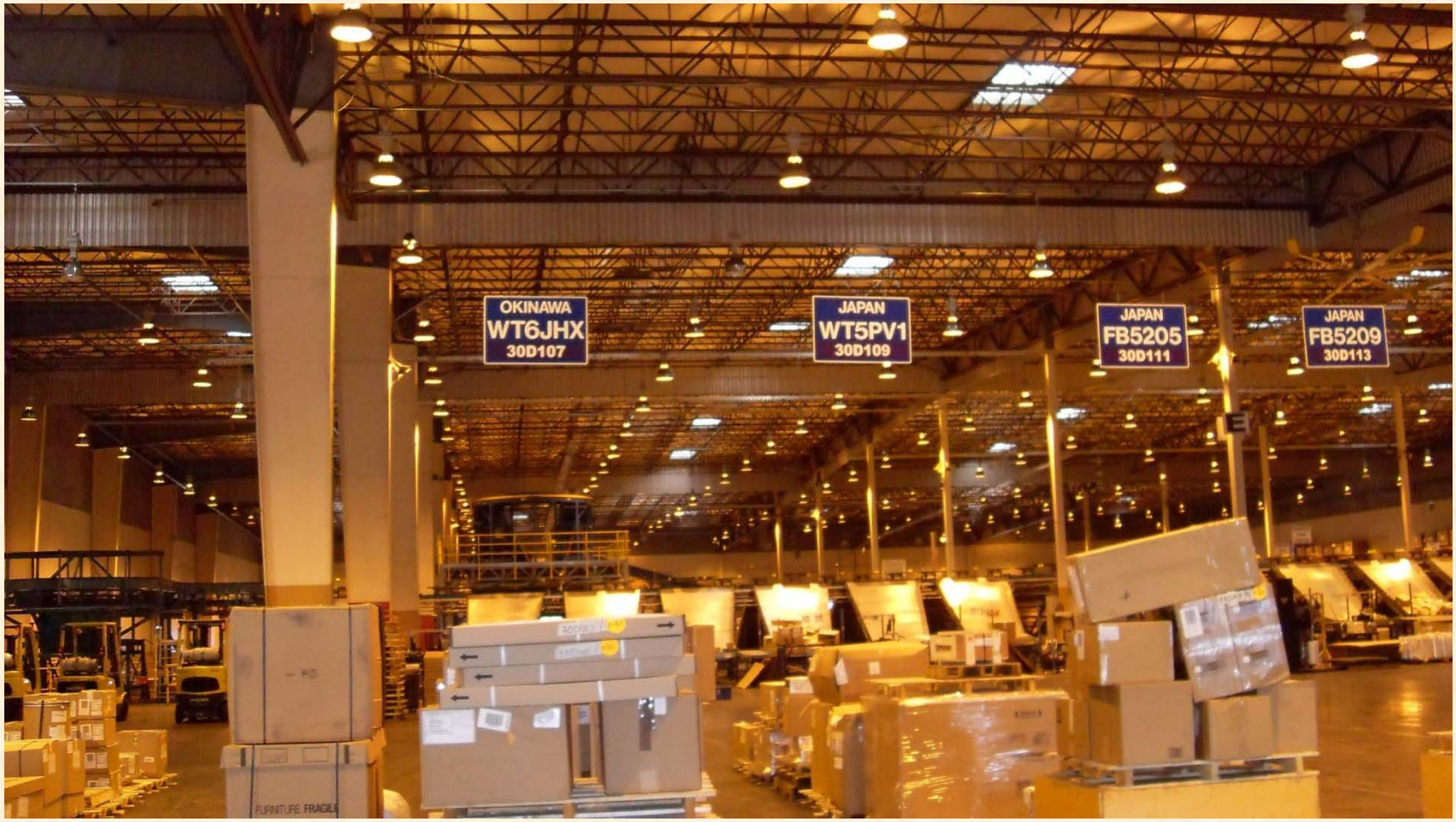
FLUORESCENT INDUSTRIAL STRIPS

Energy Saving Retrofit – Delamp and reuse existing fixtures by changing out the lamp/ballast and bracket and add a new “kit” that includes a high efficiency T8 or T5 ballast with reflector and brackets.

Up to 40%-60% Energy Savings

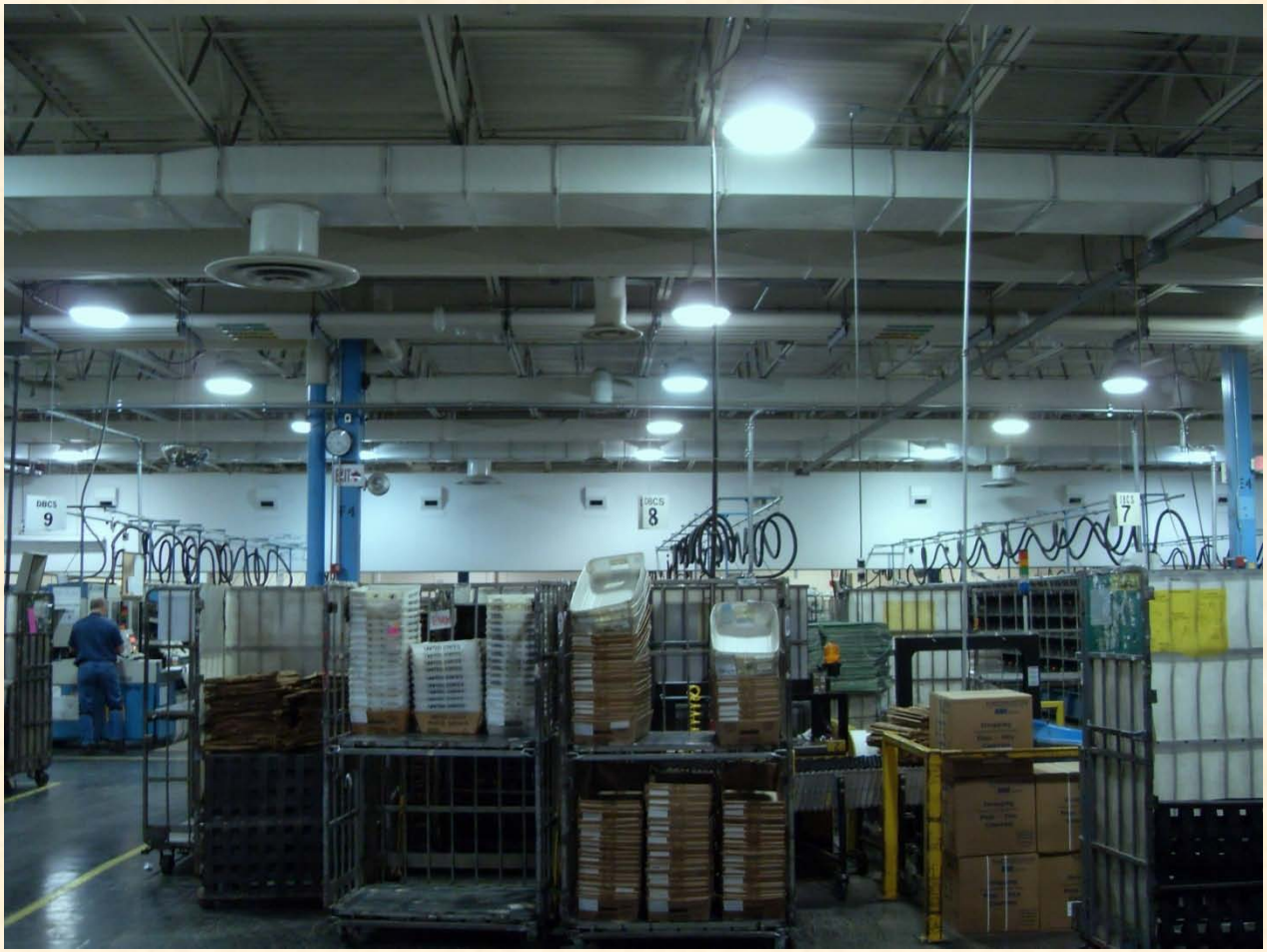
LIGHTING TECHNOLOGY

HID: High Pressure Sodium



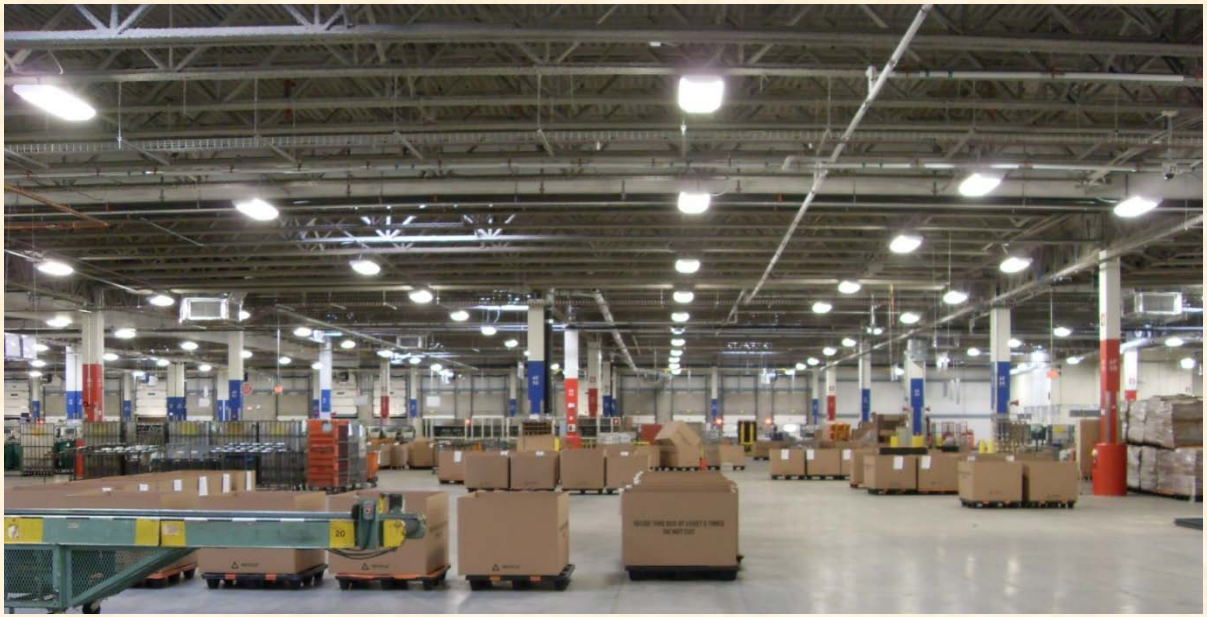
LIGHTING TECHNOLOGY

HID: Metal Halide



LIGHTING TECHNOLOGY

Relight with T8 or T5 High Bay



Energy Saving Relight– Replace HID fixtures with T8 or T5 High Bay Fixture. A relight strategy should be implemented and executed. Up to 30%-60% Energy Savings

LIGHTING COSTS

Warehouse Relight Example

Currently Lighting Energy $244,380 per year

New 6-Lamp T8 High Bay Fixture

218-Watts per Fixture High Output

218W/1000 = 0.218kW x (24hrs x 365 days) = 1,909 kWh per year

1,909 kWh x 500 fixtures = 954,500 kWh per warehouse

New Energy Costs

$114,540 per year to light the Office – 53% savings vs 400W HPS

Other Instant Benefits

Improved Light Quality

Longer Lamp Life and Lumen Maintenance

Outline

- New technologies on the horizon
- Implementing a lighting retrofit – Where to start?
- Lighting design: best practices
- Common pitfalls / common misconceptions
- Case studies
- Q&A

New Technology

LED Lighting

- No filaments
- Solid state source
- Circuitry that drives the source

Image from Cree.com

New Technology

Raleigh, NC Municipal Building Parking Garage

New Technology

LED Lighting

- Highly directional source
- Very narrow spectral output
- Heat dissipation
- Not quite ready for general illumination duties
- Phosphor coated LEDs
- OLED / PLED

Image from Cree.com

New Technology

Induction Lighting

- Electrode-less fluorescent
- Generator that drives the source
- Heat dissipation

Image from Sylvania.com

Implementing a Lighting Retrofit

- What is the task?
- Who uses the room?
- What are the room conditions?
- What are my maintenance criteria?
- What is my budget?

Best Practices

- IESNA Lighting Handbook, 9th Edition
- ASHRAE 90.1 - 2001
- NFPA Life Safety code
- Building LEED certification
- Energy Star considerations
- Disposal considerations with retrofit

Common Misconceptions

- “Just change lamps and ballasts one-for-one”
- Turning off fluorescent lights uses more power than leaving them on
- Any electronic ballast is as good as another – buy the least expensive
- What are the “IES requirements”?

Common Misconceptions

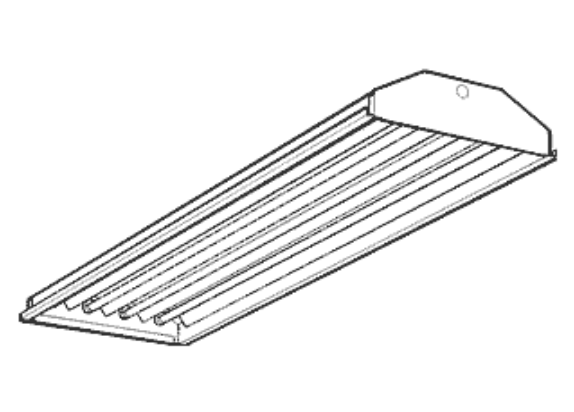
"Many of us believe that the 9th Edition of the *IESNA Lighting Handbook* represents a watershed in lighting practice. Over the past twenty years there has been a movement in lighting practice from illuminating engineering to lighting design, a movement from calculations of illuminance to judgments of aesthetics, a movement from quantity to quality. For the first time, the IESNA has, through this edition, formalized recommendations of lighting quality, reflecting this movement in lighting practice."

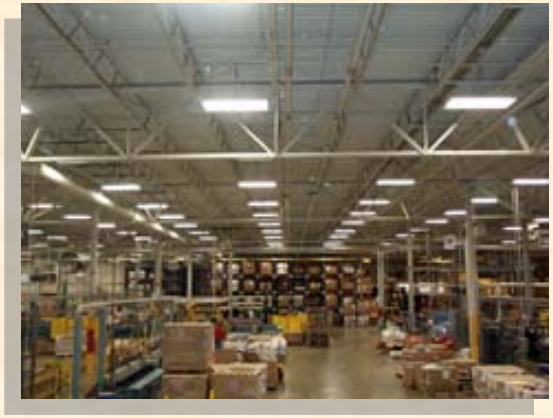
IESNA Lighting Handbook, 9th Edition, Preface, first paragraph

Successful Lighting Retrofits

- Warehouse Interior Project
- Office Interior Project
- Exterior / Parking Lot Project

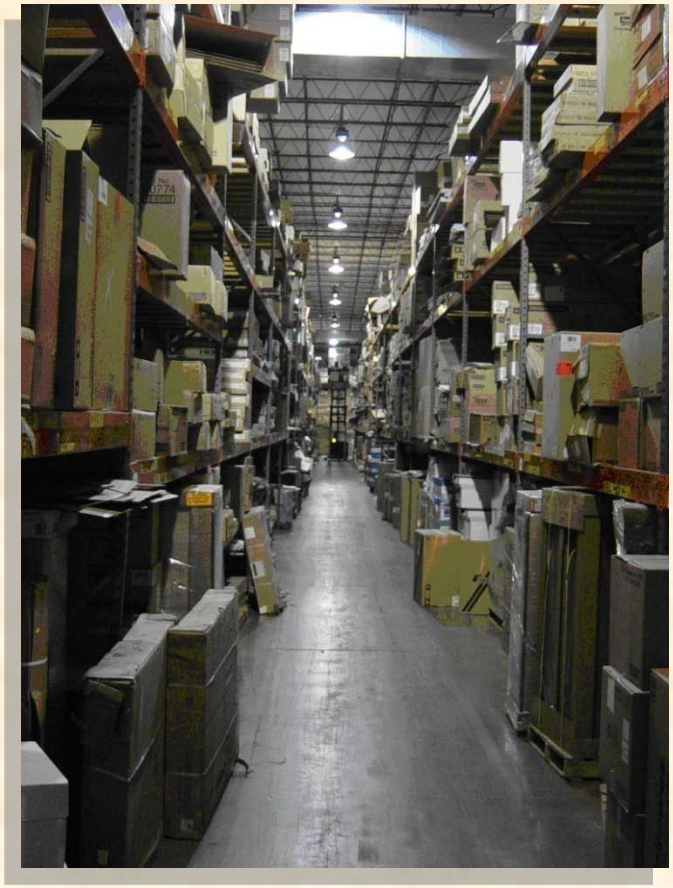
HID Alternative – Fluorescent Hi-Bay Warehouse Interior Project

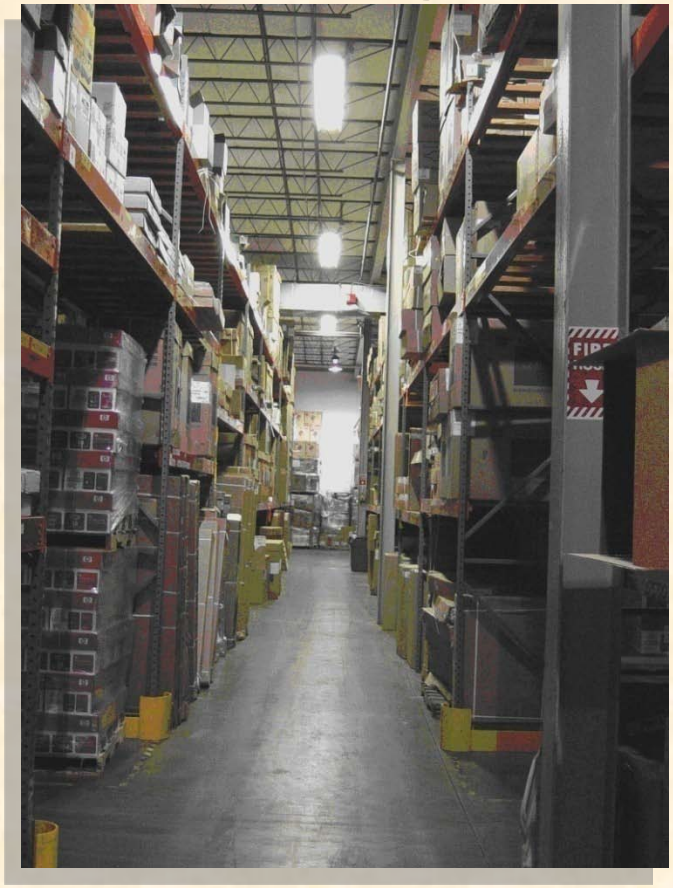




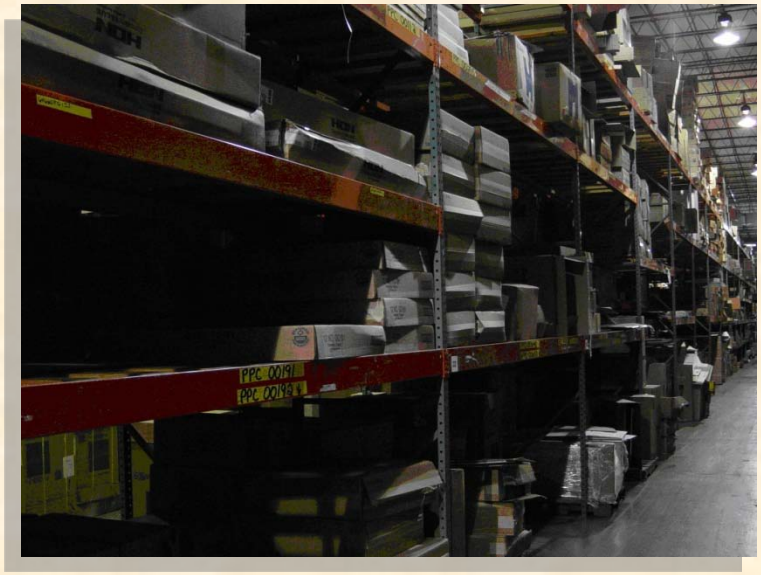
Location ID	Location	Existing Fixture Description	Existing Qty.	Existing Wattage (each)	Proposed Fixture Description	Proposed Qty.	Proposed Wattage (each)	Simple Payback (Years)
1	**Building: Warehouse**							
1	Warehouse - Warehouse	MH-320W-PS (High Bay)	43	354	New 4FT, 4-F54T5-HO Highbay w/HBF EB, mounting hardware kit; Control: 43 Integral occupancy sensor	43	240	2.6
2	Warehouse - Warehouse	MH-320W-PS (High Bay)	10	354	New 4FT, 4-F54T5-HO Highbay w/HBF EB, mounting hardware kit	10	240	3.4
	GRAND TOTAL - PROJECT		**53**			**53**		**2.7**

HID Alternative – Fluorescent Hi-Bay Warehouse Interior Project

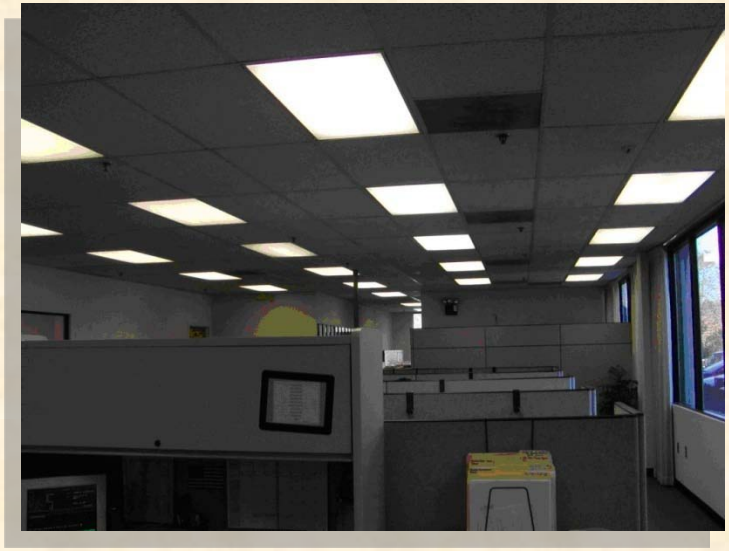




HID Alternative – Fluorescent Hi-Bay Warehouse Interior Project



Office Interior Project



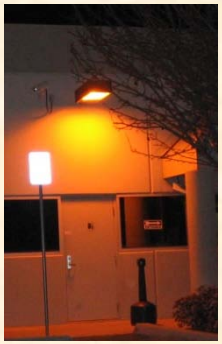
	Location	Existing Fixture Description	Existing Qty.	Existing Wattage (each)	Proposed Fixture Description	Proposed Qty.	Proposed Wattage (each)	Simple Payback (Years)
1	**Building: Office Area Lighting**							
1	Hallway - Hallway	4-F32T8 (2x4 Troffer Clear Lens)	5	112	Lamp and ballast change and add reflector - 2-F28T8-Ref	5	50	1.3
2	Break Room - Breakroom	4-F32T8 (2x4 Troffer Clear Lens)	18	112	Lamp and ballast change and add reflector - 2-F28T8-Ref	18	50	1.3
3	Sales Floor - Valence	4-F32T8 (1X8 Strip)	8	112	Lamp and ballast change - 4-F28T8	8	84	2.9
4	Private Office - Private Office	4-F32T8 (2X4 Troffer Clear Lense)	2	112	Lamp and ballast change and add reflector - 2-F28T8-Ref	2	50	3.3
	GRAND TOTAL - PROJECT		**33**			**33**		**1.6**

Exterior / Parking Lot Project

Existing

Replacement

Existing



Replacement

Facility ID Number		Building	Existing LPS shoebox pole mtd or bldg mtd floods	Existing Wattage (each)	Proposed Wattage (each - one-for-one replacement with LED)	Simple Payback (Years)
1		Dock Area Parking Lot	19	416	153	4.4
2		Front Parking Lot	8	416	153	4.4
3		Garage / Shop Parking Lot	2	416	153	4.4
4		North Warehouse Parking Lot	2	416	153	4.9
5		Office Entrance Area	10	208	79	5.1
6		Warehouse Dock Area	5	416	153	4.4
7		Warehouse Dock Area	5	416	153	4.4
		TOTAL	**51**			**4.5**

Exterior / Parking Lot Project

Exterior / Parking Lot Project

Exterior / Parking Lot Project

Exterior / Parking Lot Project

Resource List

www.energystar.gov
www.epa.gov
www.iesna.org
www.gelighting.com
www.sylvania.com
www.philips.com

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Q & A