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Energy Efficiency Lighting in Educational Facilities

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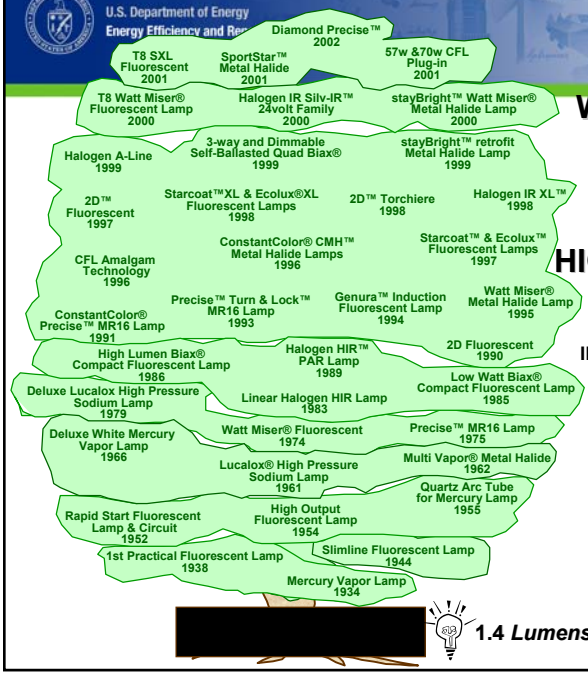
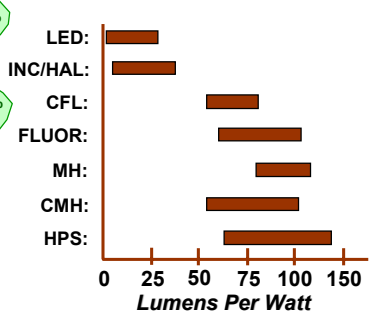
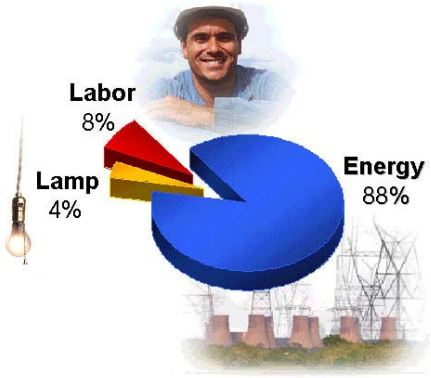
123 YEARS OF ELECTRIC LIGHTING



WITH THIS EVOLUTION COMES BETTER COLOR AND HIGHER EFFICACY (LPW)



Cost of Light



Greatest Potential for Cost Saving is in Electricity Reduction

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LIGHTING ASHRAE/IES 90.1-1999

- Hospital - 1.6 W/ft^2
- Library - 1.5 W/ft^2
- Manufacturing - 2.2 W/ft^2
- Museum - 1.6 W/ft^2
- Office - 1.3 W/ft^2
- Parking Garage - 0.3 W/ft^2
- Retail - 1.9 W/ft^2
- **School - 1.5 W/ft^2**

For New Construction and Remodeling Projects

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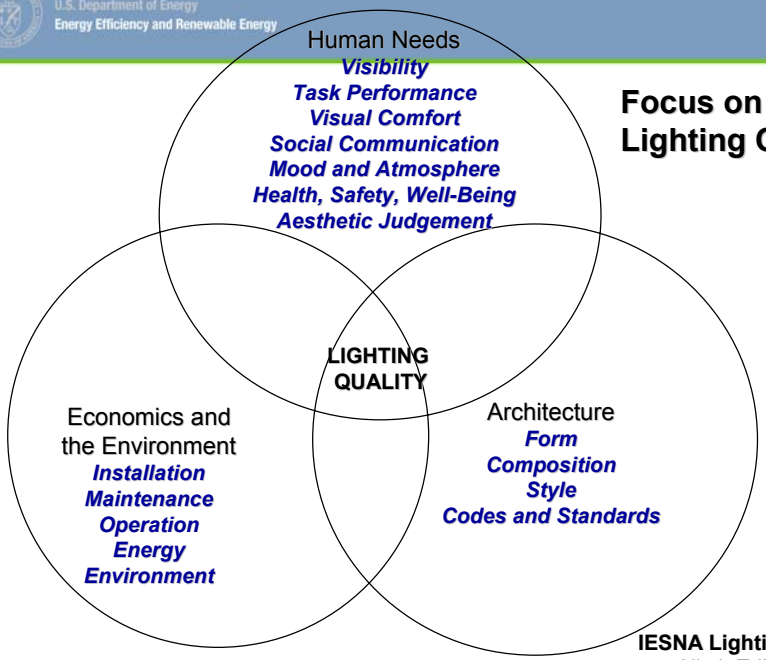

Focus on Lighting Quality

IESNA Lighting Handbook
Ninth Edition 2000

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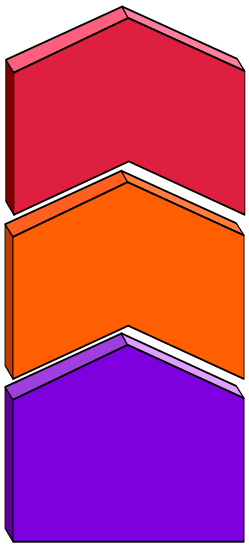

Trends in Lighting

- Increased energy efficiency
- More indirect lighting
- Integration with daylighting
- Compatibility with the architecture
- Theatrical/dynamic lighting effects
- Improved lighting controls
- Enhanced color quality lighting
  - fluorescent, ceramic metal halide
- Installation of cooler color light sources
- Lighting and the aging eye
- “Responsible” outdoor lighting
- Fluorescent high bay applications
- LED lighting applications
- Emphasis on safety and security

High Quality Lighting is Essential to the Learning Environment

- Challenge for Lighting Designers
- Lighting Issues in the Educational Environment
- Premium Efficiency Lighting
- Spacetype Categories

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Challenge for Lighting Designers

Design Lighting for Schools That Is:

- Premium Efficiency
- High Quality
- Exceeds Building Energy Codes
- Easily Maintainable
- Cost-Effective

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Lighting Issues in the Educational Environment

- Lighting Glare
- Lighting Uniformity
- Wall Illumination
- Lighting Levels
- Color Rendering and Temperature
- And of course, energy efficiency

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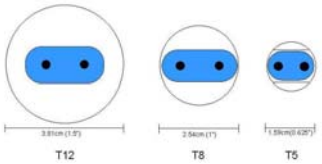
Light Source Options

- Filament Lamps
  - Regular Incandescent Lamps
  - Halogen Lamps
- Discharge Lamps
  - Fluorescent Lamps
    - Linear
    - Compact
  - HID Lamps
    - Metal Halide
    - High Pressure Sodium
    - Mercury
    - Low Pressure Sodium

Fluorescent Lamp Designations

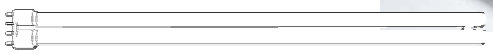
T means *tubular* in shape

- T12 = 12/8" in diameter
- T8 = 8/8" (1") in diameter
- T5 = 5/8" in diameter
- T2 = 2/8" (1/4") in diameter



Compact Fluorescent Lamp (CFL)

- Twin-tube, Quad-tube, Triple Tube
- 2D, Circline
- BX = Biax Lamp



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T5 vs. T8 and T12

Bulb and wattage	CCT (K)	Light output (lm)		Lamp efficacy (lm/W)	CRI
		Initial	Mean		
T5 28W	3,000-6,500	2,900	2,726-2,750	**104**	85
T5HO 54W	3,000-6,500	5,000	4,700-4,740	**93**	85
T8 32W	3,000-5,000	2,800-2,950	2,660-2,800	**92**	86
T12 40W	3,000-5,000	2,200-3,400	1,775-3,090	**85**	80-82

"Super" T8 Fluorescent Systems

- Improved T8 lamp (more efficient phosphors)
- Well-matched, programmed-start ballast
- Designed as a system to improve performance
- Extends lamp life up to 30,000 hours
- Improves system efficacy up to 20%
- 1.5 to 2 times more expensive than typical instant-start ballast and T8 lamp

Courtesy Lighting Research Center

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T5 Fluorescent Lamps

- T5 introduced to US in 1995
- Not compatible with T8 or T12 fixtures
- Similar light to T8, slightly more efficient
- Rated at 35ºC (95ºF), while T8 is rated at 25ºC (77ºF)
- Lamps and fixtures are still expensive, though costs will be coming down
- Higher output of T5 lamps results in fewer lamps per project

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Does a T5 give as much light as a T8?

Catalog data

Lamp type	Lamp efficacy					Lamp-ballast system efficacy							
	Initial lumen (lm)			Efficacy (lm/W)		Manufacturer A				Manufacturer B			
	25°C	35°C	Watt	25°C	35°C	Watt	BF	25°C lm/W	35°C lm/W	Watt	BF	25°C lm/W	35°C lm/W
F28T5	2,610	2,900	28	**93**	**104**	63	0.9	75	**83**	62	1.00	84	**94**
F54T5 HO	4,400	5,000	54	**81**	**93**	117	1.0	75	**85**	117	1.00	75	**85**
F32T8	2,950	2,714	32	**92**	**85**	59	0.88	**88**	81	59	0.90	**90**	83

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Compact Fluorescent Lamps

New electronic ballasts, easier to control

Color much improved from early lamps

Hard-wire

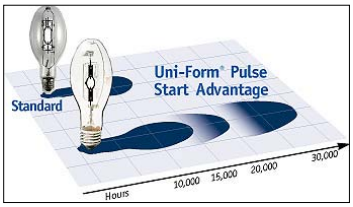
- **Ballast is separate from lamp: better thermal control**
- **Best choice for enclosed fixtures like recessed or track lighting**

Screw-in

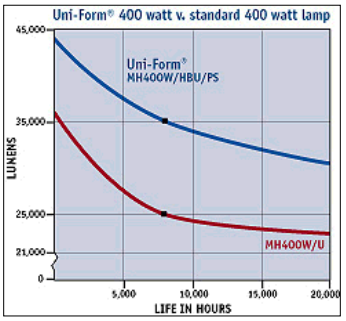
- **Self-ballasted**
- **Good for retrofit of open fixtures**

Pulse Start Metal Halide

Up to 50%
longer life than standard



Slightly better
lumen maintenance



Faster warm-up and restrike

Less Color change over time

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Colored LEDs

- **Long life**
- **Low maintenance**
- **Great flexibility**
- **Dimmable**
- **Highly directional**
- **Durable**
- **Excellent for decorative or theatrical lighting**
- **Latest development: white LEDs**

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Trends in Fluorescent Ballasts

Hi Efficiency T8
- 91% Efficiency
- LT 10% THD

Universal Voltage T8
- 108-305v Capable
- LT 10% THD

Standard Electronic T8
- 86% Efficiency
- Dedicated Voltage
- LT 20% THD
- Can Size Varies

Newest T8 Ballasts
- 91% Efficiency
- 108-305v Capable
- LT 10% THD @ 120v
- Arc Guard Lamp Protection
- Lamp Striation Control
- Small Can Size

Magnetic T12
- Old Technology…82% Efficiency
- Low System Efficiency
- LT 30% THD
- Large Can Size

Also: dimming ballasts (variable, step)
programmed start ballasts
low - normal- high ballast factor

Price

Performance Features

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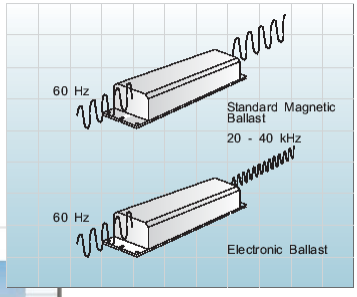
Types of Ballasts

- **Standard Magnetic**
- **Energy Efficient Magnetic**
- **Electronic Ballasts**



Electronic Ballasts

- **High ballast factor (efficiency)**
- **Cooler Operation**
- **No flicker**
- **Less noise**
- **Easier to design controllable ballasts, including dimming ballasts**
- **Theoretically less expensive and longer lasting**

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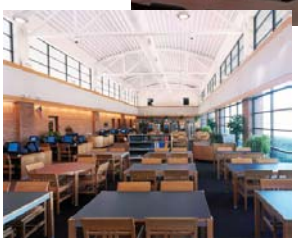
Standard and Energy Efficient Ballasts

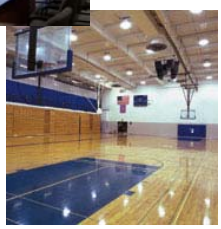
Lamp Description	Standard Ballast	System LPW	Efficient Ballast	System LPW
Standard T-12 lamp F40CW/ES (a)	Standard ballast (b)	60	Standard energy-efficient magnetic ballast (c)	67
Modern T-8 lamp F32T8/741(a)	Standard energy-efficient magnetic ballast	75	Electronic high-frequency instant start ballast	86
Compact fluorescent lamp 26 watt	Efficient magnetic ballast	50	Electronic high-frequency preheat ballast	60
Metal halide lamp 400 watt	Standard magnetic ballast	67	Linear reactor ballast	72

Spacetype Categories

Different Approaches for Different Spacetypes

- Classrooms
- Gymnasium
- Auditorium
- Cafeteria
- Offices
- Hallways
- Exterior





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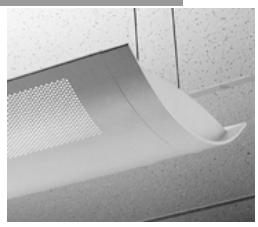
Classrooms

Efficient Fixtures – T8, T5, CFL

- Recessed Parabolic and Direct/Indirect
- Surface-Mounted Fixtures
- Fluorescent Wall-Washing Fixtures
- Pendant Direct/Indirect
- Pendant Fully Indirect

Occupancy Controls

Daylight Integration



Gymnasium

High Intensity Fluorescent – T8, T5, CFL

- CFL High Bay
- T5 High Bay
- T8 High Bay

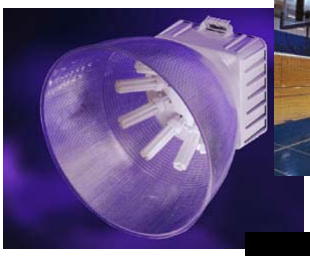
HID

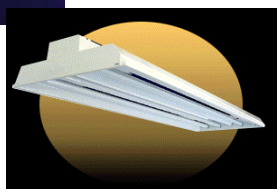
- Pulse Start Metal Halide

Daylight Integration

Controls

- Occupancy
- Light Level





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Auditorium

Dimmable Incandescent

- Still the Standard for Theatrical Lighting

Fluorescent – T8, T5, CFL

- Surface-Mounted Fixtures
- Fluorescent Wall Sconce Fixtures
- Compact Fluorescent
- T5 & T8 HO High Bay

HID

- Pulse Start Metal Halide
- Ceramic Metal Halide

Controls

- Occupancy
- Light Level

Cafeteria

Fluorescent – T8, T5, CFL

- Pendant Direct/Indirect
- Recessed Direct/Indirect
- CFL Pendant
- T8, T5 and CFL Low/High Bay

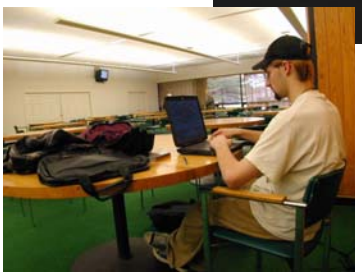
HID Low/High Bay

- Pulse Start Metal Halide
- Ceramic Metal Halide

Daylight Integration

Controls

- Occupancy
- Light Level



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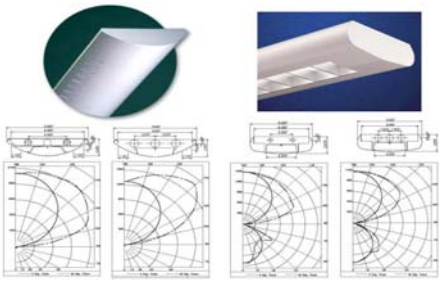
Offices

Fluorescent – T8, T5

- Recessed Parabolic and Direct/Indirect
- Surface-Mounted Fixtures
- Fluorescent Wall-Washing Fixtures
- Pendant Direct/Indirect
- Pendant Fully Indirect

Occupancy Controls

Daylight Integration



Hallways

Fluorescent – T8, T5, CFL

- Recessed Parabolic and Direct/Indirect
- Surface-Mounted Fixtures
- Fluorescent Wall-Washing Fixtures
- Pendant Direct/Indirect
- Pendant Fully Indirect
- Recessed CFL

Exit Signs

- LED
- Electroluminescent

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Exterior Lighting

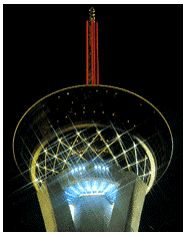
HID

- Pulse Start Metal Halide
- High Pressure Sodium

Full Cut-Off Fixtures

- Eliminates All Stray Light Pollution
- Provides Effective Light Where Needed

LED



Control

- Photocell
- Scheduling

Questions?