



U.S. Department of Energy  
Energy Efficiency and Renewable Energy

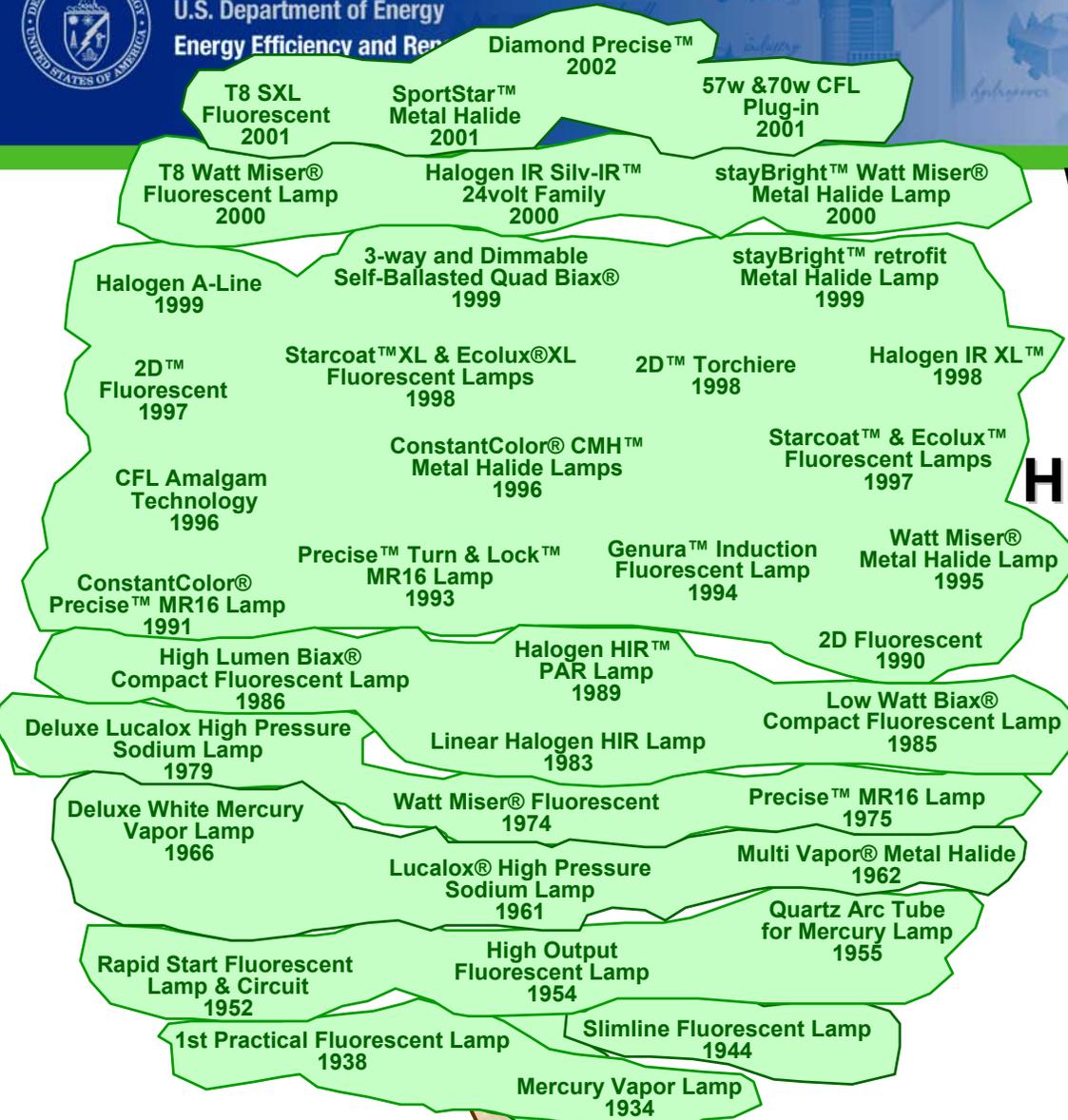
# Energy Efficiency Lighting in Educational Facilities



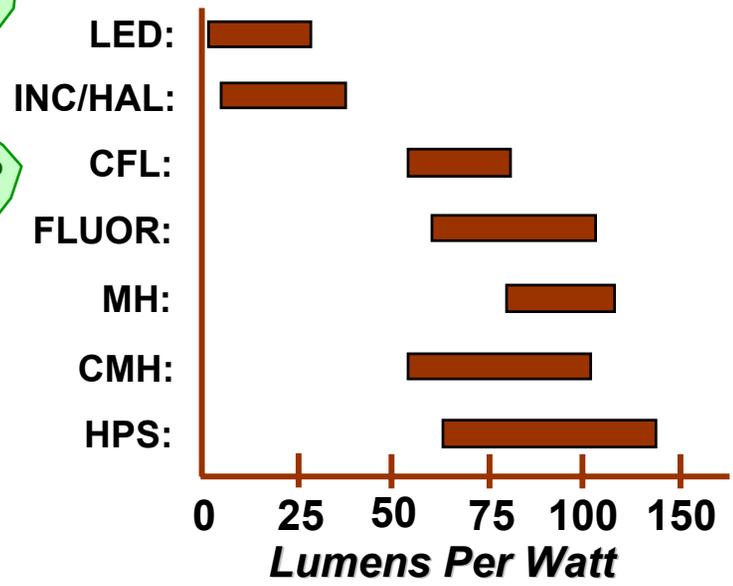
# 123 YEARS OF ELECTRIC LIGHTING



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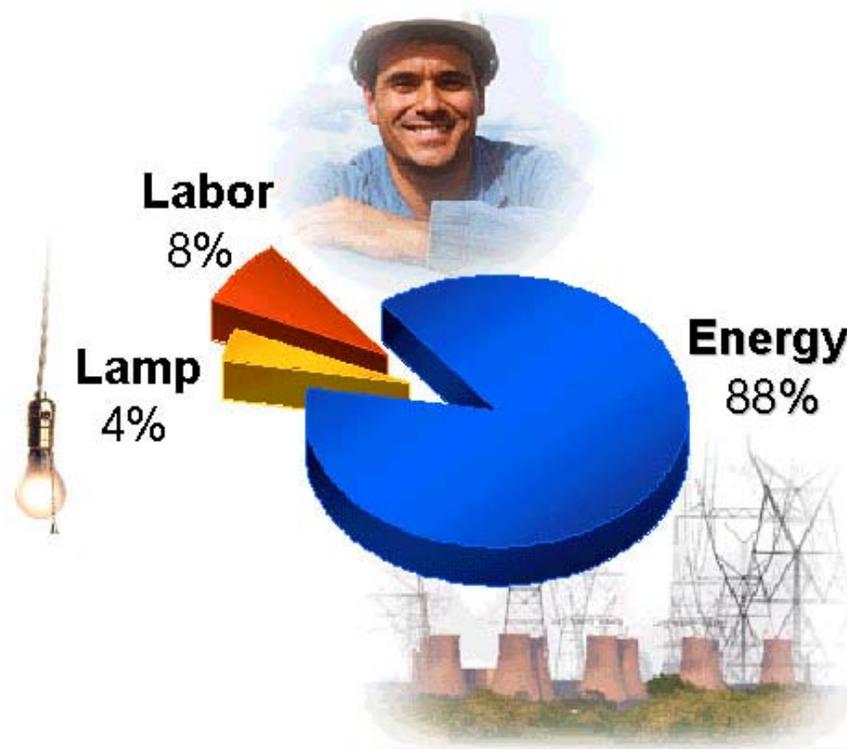
**WITH THIS EVOLUTION  
COMES  
BETTER COLOR  
AND  
HIGHER EFFICACY (LPW)**



**1.4 Lumens Per Watt**



# Cost of Light



**Greatest Potential for Cost Saving is in Electricity Reduction**



## LIGHTING ASHRAE/IES 90.1-1999

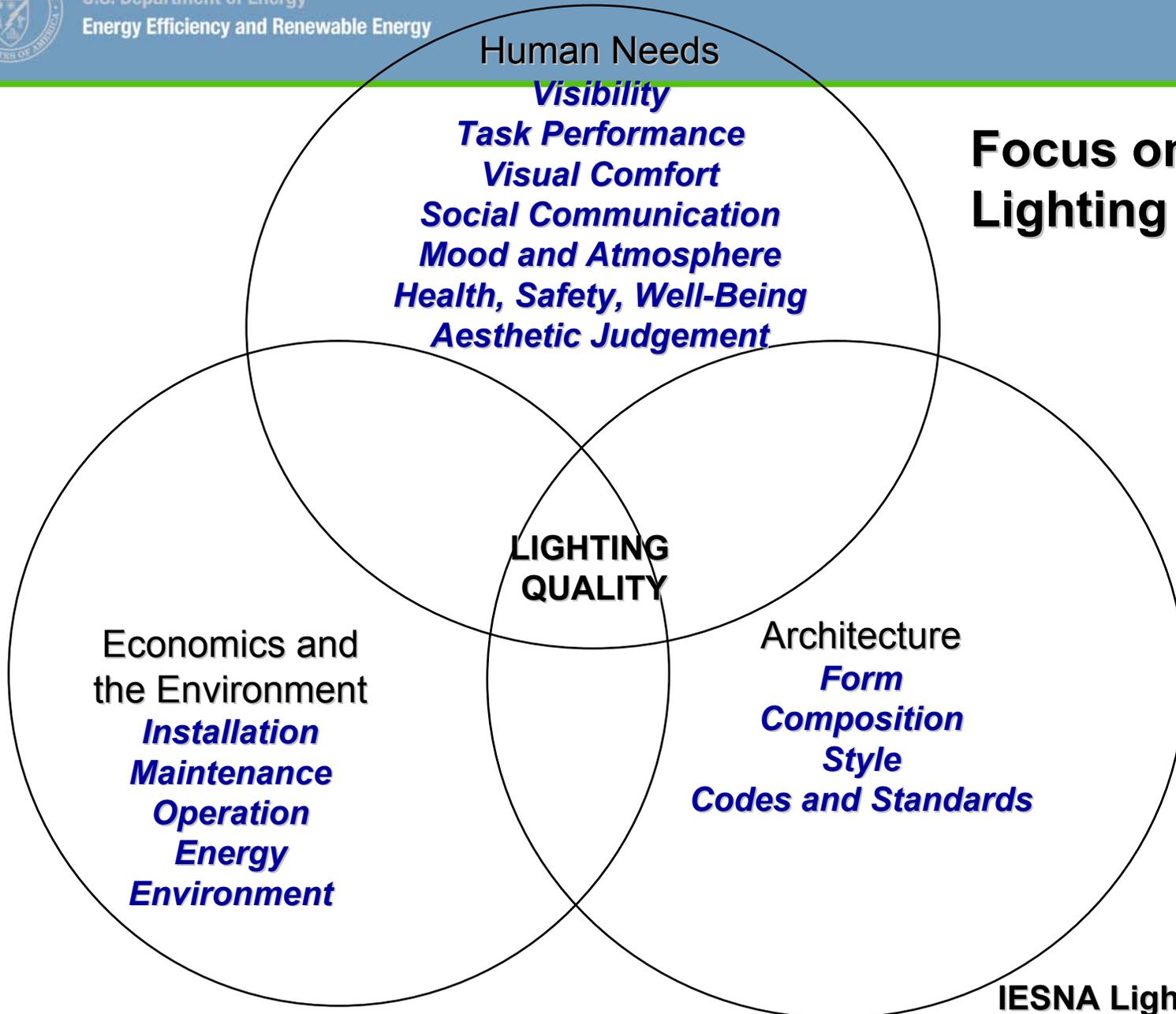


- Hospital - 1.6 W/ft<sup>2</sup>
- Library - 1.5 W/ft<sup>2</sup>
- Manufacturing - 2.2 W/ft<sup>2</sup>
- Museum - 1.6 W/ft<sup>2</sup>
- Office - 1.3 W/ft<sup>2</sup>
- Parking Garage - 0.3 W/ft<sup>2</sup>
- Retail - 1.9 W/ft<sup>2</sup>
- **School** - **1.5 W/ft<sup>2</sup>**

For New Construction and Remodeling Projects

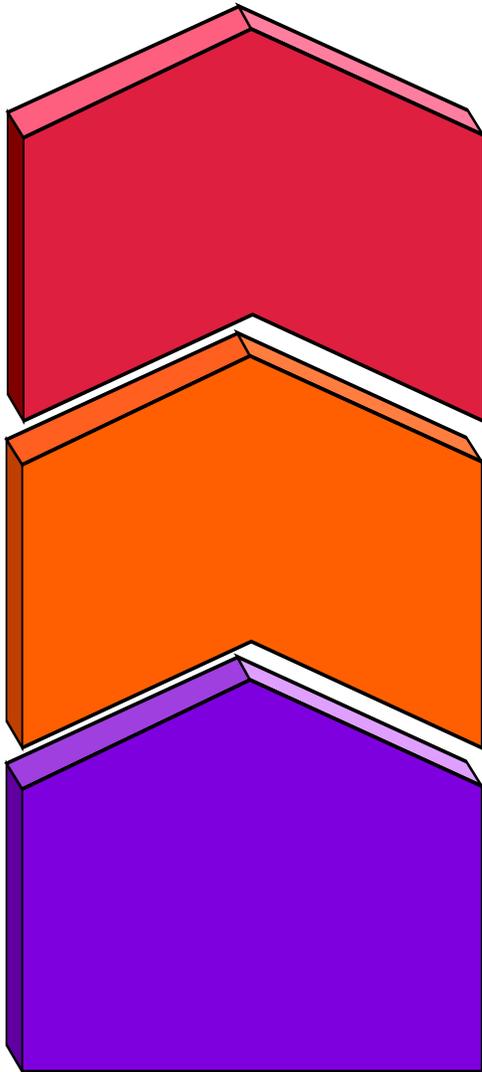


# Focus on Lighting Quality





# 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**





# Challenge for Lighting Designers

## Design Lighting for Schools That Is:

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





# Lighting Issues in the Educational Environment

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





# Light Source Options

Filament  
Lamps

Regular  
Incandescent  
Lamps

Halogen  
Lamps

Discharge  
Lamps

Fluorescent  
Lamps

HID  
Lamps

Linear

Compact

Metal Halide

High  
Pressure Sodium

Mercury

Low Pressure Sodium



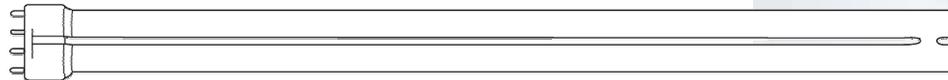
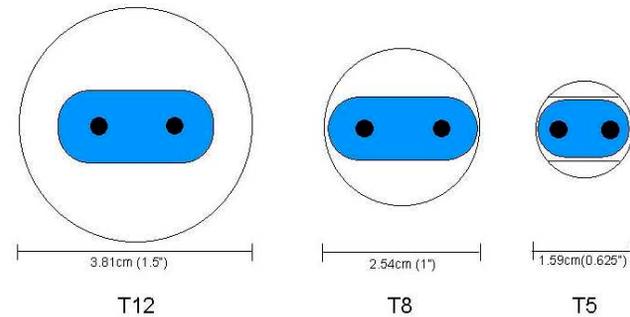
# Fluorescent Lamp Designations

**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 = Bi-ax Lamp**





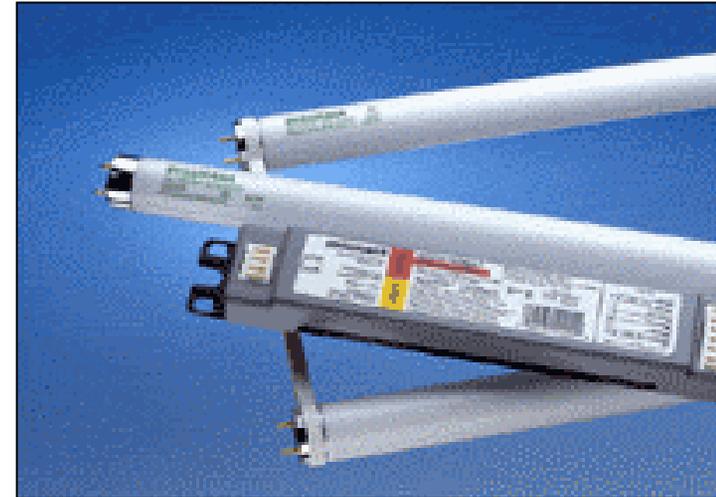
## T5 vs. T8 and T12

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**





# 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 35°C (95°F), while T8 is rated at 25°C (77°F)**
- **Lamps and fixtures are still expensive, though costs will be coming down**
- **Higher output of T5 lamps results in fewer lamps per project**





# Does a T5 give as much light as a T8?

## Catalog data

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



# 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**

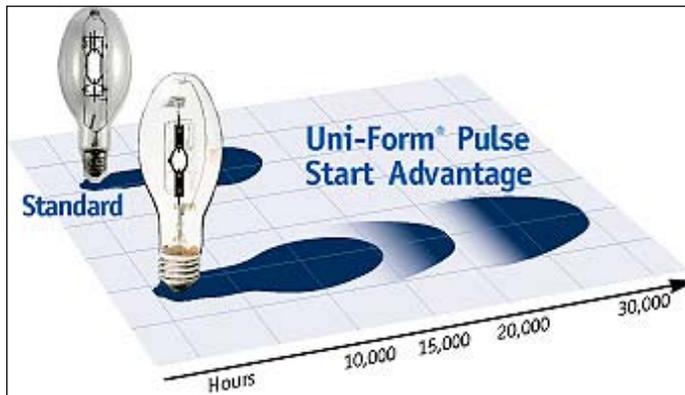




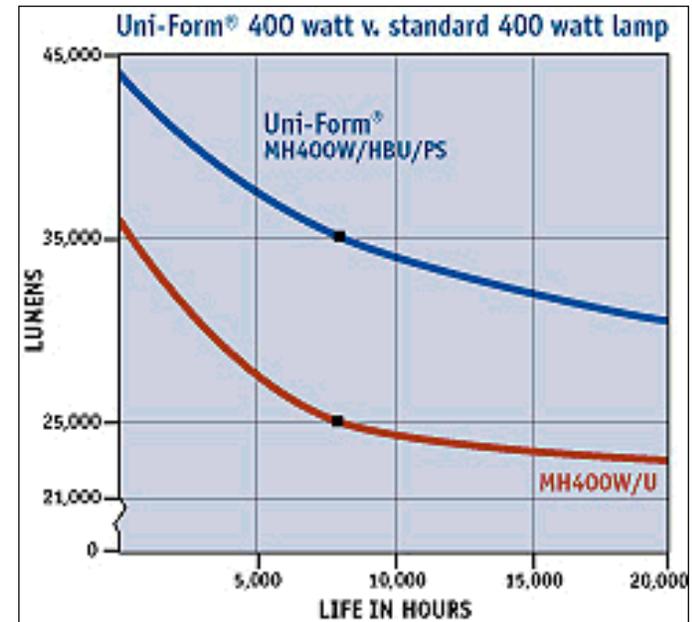
# Pulse Start Metal Halide

**Up to 50%  
longer life than standard**

**Slightly better  
lumen maintenance**



**Faster warm-up and restrike  
Less Color change over time**





# Colored LEDs

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





# Trends in Fluorescent Ballasts

Price

## 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

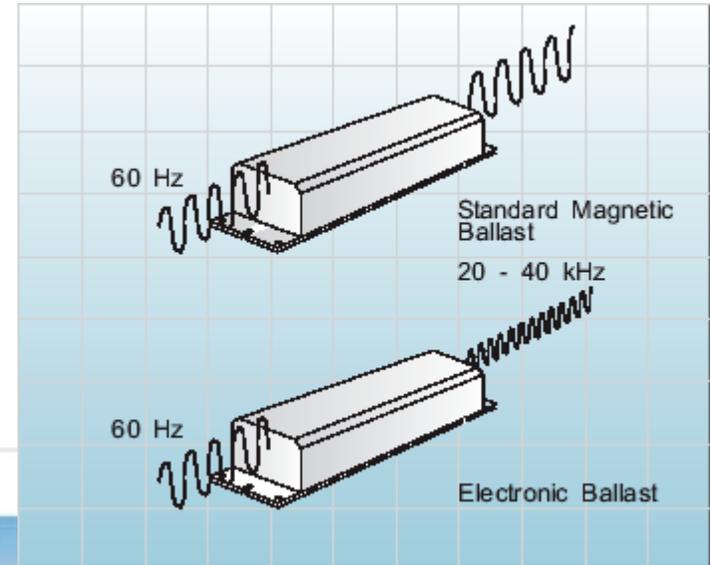
Also: dimming ballasts (variable, step)  
programmed start ballasts  
low - normal- high ballast factor

Performance Features



# 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**



# Standard and Energy Efficient Ballasts

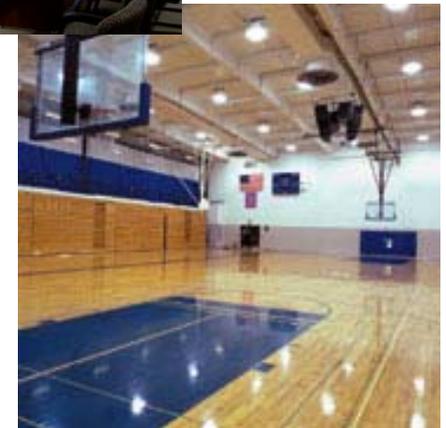
Lamp Description	Standard Ballast	System LPW	Efficient Ballast	System LPW
Standard T-12 lamp F40CW/ES (a)	Standard ballast (b)	60	Standard energy-efficient magnetic ballast (c)	67
Modern T-8 lamp F32T8/741 (a)	Standard energy-efficient magnetic ballast	75	Electronic high-frequency instant start ballast	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**





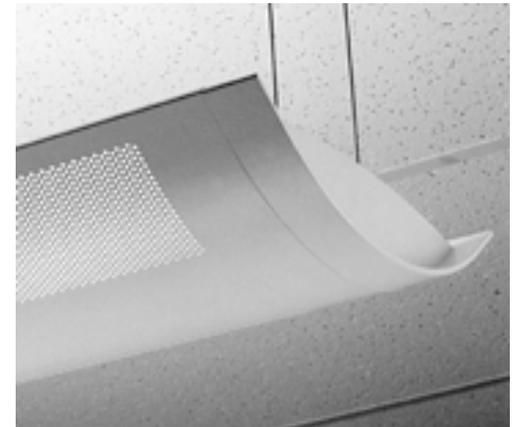
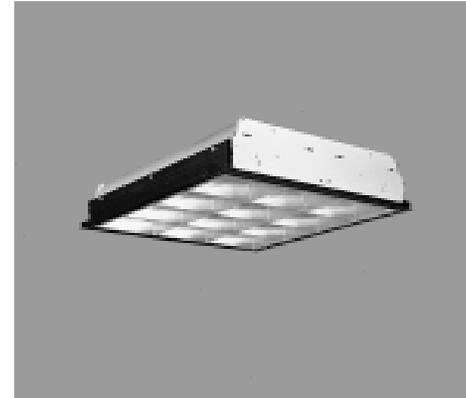
# Classrooms

## 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

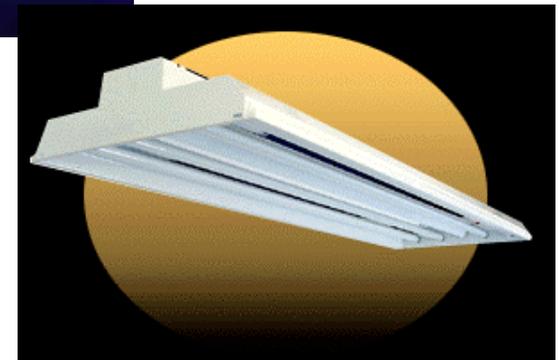
## HID

- Pulse Start Metal Halide

## Daylight Integration

## Controls

- Occupancy
- Light Level





# 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**





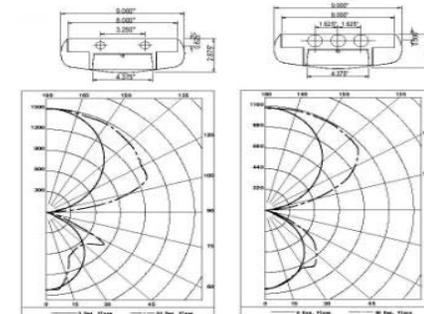
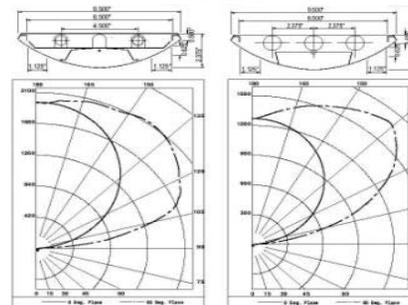
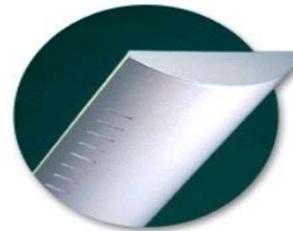
# Offices

## 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

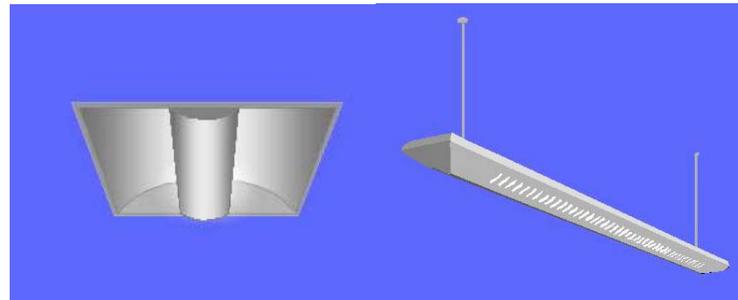
## Fluorescent – T8, T5, CFL

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



## Exit Signs

- LED
- Electroluminescent





# Exterior Lighting

## HID

- Pulse Start Metal Halide
- High Pressure Sodium

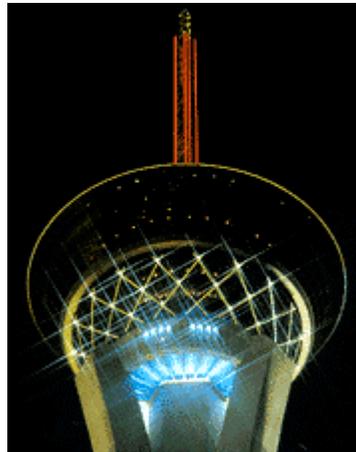
## Full Cut-Off Fixtures

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

## LED

## Control

- Photocell
- Scheduling





# Questions?

