



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

Lighting & Controls

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U.S. Department of Energy
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The Hallmarks of “Good” Lighting

- Aesthetically Pleasing
- Energy Efficient
- Adequate Task Light Level
- Visually Comfortable
- Easy to Maintain
- Enhance Learning and Teaching Environment
- Minimal environmental impact

***Today’s
Lighting
Technology
can do this!***



Technologies

- Lighting Controls



General Rule of Thumb

- The installation of properly applied controls to a lighting system will reduce energy consumption by one third.



Purpose of Controls

- Enhance Building Environment
- Visual Comfort
- Lighting Quality
- Adaptability
- Conserve Energy
- Conserve Money
- Conserve Equipment





Direct Benefit of Controls

- Straight energy savings
- Maintenance savings
- System life extension
- Reduction in demand charges
- Cost savings on “Time of Use” energy rates



Indirect Benefits of Controls

- Impact on building HVAC system
 - for every 4-5 Watts of Light, 1 Watt heat
- Lower maintenance cost due to longer effective lamp life.





Major Strategies for Lighting Controls

- Time based
- Occupancy based
- Light level based



(Can be mixed and
matched for effectiveness)



Time Based or Scheduled Controls

- Provides light to an area when scheduled for use
- Does not control amount of light
- Not suitable for areas with highly variable occupancy.



Time Based or Scheduled Controls

Energy Management Systems

- Can control lighting and other systems
- Trend is toward fully integrated timing systems
- Lighting, HVAC, Security and Accounting



Occupancy Based Controls

Occupancy Sensors

- Regulate lighting system operation based on actual use (self adapting)
- Do not require scheduling
- Off delay time must be set with consideration to source used and application.

Occupancy Sensor Types

- Infrared - Direct Line of Sight
- Ultrasonic - Indirect, Spatial limits
- Dual Technology – Prevents False Tripping
- Ceiling and Wall Mounted
- Line and Low Voltage



Lighting Level Based Controls

- Vary light output of system to match desired target illuminance
- Provide only the quantity of light required
- Can compensate for lamp/fixture depreciation
- Two methods of control
 - Selective switching (banks of lights or stepped dimming)
 - Continuous dimming



Lighting Level Based Controls

Photocells/Sensors

- Photocells on/off
- Photosensor variable to amount of ambient light
- Generally used with dimming or “staged” lighting systems
- Can be used to compensate for both natural light levels and lamp lumen depreciation.



Energy Savings from Lighting Controls

- Typically 35%-45% in Commercial and School Buildings
 - California Energy Commission
- 58 Office Study – 43% Energy Savings from Occupancy Sensors increases to 61% when combined with manual dimming capability
 - Lighting Research Center



Building Energy Savings through Control Strategies

	Option 1	Option 2	Option 3	Option 4	Option 5
Scheduling Control	<input type="radio"/>				
Load Shedding & Daylight Dimming		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Optimized High Performance Luminaires and Layout			<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Workspace Occupancy Sensing				<input type="radio"/>	<input type="radio"/>
Personal Dimming					<input type="radio"/>
Total Energy Cost Savings Realized	5%	10%	40%	60%	70%



Technologies

- Lamps
- Ballasts

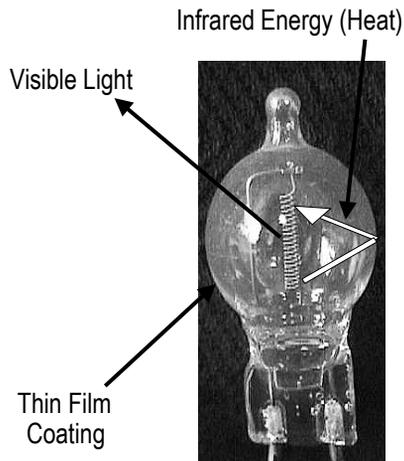


Technologies

- Incandescent/Halogen



New Kid on the Block!



IR Halogen Technology

- More visible light generated for each watt consumed
- Lower energy costs and less heat generated
- Multi-layered thin film Infrared coating on outer surface of halogen capsule
- Infrared energy (heat) is recycled within the IR capsule



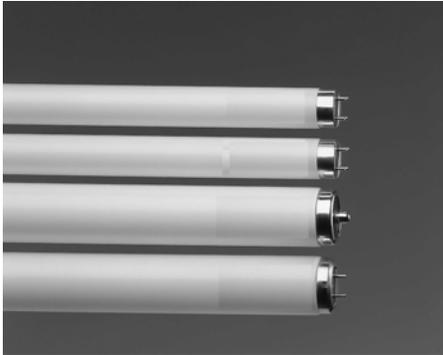
Technologies

- Fluorescent Systems



The Lamps

Linear Fluorescent



Compact Fluorescent



The Fluorescent System

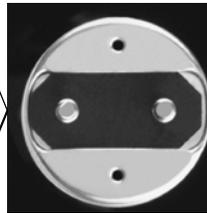




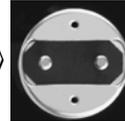
Lamp technology has moved forward



1.5" T12



1.0" T8

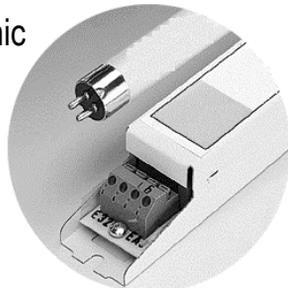


0.625" T5



Fluorescent Ballast Types

- Magnetic
 - Standard
 - Energy-saving
- Electronic





Fluorescent Systems

Electronic Ballasts

Advantages

- Multiple lamp operation
- Very energy efficient
- Lower operating cost
- Relatively lightweight (potted/unpotted)
- Quieter and cooler operation
- Special functions/features available
 - Lamp End of Life Sensing
 - Programmed Starting
 - Dimming
 - Status Reporting
 - Universal input voltage

Disadvantages

- Slightly higher per unit cost – lower per system cost

Magnetic Ballasts

Advantages

- Lower per unit cost

Disadvantages

- Higher operating cost compared to Electronic
- Relatively heavy compared to electronic
- 1 or 2 lamp operation only
- Series lamp operation
- Recycling Issues (PCBs in older units)



Fluorescent Systems

Preheat Fluorescent Ballasts

- Time delay to lamp start - flicker
- Cathodes are heated prior to lamp start (0.5-1.0s)
- Lamp start in 1.0 - 2.0 seconds
- 2 step process: Coil heat then OCV 0.7-2 kV applied
- External starter required

Rapid Start Fluorescent Ballasts

- Cathodes are heated constantly by applying coil voltage
- Series operated
- Ground plane required for starting
- Operation down to 50°F

Instant Start Fluorescent Ballasts

- Most energy efficient system- no cathode heating
- Discharge arc initiated by applying high OCV to jump start lamp
- Parallel operation
- Operation down to 0°F
- NEMA recommendation – shunted sockets for retrofit



Programmed Rapid Start Fluorescent Ballasts

- Coil heat applied w/reduced or no open circuit voltage (OCV)
- OCV is then applied (After coils reach optimum temperature)
- Typically 50,000 to 100,000 start cycles
- Up to 250% longer life than current systems (IS/RS)
- Coil heat turned off or reduced after lamp starts
- Lower energy consumption than rapid start
- Longest lamp life in all applications
 - Including high switching cycles – Occupancy Sensors
- <10% THD
- Multiple ballast factor options 0.71 – 1.20



Fluorescent Ballast Starting Modes

	GOOD Instant Start	GOOD Rapid Start	BEST Programmed Start
Cathode Voltage			
Starting Voltage			
Start Cycles	up to 15k	up to 15k	50k +
Start Temp	0 deg F	50 deg F	0 deg F
Input Power (2L)	59W	63W	60W
Wiring	Parallel	Series	Series (Parallel)



Fluorescent Applications



Fluorescent Systems

T5 Systems





T5 vs. T8

T8 Applications

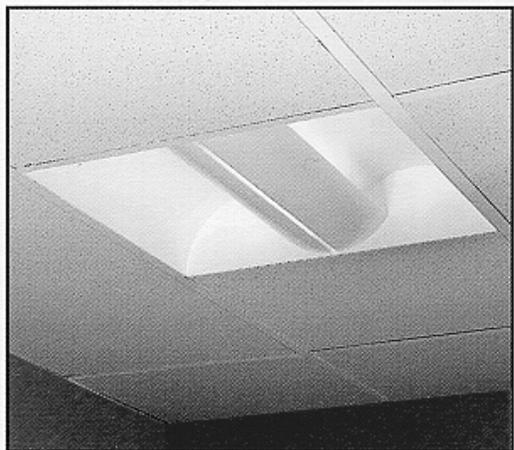
- Retrofitting T12 fixtures
- New direct fixtures
- New high lumen lamps +10% light
- New high ballast factor lamps + 20% light

T5 / T5HO Applications

- New indirect fixtures
- Multi-lamp high bay fixtures
- Not really a retrofit



T5HO





T5HO – Indirect



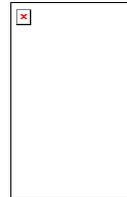
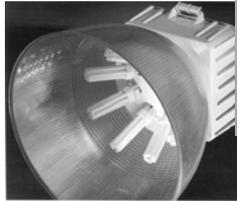
T5 – Direct/Indirect





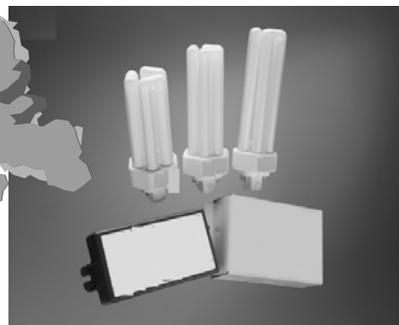
CFL Systems

- Applications: downlights, wall washers, wall sconces, table lamps, floor lamps, pendants, low and high-bay industrial/sports lighting



Compact Fluorescent Lamps

- **Up to 75% more efficient than incandescent**
- **6 - 13 times the life of incandescent (10,000 hrs)**
- **Reduce maintenance and re-lamp labor costs**
- **Good for the environment**





Compact Fluorescent Light Output Equivalency



15 - watts
20 - watts
23 - watts



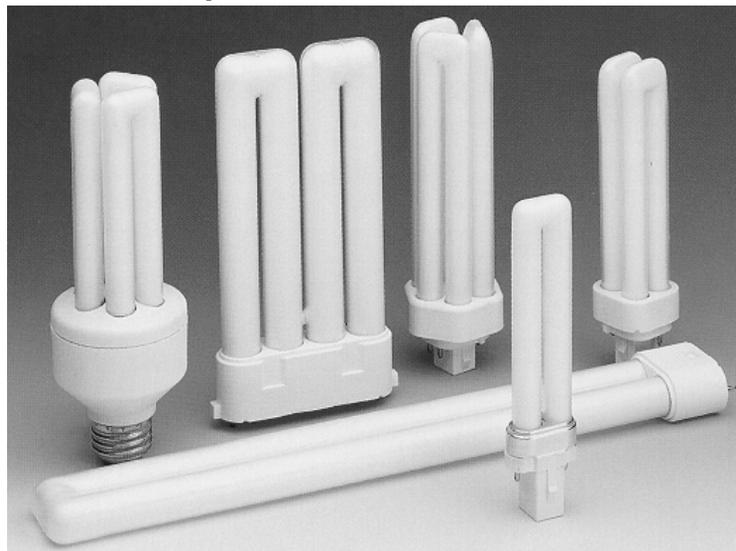
Divide
Incandescent
wattage by 4



60 - watts
75 - watts
90 - watts

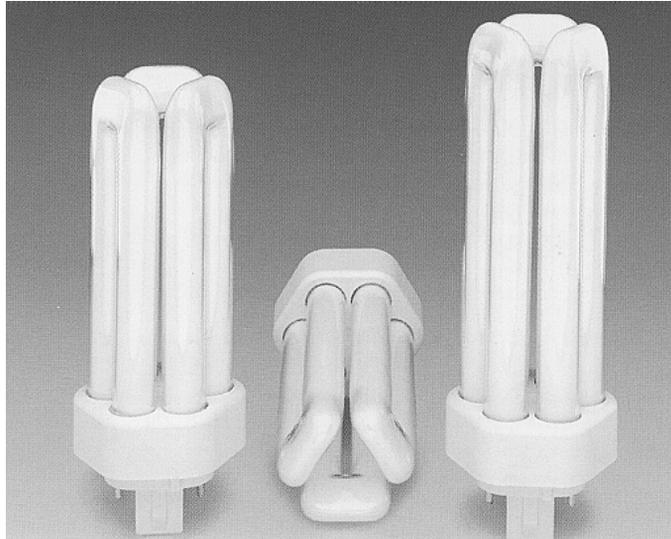


Compact Fluorescent Sources

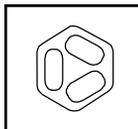




Triple Tube Compact Fluorescent Sources



Triple Tube Compact Fluorescent

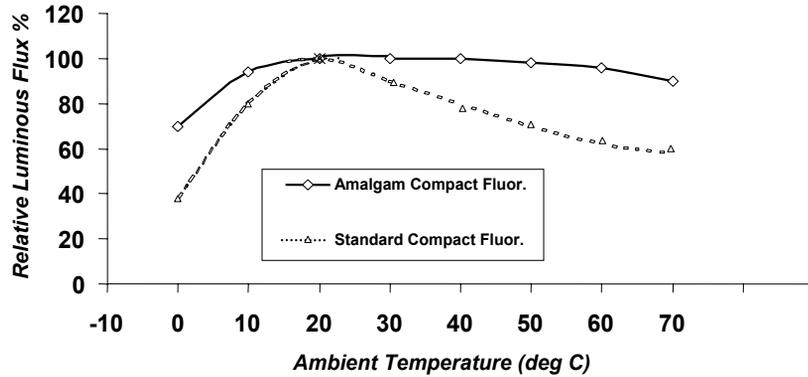


**TRIPLE-TUBE
DESIGN**

- Improved high temperature performance
- Maintains >90% light output from 40-140°F
- Universal burning position
- Wide Range of Colour Temperatures
- 10,000 hours Life
- Flicker free, good LPW
- Increased flexibility in fixture design and application



**Luminous Flux/Temperature Curve
Amalgam Compact Fluorescent vs. Standard**



Technologies

- Electrodeless Fluorescent Systems



Electrodeless Fluorescent Systems

Electrodeless Fluorescent Systems



Genura™
GE 23-Watt
Reflector Lamp



Electrodeless Fluorescent Systems

Electrodeless Fluorescent Systems

- Long Life – up to 100,000 Hours
- Instant On, Instant Restrike
- High Color Rendering White Light





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Electrodeless Fluorescent Systems



Outdoor Lighting



Industrial Lighting



Tunnel Lighting



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Electrodeless Fluorescent Systems



Outdoor Lighting



Technologies

- HID Systems



Why Use HID Lighting?



- Crisp white light source
- High light output in compact sources
- Requires fewer lamps
 - Lower installation & maintenance costs
 - Less cluttered, more attractive design
- Uses less energy (very efficient)
 - Compact HID lamps are 3 to 6 times more efficient than incandescent (100W 1HID=5 incandescent)
 - Full size Metal Halide and standard HPS lamps are ~2 times more efficient than Mercury Vapor lamps





Ceramic Metal Halide

QUARTZ ARC TUBE



CERAMIC (PCA) ARC TUBE



Pulse start lamp/ballast combinations

- 320w, 350w, 400w, 450w
- Variety of lumen packages to fit the need
- As high as 20% energy savings
- Better lamp lumen maintenance
- Longer lamp life
- Faster starting
- Holds color better.



HID Applications

DIY Stores, Gymnasiums, Superstores, Outdoor

- Quality
- Color Rendering
- Color Temperature
- Open Fixtures (Indoor only)
- Ease of Maintenance
- Increased Illumination Levels



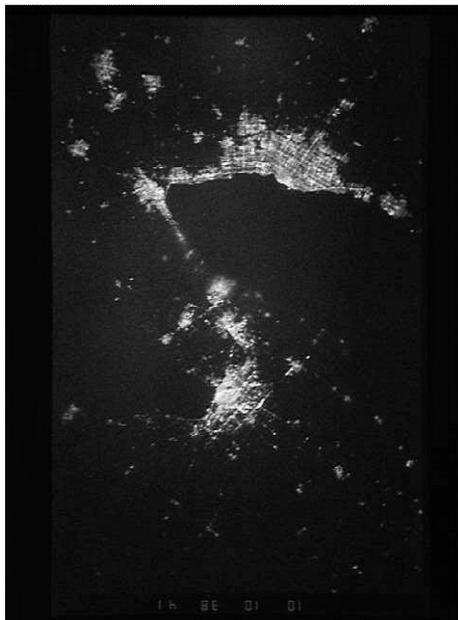
Outdoor lighting



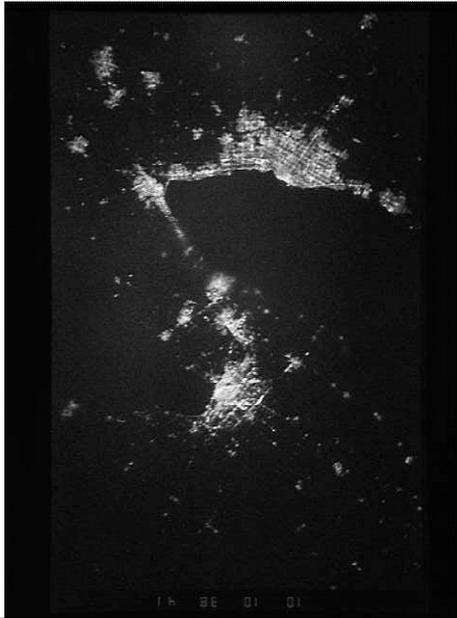
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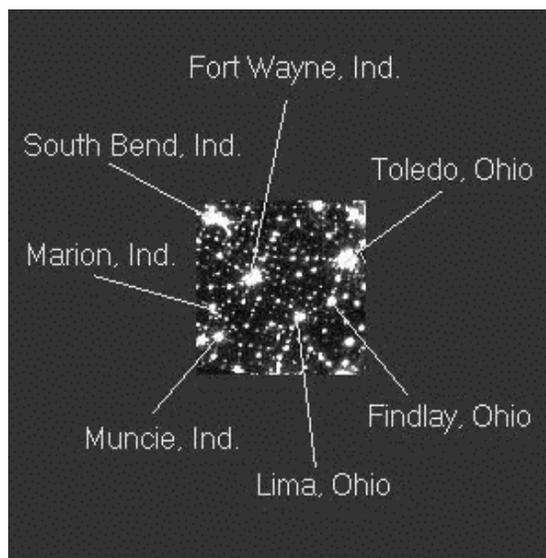
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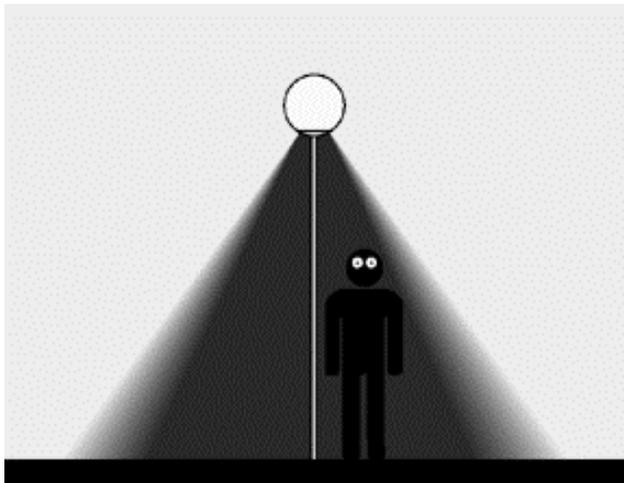
1 2 3 4 5



**Satellite
Night
Image
Western
end of
Lake Ontario**



**Satellite
Night
Image**



The Worst



The Usual



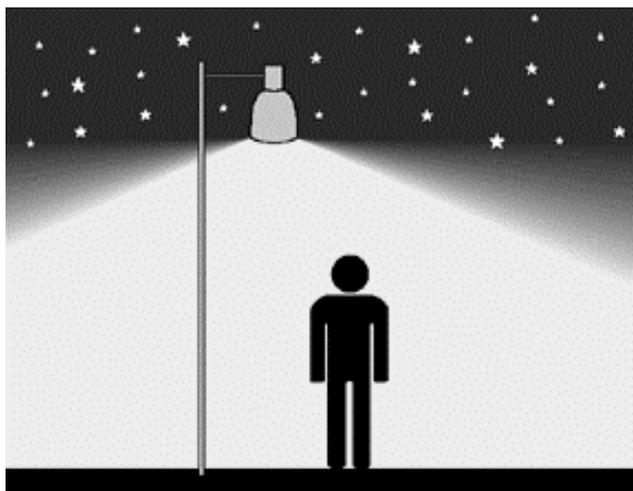
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The Usual



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**Most
Desirable**



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**Directional
Outdoor
Low-Mounted**



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**Cut-off
Area
Lighting
Luminaire**



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**Controlled
Area
Lighting
Luminaire**



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Sports Lighting - Good Cut-off



High – low HID switching Ballasts

- During idle times
 - Reduces energy by 50%
 - Reduces light out put to 30% of high.
- Process
 - Dual Capacitor
 - Dimming



Applications:

Parking Garages

gymnasiums

Loading docks

shipping areas

storage rack areas



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