



## ***LIGHTING FOR TODAY AND TOMORROW WITH SOLID STATE LIGHTING***

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***National Grid Your Partner in Energy Solutions***

***Tom Coughlin  
Lighting Program Manager – Energy Efficiency***

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# **LIGHTING FOR TODAY AND TOMORROW WITH SOLID STATE LIGHTING**

## **Agenda:**

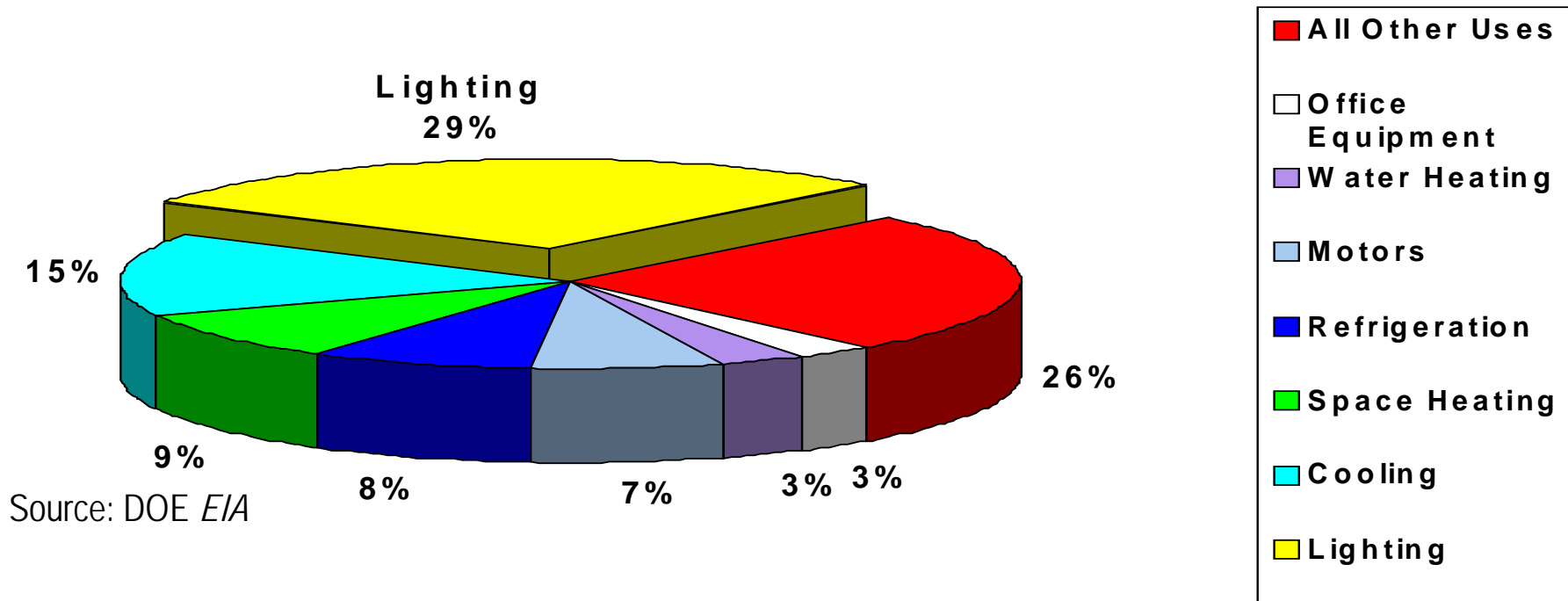
- ***Review the fundamentals of solid state lighting (LEDs)***
- ***Discuss what is being done at the Federal and Regional levels to develop standards around this emerging technology.***
- ***Overview of SSL technologies that qualify for Prescriptive Incentives under National Grid Retrofit Lighting Initiative***
- ***Review Project Opportunities***
- ***Summary LED technology***

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# Why LED Lighting?

## Energy Usage in Non-Residential Buildings

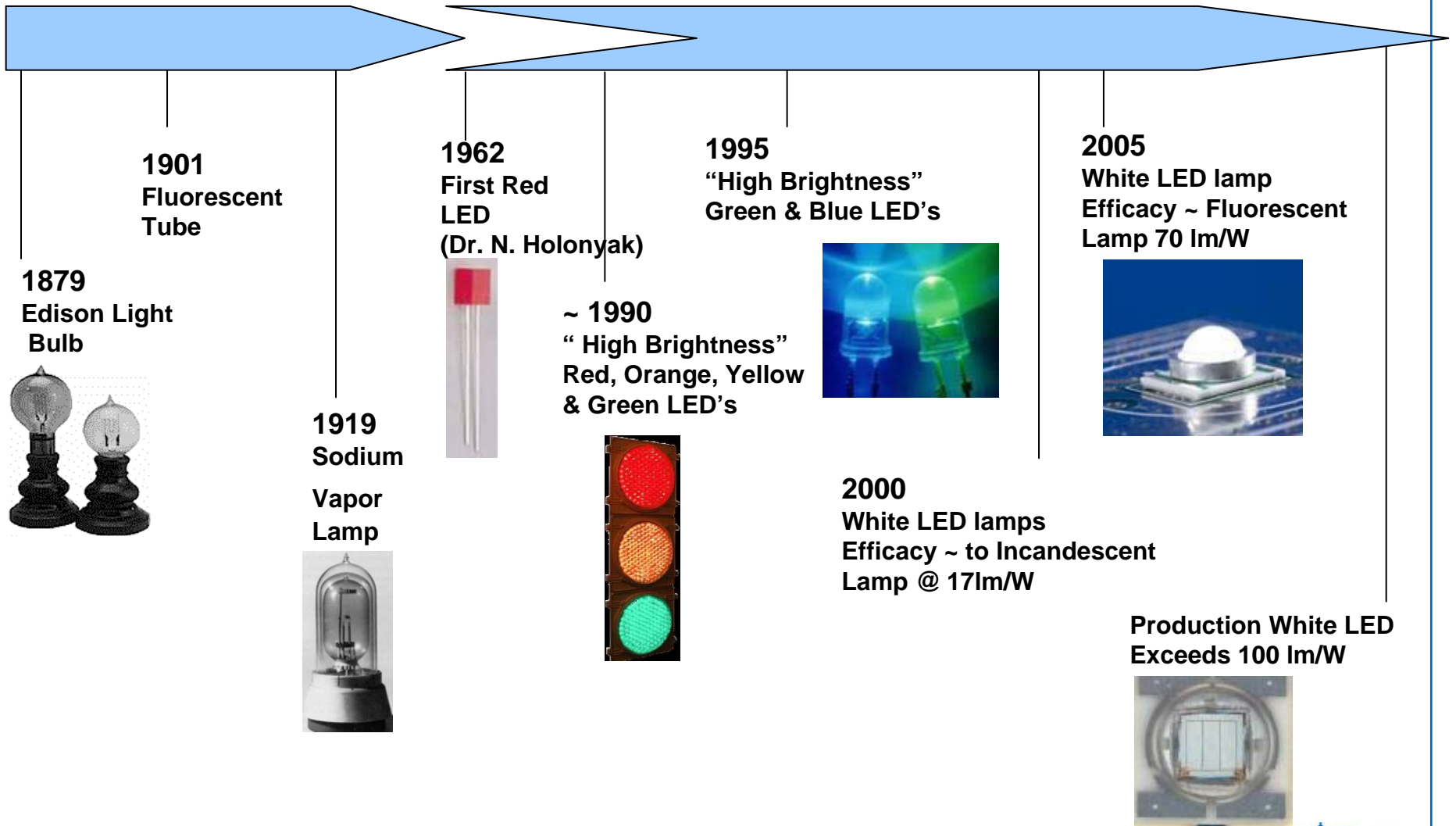


Source: DOE EIA

### The widespread use of LEDs over the next 10 years can:

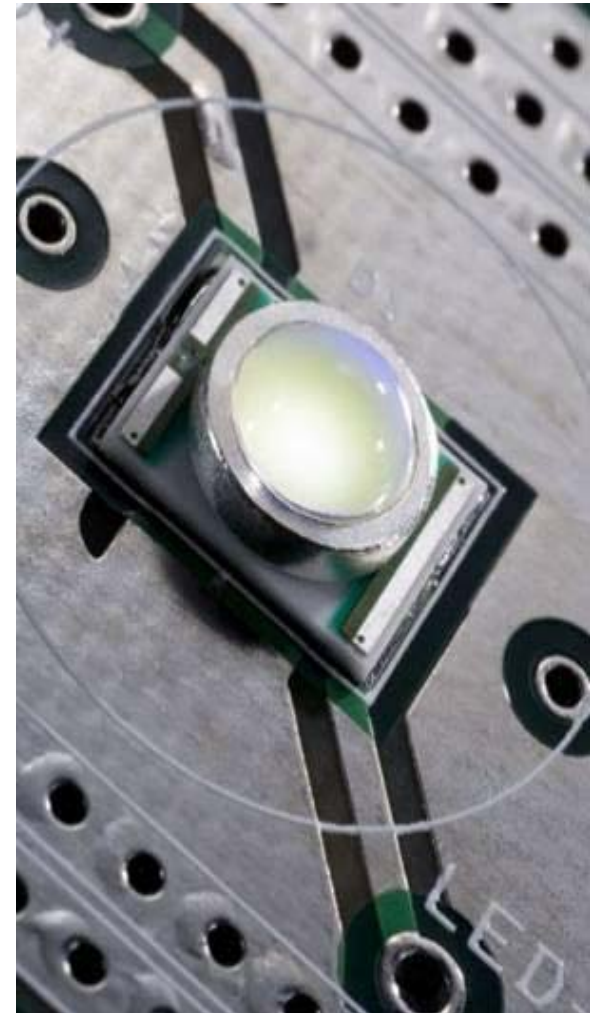
- Save energy (up to 60% Energy savings over standard technology within Lighting sector above)
- Save money
- Help protect the environment (no mercury)

# ...A Brief History of Lighting



## ***Basic Advantages of LED Technology***

- **Directional Light Source**
- **LED's are a semi-conductor  
(non filament source)**
- **Extended Lifetime Rating (>50,000 hours)**
- **Inherently Rugged**
- **LEDs increasing in Efficacy  
( > 100 lm/W)**
- **Instant ON, no re-strike times**
- **Environmentally sound, no mercury**
- **Dimmable**
- **Cold temperature compliant**



# How does LED Technology (Light Emitting Diode) Work?

## Emitter

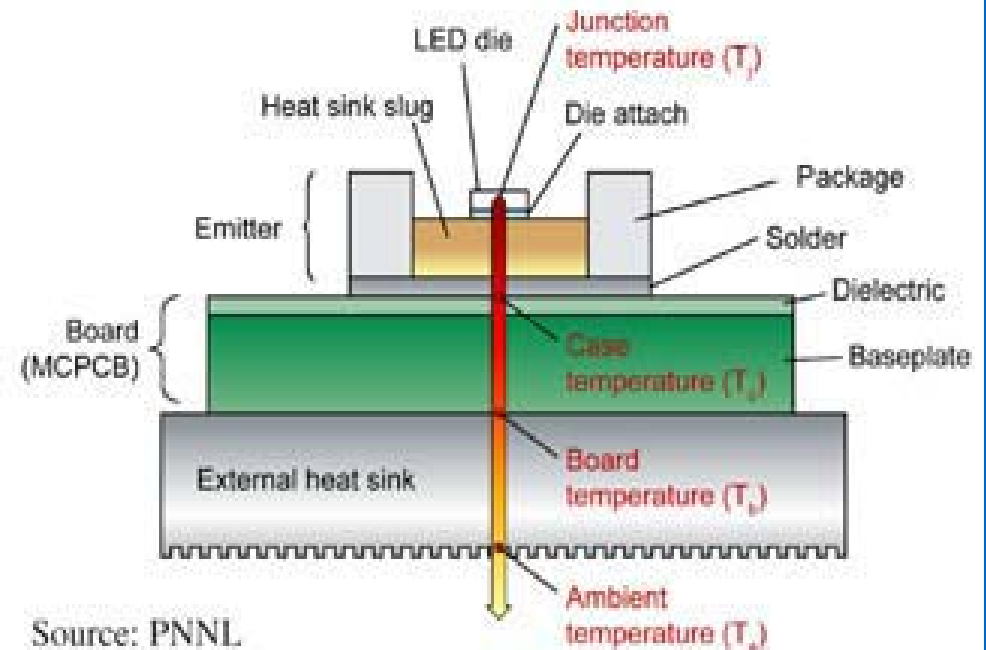
- *Composed of LED die, optics, encapsulant and heat sink slug*
- *Determines raw brightness & efficacy*
- *Location of junction Temperature  $T_j$*

## Metal-Core Printed Circuit Board (MCPCB)

- *Special circuit board with dielectric layer bonded to metal substrate (usually aluminum)*
- *Determines color point & color point stability (CRI, Kelvin)*

## External Heat Sink (Package)

- *Protects chip & phosphor*
- *Assists with heat dissipation (LED lifetime rating L70)*



## Affects on Junction Temperature

- **Drive current**
  - *higher drive current the greater heat generated at die*
  - *move heat away from die to maintain output, life, and color*
- **Ambient Temperature**
- **Design Thermal Path from die surroundings**

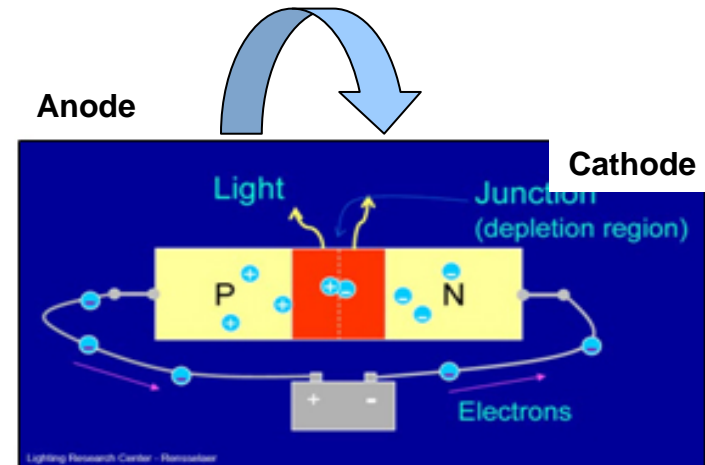
# How does LED Technology Work?

## How Traditional Light sources produce light

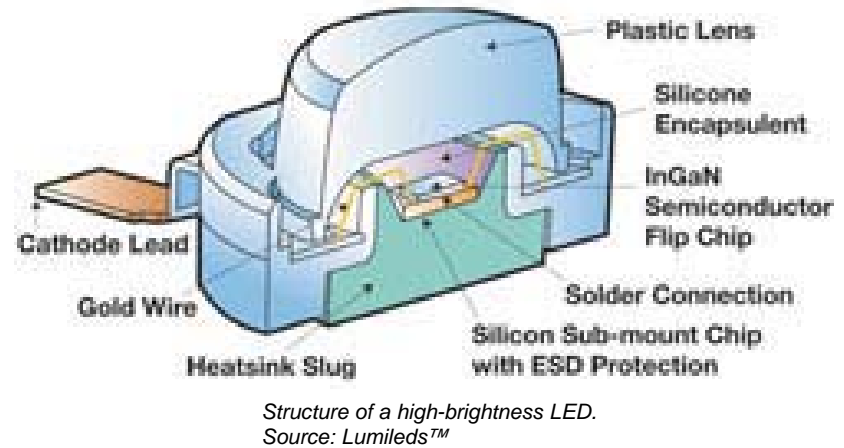
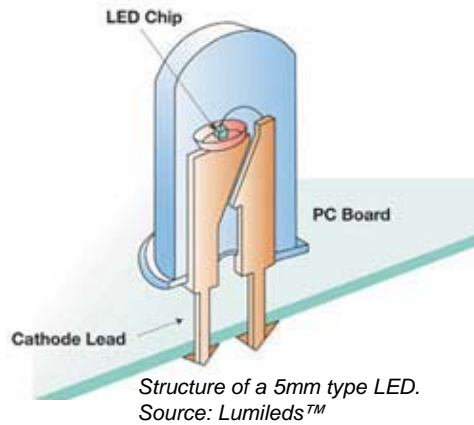
- **Incandescent lamps a filament is heated by electric current until it glows ( emits lights)**
- **In Fluorescent lamps an electric arc excites mercury atoms emitting UV radiation. The UV radiation strikes the phosphor coating and emits visible light**

## How LEDs produce light

- **An LED chip consists of semi-conducting material treated to create a p-n junction. When connected to a power source, current flows in one direction from the positive (p-side) to the negative (n-side)**
- **Electrons (charge carriers) flow into the junction, fall into a lower energy level and release photons (light)**
- **The light color is determined by the materials used to make the diode**
  - **White LEDs – blue LED w/yellow phosphor**
  - **Red LEDs – aluminum gallium arsenide**
  - **Blue LEDs – indium gallium nitride**
  - **Green LEDs – aluminum gallium phosphide**



# How does LED Technology Work?

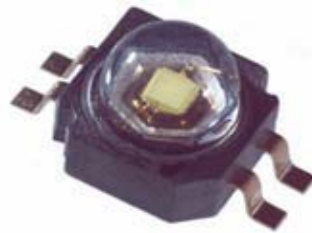


## Low power LEDs

- Various sizes 3, 5, and 8 mm ( common 5 mm)
- ~0.1 watts, low current & voltage (20 mA & 3.2 v DC), produce 2-4 lumens

## High power LEDs

- ~ 1-3 watts, various drive current 350,700, or 1000mA, produce 40-80 lumens per 1 watt package



# How do I Evaluate LEDs?

- **Review LM-79 photometric test data**
- **Review LM-80-08 LED Package temperature Data**
  - Defines testing parameters for lumen depreciation of SSL packages over time ( recommends 6000 hours testing)
  - Taken at 55 °C, 85 °C, and Third Temp.
- **In-Situ Temperature Measurement test (ISTMT) data**
  - Report indicating the temperature of the hottest LED In-Situ
  - “In-Situ” Real-world LED temperature in environment (i.e. fixture or integral lamp)
  - Along with LM-80-08 validates lumen maintenance and useful life of product (L70 lifetime determination)



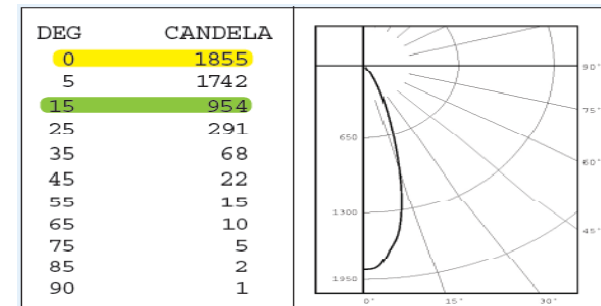
# Understanding LM-79 Photometric Report

## LM-79 Reports data for:

- **Electrical characteristics**
  - Input Voltage
  - Input current
  - Input power
  - Separate measurements for separate photometric tests
  - Basis for luminaire efficacy ( lumens per watt, lm/w)
  
- **Light output and efficacy**
  - Reported as discrete values
  - Embedded in zonal lumens table
  - Light output (lumens) / input wattage (watts)
  
- **Light distribution**
  - Estimating beam angles
  - Predicting illuminance patterns
  
- **What's Not Included in LM-79**
  - Lumen Maintenance and Life (LM-80-08)
  - New Technical Memorandum (TM-21)  
is in development for estimation beyond 6000 hours  
(by IESNA)



Zone	Lumens	%FIXT
0-30	702	68.69
0-40	971	95.06
0-60	1021	99.98
0-90	1022	100.00
90-180	0	0.00
<b>0-180</b>	<b>1022</b>	<b>100.00</b>



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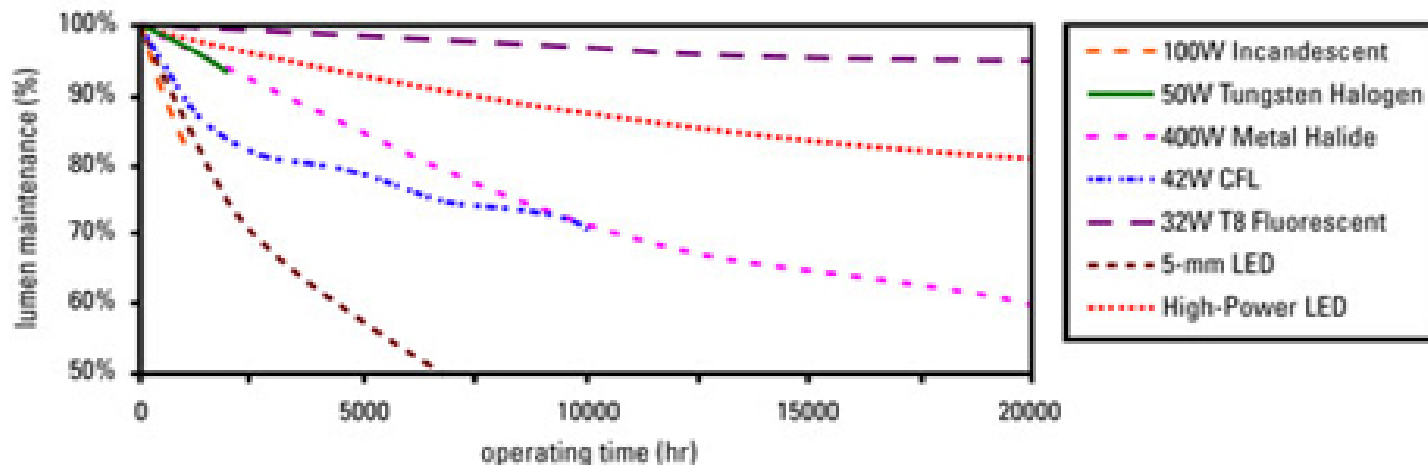
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# What is LED “Life”?

## What is Lifetime?

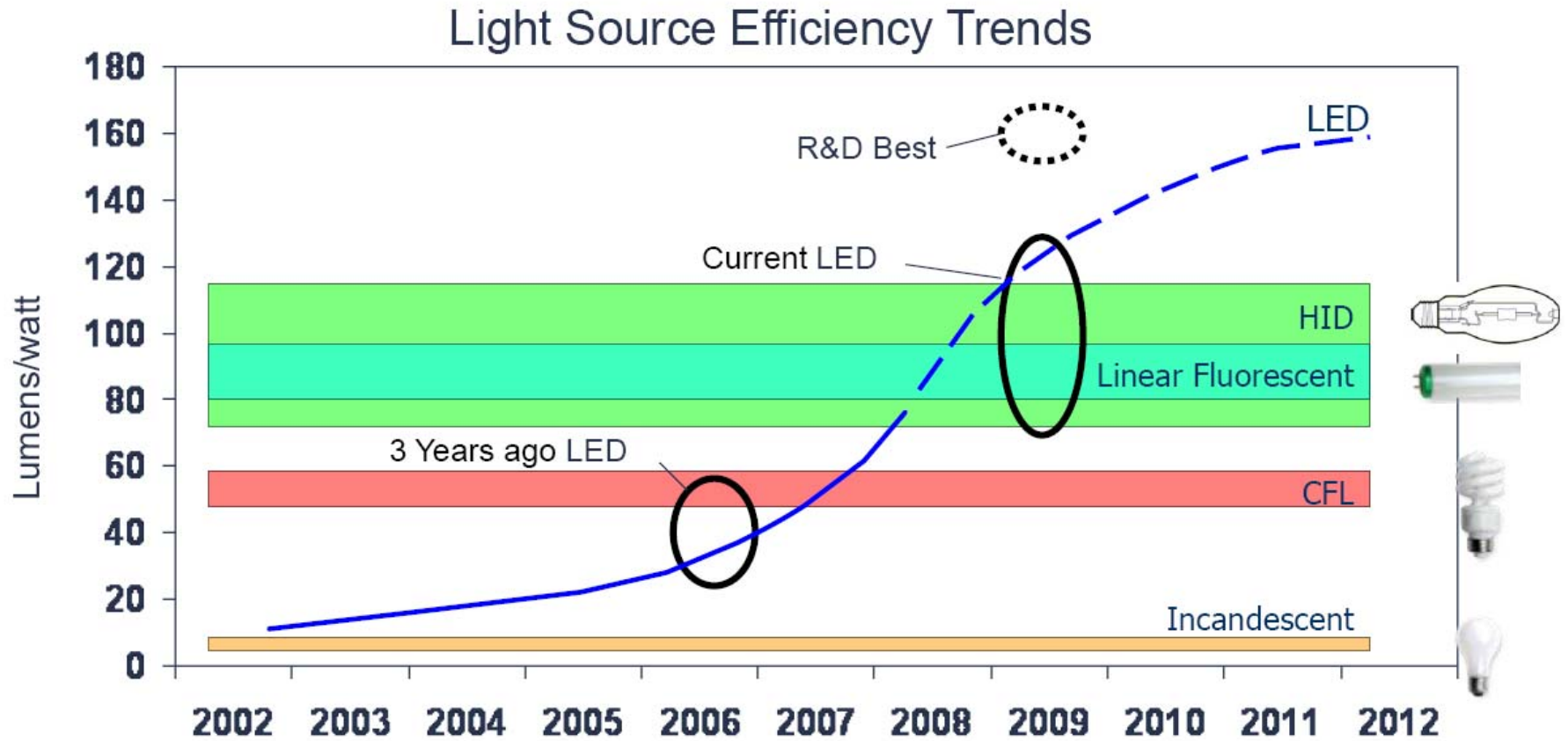
- **Industry considers LED life to be the point at 70% of light output**  
( Based on research indicating the human eye does not detect a decrease in light until it exceeds 30%)
- **Manufacturers publish lumen depreciation curves based on testing their products to 6,000 hours and extrapolating to 70% level to determine lifetime**  
(accounting for drive current & LED junction temperature)
- **Note: Lifetime Determination for fluorescent lamps is at 25°C burn for 3 hours, off 20 minutes at the point that 50% of the lamps fail**

Typical Lumen Maintenance Values for Various Light Sources



Source: Adapted from Bullough, JD. 2003. *Lighting Answers: LED Lighting Systems*. Troy, NY. National Lighting Product Information Program, Lighting Research Center, Rensselaer Polytechnic Institute.

# How do LEDs Compare to Standard Light Sources?



# ***What is being done at the Federal level to develop standards around this emerging technology ?***

## ***Energy Star Kicked off the SSL initiative in Sept. 2008***

- ***Intent on making sure there is consistency in the market***
- ***Developing standards (2 final and 1 draft specifications)***
  - Energy Star Program Requirements for Integral Led Lamps
    - **(dated final: 03/22/10)**
  - Energy Star Program Requirements for Solid State Lighting Luminaires
    - Eligibility Criteria – Version 1.1 **(dated final: 12/19/08)**
    - Energy Star Program Requirements for Solid State Lighting Luminaires
      - Eligibility Criteria – Version 1.2 **(dated draft: 07/01/09)**
        - Additional categories Outdoor Area, Wall Mount & Parking Garage Luminaires
- ***List products by category under Residential & Commercial Groups***
- ***The list is evolving slowly***
- ***Energy Star now governed under EPA not DOE***



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# ***What is being done at the Regional level to develop standards around this emerging technology ?***

## ***DesignLights Consortium Kicked off the SSL initiative in Nov. 2009***

- ***Design Lights Consortium will be creating a SSL product qualifying list for products not yet covered under the Energy Star***
- ***The DLC has hired the Lighting Research Center (LRC) to evaluate product***
- ***Developing standards (current technical requirements dated 03/04/10)***
- ***Website: <http://designlights.org/solidstate.about.php>***

**DESIGNLIGHTS**  
CONSORTIUM



THE NORTHEAST'S PREMIER RESOURCE FOR HIGH-QUALITY,  
ENERGY-EFFICIENT, COMMERCIAL LIGHTING DESIGN AND INFORMATION!



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# What LED technologies are covered under Commercial Prescriptive Incentives?

- **Measure Code 80: LED Downlights**

- Intent to replace Incandescent and CFL downlights
- Energy Star qualified



- **Measure Code 81A & 81B: Integral LED Directional Replacement lamps**

- Intent to replace Incandescent MR16, PAR30 & PAR38 lamps
- Energy Star qualified



- **Measure Code 82A & 82B: Freezer/Cooler LED fixtures**

- Intent to replace T-12 lamps
- Saves on maintenance & 1.24kW per ton of cooling
- DesignLights Consortium qualified









- **Measure Code 83: Low Bay, Garage and Canopy LED fixtures**

- Intent to replace HID fixtures in 24/7 hour applications
- DesignLights Consortium qualified
- Will these replace Vapor Tight fluorescent fixtures? **Soon**



# National Grid - Lighting Project Information Form

80	LED Downlight Fixtures - Hard Wired	\$50	This incentive only applies to hardwired LED fixtures on Energy Star's list (for more information see <a href="http://www.energystar.gov">www.energystar.gov</a> )	25	
81A	Integral LED Directional Replacement Lamps - MR16 & PAR16	\$15	Eligible LED Directional Integral replacement lamps for these reflector styles: MR16 and PAR16. Eligible lamps are required to be listed by Energy Star (for more information see <a href="http://www.energystar.gov">www.energystar.gov</a> )	12	
81B	Integral LED Directional Replacement Lamps - PAR20, PAR30 AND PAR38	\$35	Eligible LED Directional Integral replacement lamps for these reflector styles: PAR20, PAR30S, PAR30L and PAR38. Eligible lamps are required to be listed by Energy Star (for more information see <a href="http://www.energystar.gov">www.energystar.gov</a> )	25	
82A	LED Cooler or Freezer Case Fixtures - 5' Fixture	\$50	Eligible LED Cooler and Freezer Case fixtures are required to be listed by Energy Star or Design Lights Consortium (for more information see <a href="http://www.energystar.gov">www.energystar.gov</a> and <a href="http://www.designlights.org">www.designlights.org</a> )	30	
82B	LED Cooler or Freezer Case Fixtures - 6' Fixture	\$65	Eligible LED Cooler and Freezer Case fixtures are required to be listed by Energy Star or Design Lights Consortium (for more information see <a href="http://www.energystar.gov">www.energystar.gov</a> and <a href="http://www.designlights.org">www.designlights.org</a> )	40	
83	LED Low Bay Fixtures - Garage and Canopy Fixtures	\$150	Eligible LED Low Bay fixtures are required to be installed in 8,760 hour applications and be listed by Energy Star or Design Lights Consortium (for more information see <a href="http://www.energystar.gov">www.energystar.gov</a> and <a href="http://www.designlights.org">www.designlights.org</a> )	60	

# LED technology span various Market Segments

Past

Present

Future

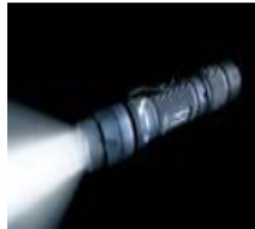


Color Specialty

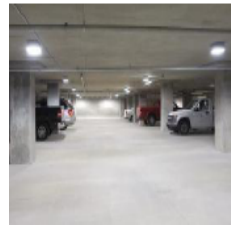
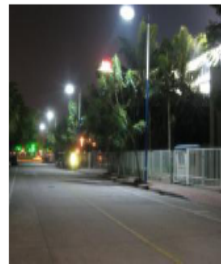


**Colored LEDs**

White Specialty

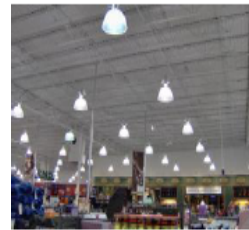


Outdoor Light



**Cool White LEDs**

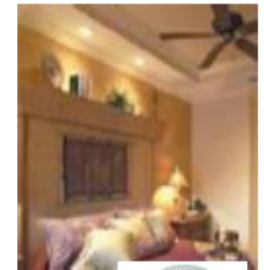
Indoor High Bay



Indoor Commercial



Indoor Directional



**Warm White LEDs**

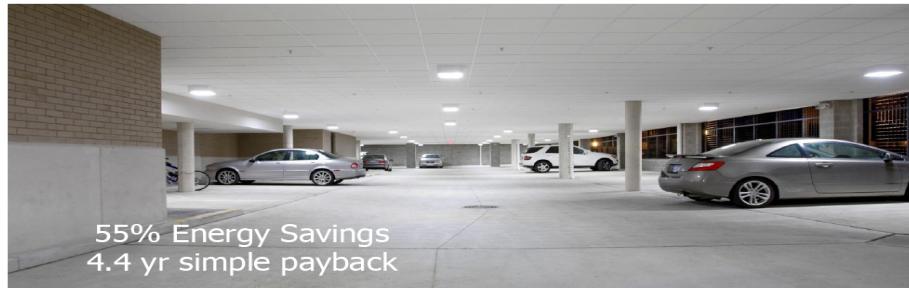


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# LED Lighting- Parking Garages and Industry

## 735 Forest – Birmingham, MI



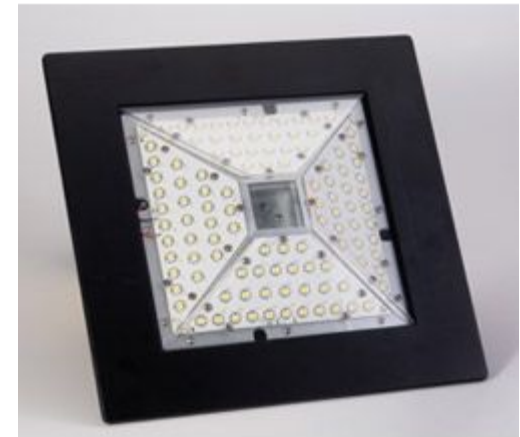
<http://www.735forest.com/>



Image by BetaLED



Lighting Science Lowbay Fixtures at Work



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# LED Lighting- Commercial Interiors



Image by Cooper Lighting - Halo



Image by CREE

# ***LED Lighting – Retail Case Refrigeration***



Image by GE



Image by Hussman

# Lighting for Today and Tomorrow with Solid State Lighting Summary

- **LED Technology Overview**

- Customers understanding & embracing LED technology
- Multitude of LED product available to various market sectors
- Federal & Regional Standards in place
- Performance Increasing (Caliper data)

- **Viable LED Applications**

- Indoor Downlights (Energy Star qualified)
- Parking Garages (DLC qualified)
- Freezer Cases (DLC qualified)
- Integral Replacement lamps (Energy Star Qualified)

- **LED Development (next 3-5 years)**

- Higher wattage roadway
- Commercial Interior fixtures ( i.e. recessed 2x4 troffers)

- **Continuing Education to Market**

- EPA Energy Star standards
- Designlights Consortium technical requirements
- National Grid



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ARCHITECTURAL

# **LIGHTING FOR TODAY AND TOMORROW WITH SOLID STATE LIGHTING**

***Energy Solutions for Tomorrow: Partnering with National Grid***

◆ **Tom Coughlin**

*phone: 781-907-1582*

**Or Call your local account manager!**

