

PHILIPS

LED Technology

September 10th 2009
Breezy Point Resort

Tubes To Transistors All Over Again

Analog

Vacuum tube

LP records

Film

Rotary phone

VHS

Linkages

Typewriter

Digital

Transistor

CDs → mp3

CCD

Cell phone

DVD

'Fly by wire'

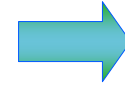
Computer



Lighting is the last refuge of analog

LEDs Are the Lighting Source for Tomorrow

Conventional Lighting Sources



LED Lighting Source

- Incandescent



- Halogen



- Fluorescent



- Gas-discharge (example: neon)



- Light emitting diodes (LEDs)

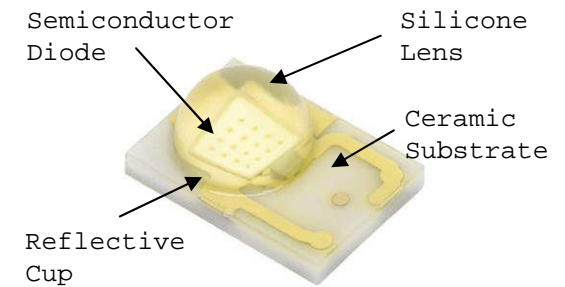


Benefits of LED Lighting

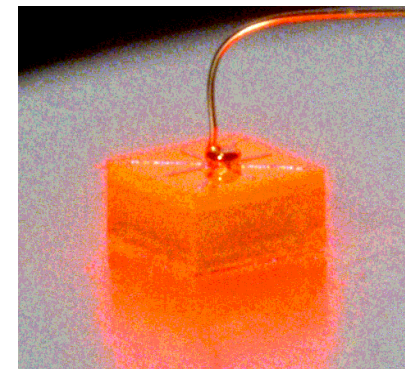
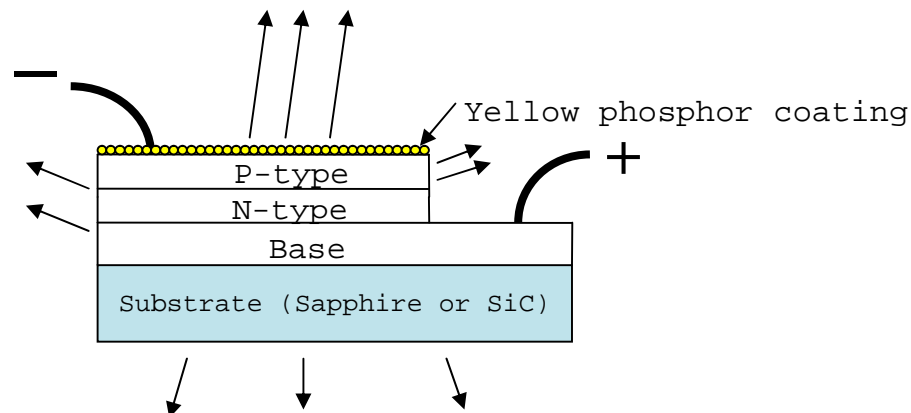
- Ultra long source life
- Low power consumption
- Low maintenance
- No moving parts
- No UV radiation
- Cool beam of light
- Digitally controllable
- Sustainability

LED Technology

- A semiconductor device that converts electrical energy directly into a discrete color of light
- Made from compound materials
- Made in chip fabrication factories
- Not brass, glass and gas
- White LEDs are blue LEDs + phosphor



Philips Lumileds Rebel



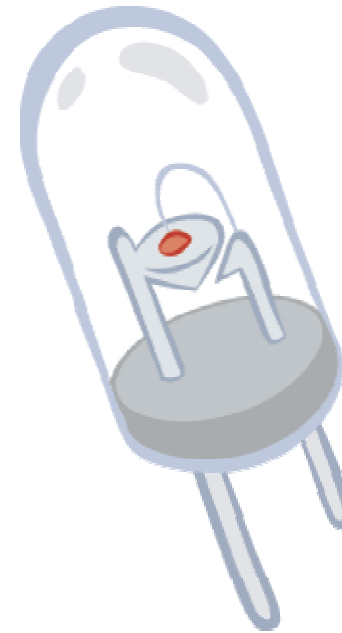
A Brief LED History

- 1962 First LED (Holonyak at GE)
 - 0.001 lumens
- 1960's Red LEDs (HP & Monsanto)
 - 0.01 lumens
- 1970's–1980's Green LEDs, Watches, Calculators
 - 0.1 lumens
- 1990's Blue LEDs (Nakamura at Nichia)
 - 1 lumen
- 2000+
 - 10-100 lumens
- 2005
 - 1000 lumens (multichip packages)
- General Illumination

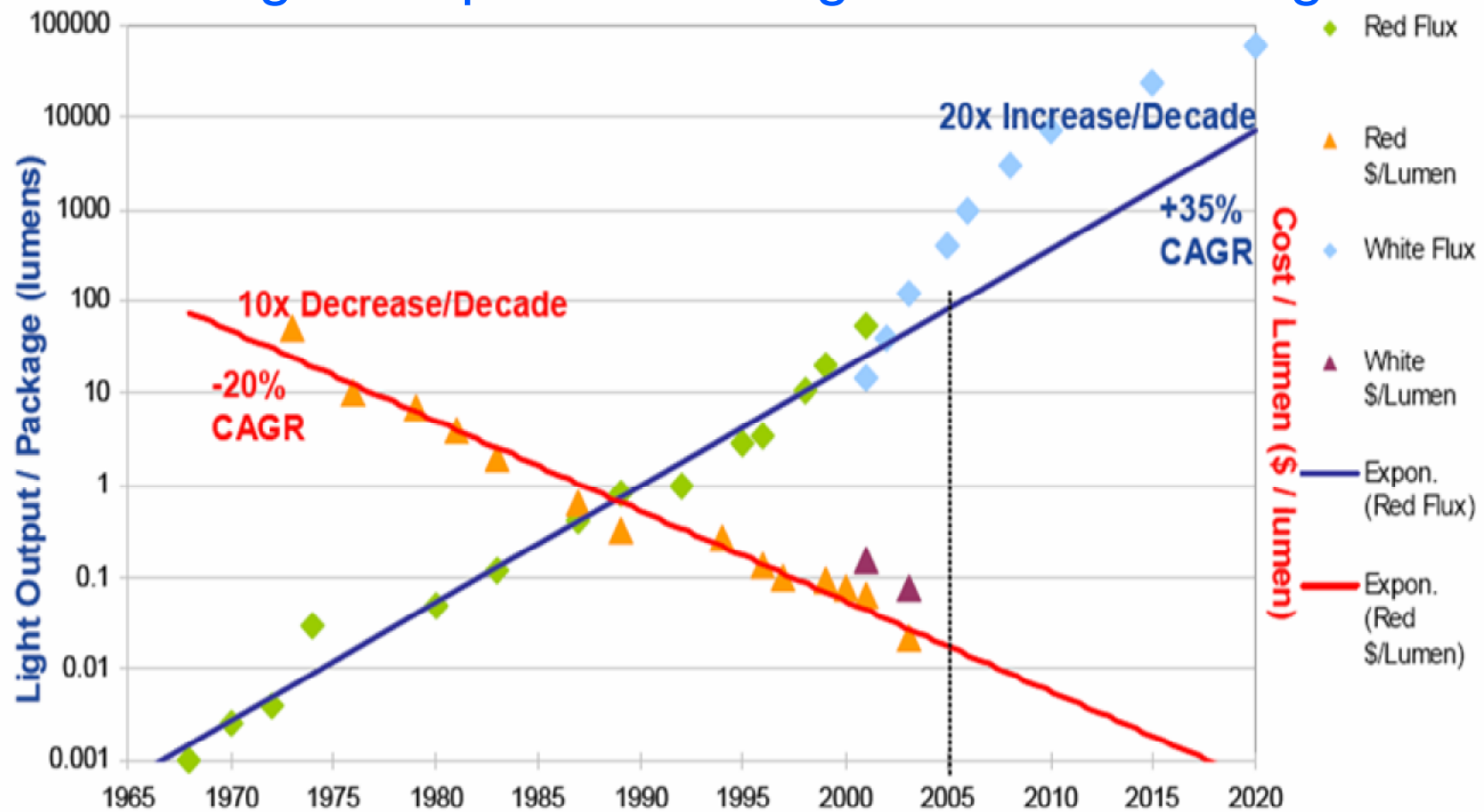


LED Benefits

- Ultra long source life
- Low maintenance
- No moving parts
- Low power consumption
- No radiated heat (IR) from light
- No UV emissions
- Natural coupling for digital control



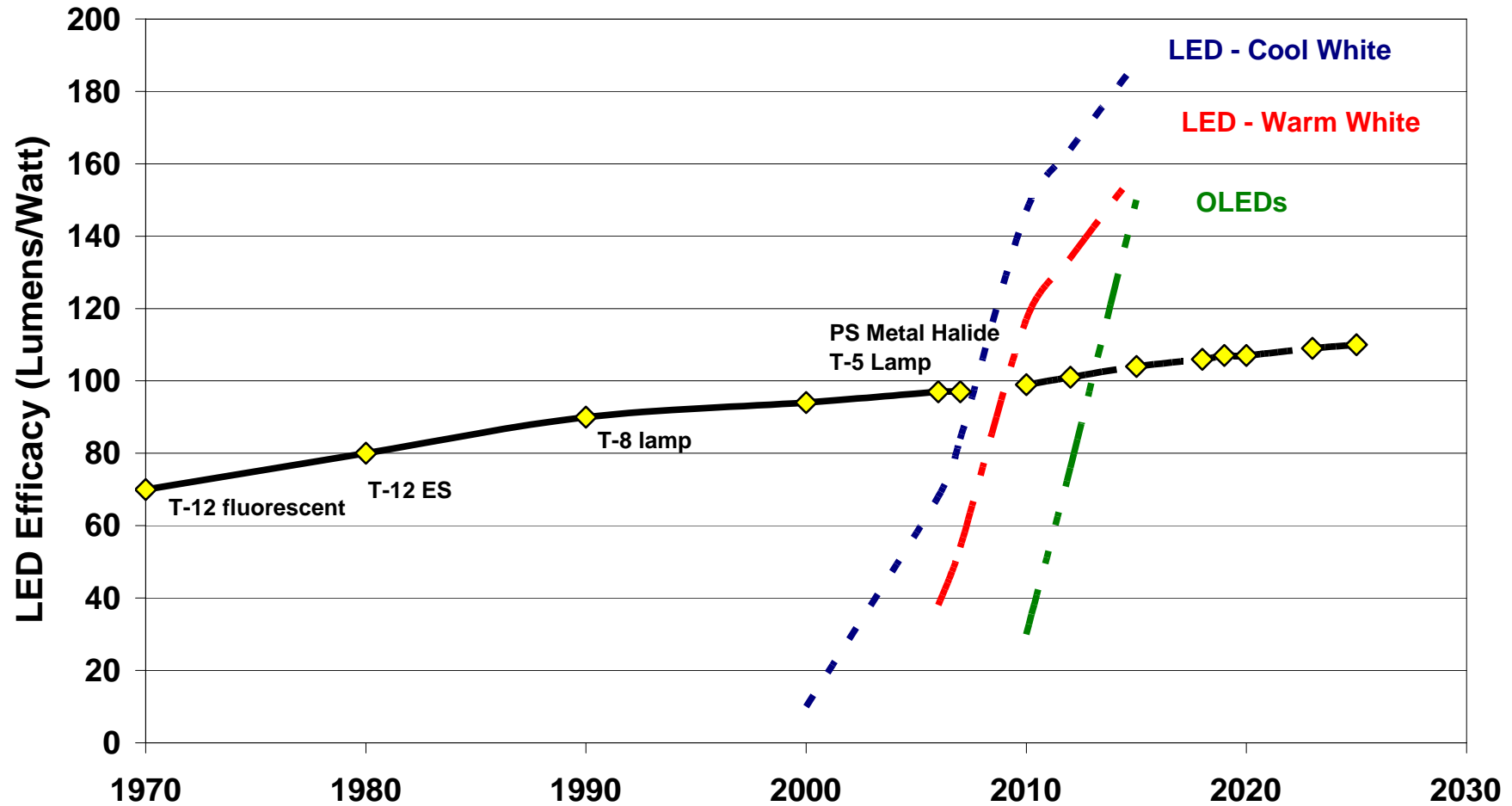
Haitz' Law: LED Light Output Increasing/Cost Decreasing



Source: Roland Haitz & Lumileds

White Light Efficacy Projections

Projections from US DOE 1/08



Lighting Industry Facts

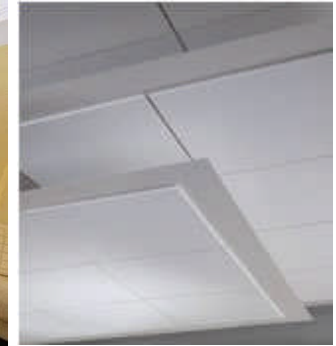
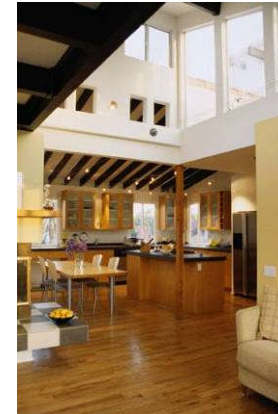
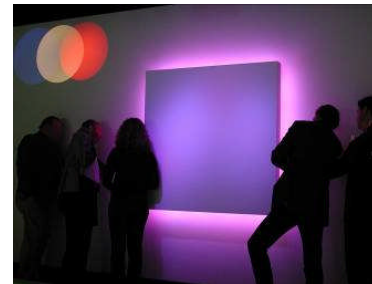
- Lighting Products \$70 B Globally
- Lighting consumes in US:
 - 8% of energy
 - 22% of electricity
- Lighting energy costs \$40B/yr
- LED Lighting could reduce lighting energy 50% by 2025
- Savings from 2000 to 2020 could
 - Eliminate need for >100
1000MW power plants
 - Save over \$100B



Source: US DoE, Freedonia

Source: NASA Visible Earth

SSL Applications



The Early Years

- Traffic Signal
- Automotive Tail Lamps
- Signage, gadgets

Current

- Architectural
- Entertainment
- Specialty, Automotive headlamp

Emerging

- General Illumination

Early Years:

- Example: Traffic Lights
 - The cost to run an incandescent traffic light is \$16/year
 - The cost to run an LED traffic light is \$2/year
 - Replacing US traffic signals could save \$200M/year
 - 40% adoption as of 2006



*Source: 2001: Optoelectronics Industry Development Association Tech Roadmaps
Source: Arthur D. Little study for U.S. Department of Energy*

Current



Emerging Trends



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Legislation &
Incentives

Energy Independence & Security Act of 2007

- Objective – By 2018
 - Reduce Residential Lighting Energy by 50%
 - Reduce Commercial by 25%

- **Legislation: Ban the Bulb**



General Service Incandescent Lamp Standards and Effective Dates

Current Wattage	Rated Lumen Ranges	New Maximum Rated Wattage	Minimum Rated Lifetime	Effective Date (Manufactured on or after)
100	1490-2600	72	1,000 hours	1/1/2012
75	1050-1489	53	1,000 hours	1/1/2013
60	750-1049	43	1,000 hours	1/1/2014
40	310-749	29	1, 000 hours	1/1/2014

Energy Independence & Security Act of 2007

L•PRIZE™

- Bright Tomorrow Competition
 - DOE Sponsored
 - 60W Incandescent Replacement
 - \$10 Mil. Prize
 - Requirements:
 - 900 Lumens / 10W (90 LPW), ≥ 90 CRI
 - 2000 Units
 - PAR 38
 - \$5 Mil Prize
 - Requirements:
 - 1350 lumens / 11W (123 LPW), ≥ 90 CRI
 - 2000 Units



California's Title 24

2005 Standard – Currently in effect

- **Residential - Installed Luminaires**

Table 6-1 – High Efficacy Lamps

Lamp power	Required lamp efficacy
< 15 W	40 lm/W
15-40 W	50 lm/W
>40 W	60 lm/W

Note: the wattage of the ballast is not included when determining lamp efficacy.

- **Non-Residential**

- Requires Compliance with:
 - power density limits for lighting in buildings
 - use of controls
 - cut-off limits (outdoor)
 - No mention of LEDs

California's Title 24

2008 Standard effective July 1, 2009

- Residential - Installed Luminaires
 - Requires “High Efficiency Luminaires”, or motion sensors
 - New rules:
 - LED Luminaires must be certified by CEC to be HE
 - Efficiency requirements for LED + Heat Sink
 - If LED “Lamp” is removable must have GU-24 Base

Table 6-2– High Efficacy LED Lighting Source Systems

<u>System power rating for LED lighting</u>	<u>Minimum system efficacy for LED lighting</u>
<u>5 W or less</u>	<u>30 lm/W</u>
<u>over 5 W to 15 W</u>	<u>40 lm/W</u>
<u>over 15 W to 40 W</u>	<u>50 lm/W</u>
<u>over 40 W</u>	<u>60 lm/W</u>

California's Title 24

2008 Standard effective July 1, 2009

- Non-Residential Lighting Changes
 - Lower LPDs
 - New Fixture Rating Methods
 - Fewer Exclusions
 - New Daylighting Credits
 - LEDs:
 - Signage Power Supplies >80% Efficient
 - Outdoor Lighting – Multilevel switching or dimming

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Standards

Energy Star



Solid State Lighting Luminaires

- Category A:
 - 9/30/08: Under cabinet Kitchen, Under cabinet Task, Recessed Downlight, Portable Desk / Task, Step, Porch, Path
 - 12/15/08: Surface / Pendant, Roadway, Outdoor Decorative, Wallpack, Cove, Parking Garage, Bollard, Troffers, Accent
 - Criteria:
 - Luminaire Efficacy, CCT, Lumen Maintenance, etc.
 - Need Approved Testing Standards
- Replacement Lamps: Under investigation for Addition
- Category B:
 - All Luminaires 70 LPW by 2011

Energy Star



EPA Standard

- **Scope: Indoor & outdoor residential light fixtures used for primary illumination**
 - Issued 6/08
 - Replication & contradiction with DOE Standard
 - Different requirements & testing criteria
 - Controversy & Suspension by Organizations
 - EPA collected public comments until August 25

LEED - Leadership In Energy & Environmental Design

LEED: Voluntary, consensus-based national standard for high-performance, sustainable buildings

- Points-based system with whole building approach
- Three possible levels - Silver, Gold, Platinum
- Solid state lighting can increase points in three categories
 - Energy & Atmosphere
 - Materials & Resources
 - Innovations in Operations



Industry Standards

- **ANSI / ASHRAE / IESNA Standard 90.1**
 - First published in 1975, latest update 2007
 - Adopted by State
 - Requires min. energy efficiency levels
 - Excludes low-rise & residential
 - Applies to:
 - New buildings & systems, Additions
 - New systems and equipment in existing buildings
 - Lighting:
 - Mandatory requirements for controls and efficiency
 - Power limits for interior and exterior lighting.

Industry Standards

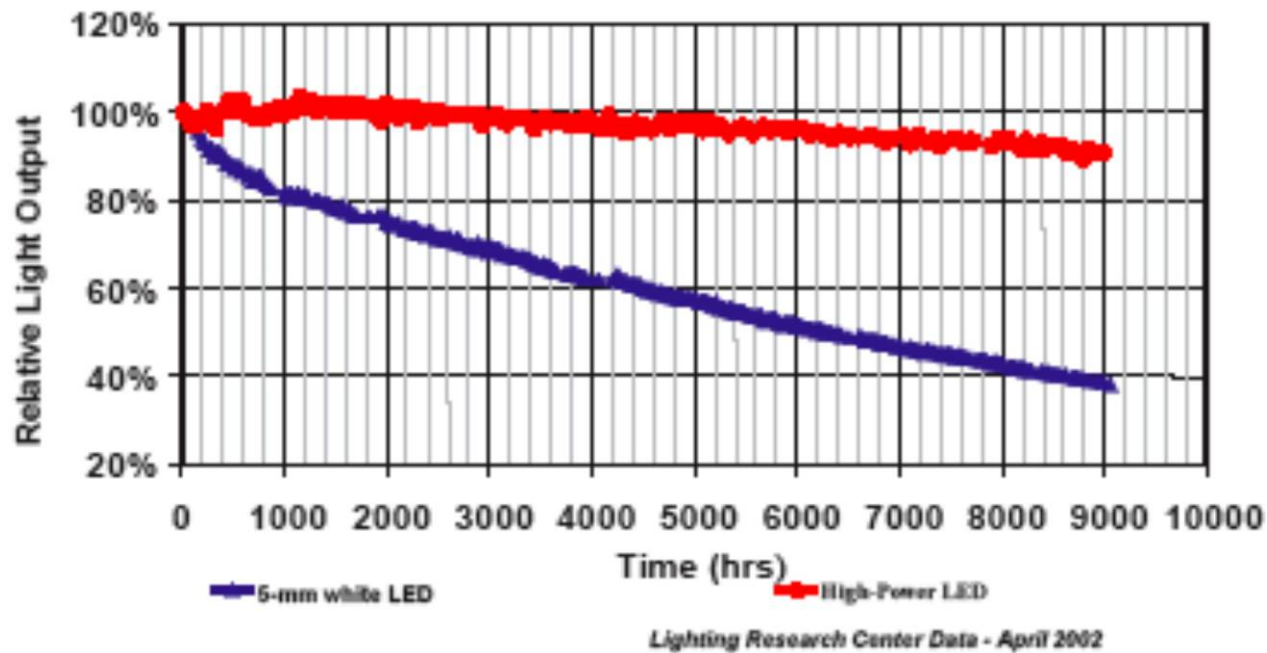
- **RoHS:** Restriction of Hazardous Substances
 - Adopted 2/03 by European Union
 - Restricts use of Hazardous Materials:
 - Electronic devices & equipment
 - Lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE) flame retardants
 - California adopted similar legislation w/ narrower scope of products and places restrictions on different hazardous materials.

SSL Standards in Development

Standard	Standard	Status 10-4-08
Definitions for SSL	IESNA RP16	Complete
Chromaticity of White SSL	BSR C78.377A	Complete
Elec. & Photometric Measurements	IESNA LM79	Complete
Lifetime (Lumen Depreciation)	IESNA LM80	Complete
Photobiological Safety	CIE S009	In ballot
Drivers	BSR C82.XX	Started
CANENA LED Safety Standards	Requested to CSA & UL	In-process
Binning & materials for arrays	Committee formed	In-process
New CRI Standard	CIE TC-1-69	In-process

Standards: Lifetime of LEDs vs. Traditional Lighting

- LEDs fade over time (Lumen Maintenance)
- How is Lifetime defined?
 - New standard, LM-79



Standards: Lifetime of LEDs vs. Traditional Lighting

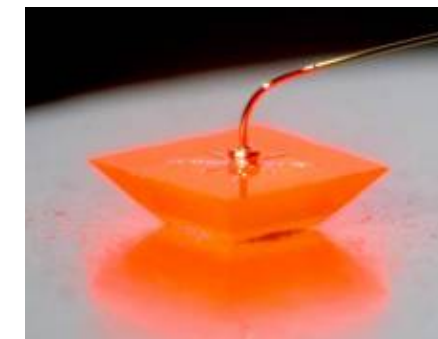
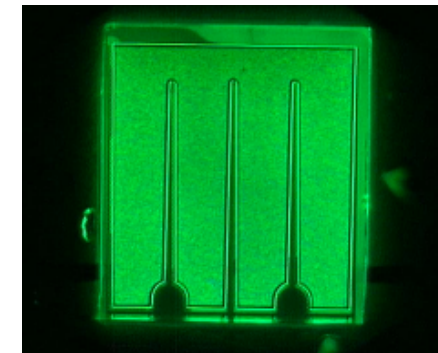
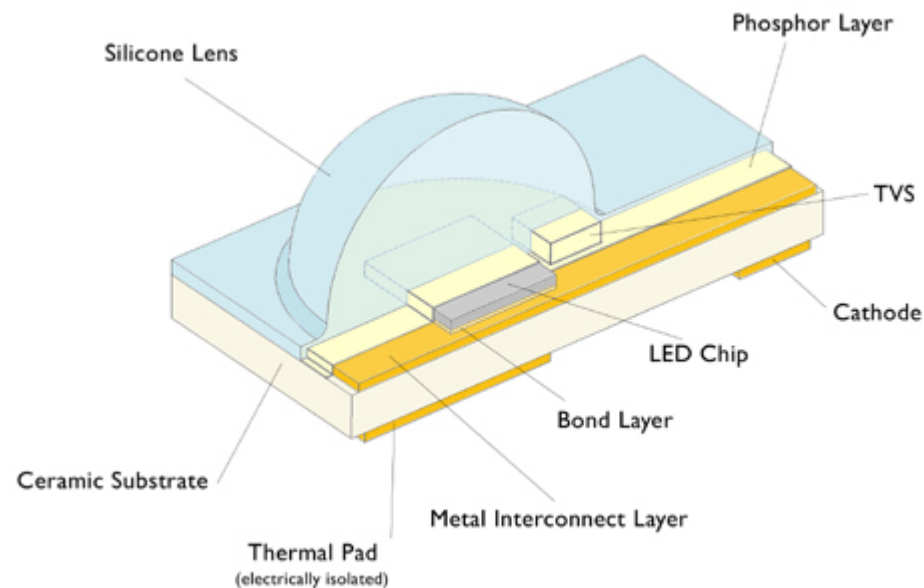
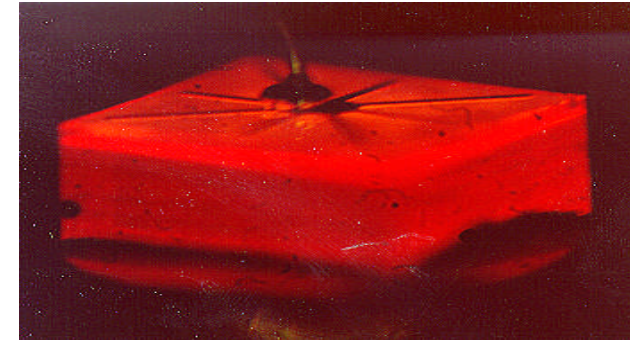


	Traditional Lighting	LEDs (LM 80)
Level	Lamp	Fixture (System)*
Rated Life	50% failure	Illumination: 70% LM Effects: 50% LM
Useful Life	<ul style="list-style-type: none"> • At Failure - Spot Relamp • Low LM, Color Shift, Failures - Group Relamp (40-80% of lifetime) 	By definition: <ul style="list-style-type: none"> • Illumination: 70% LM • Effects: 50% LM

* Replaceable modules in discussion

Fact : LEDs do NOT last forever

- Rare Failures of LED chips
- Most failures are LED package
 - Encapsulant
 - Die Attach



Lumen Maintenance

- LM 79-08 - Electrical and Photometric measurements of SSL products
 - Defines how to measure photometry and chromaticity
 - Fixture must be measured at 25C ambient, after stabilization, no seasoning (1000 hour “burn-in”)
 - Does not cover sampling methods to obtain representative results
 - This means that this standard does not say anything about product quality
- What does this mean to you?
 - If datasheet includes performance data without stating ambient temperature of measurement, then data is suspect

Lumen Maintenance

- LM 80 - Lumen depreciation of LED Light Sources
 - Criteria
 - L70 (hours): Time to 70% lumen maintenance for general illumination applications
 - L50 (hours): Time to 50% lumen maintenance for accent or decorative applications.
 - Testing:
 - Measure using complete SSL system
 - Defines LM measurement standards for LED suppliers
 - Standard suggests listing LM for the different temperatures so end users can see effects of temp.
 - Does not cover sampling methods to obtain representative results, just indicates results must be representative
 - This means that this standard does not say anything about product quality

Lumen Maintenance

- What does this mean to you?
 - In combination with LM 79-08, data should be reported to L50 or L70 (depending on application) measured at more than one ambient temperature
 - If not reported in compliance with these standards then data is suspect

Lumen Maintenance

- Use the data appropriate to your application
- Challenge Manufacturers to validate their products
 - What were their design conditions, i.e. max temperature at target lumen maintenance?
 - What is their expected performance at different ambient temperatures?

Undercounter Light (in hrs)			
	L ₅₀	L ₇₀	Power supply
25°C	n/a	55,000	84,000
50°C	n/a	31,000	24,000

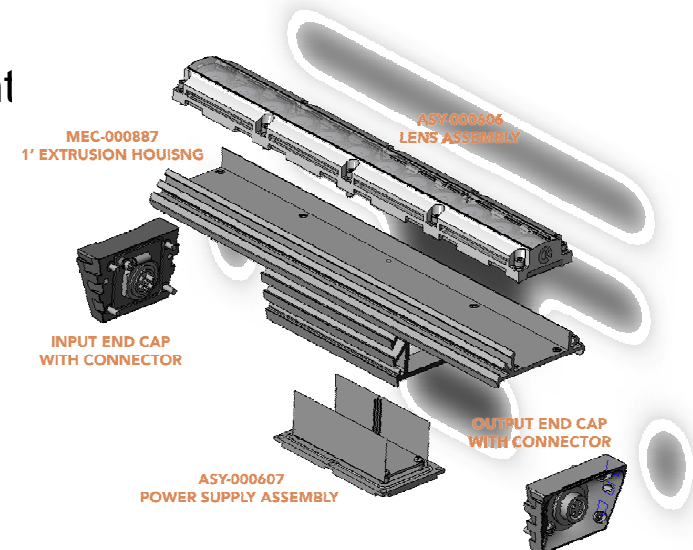
High output Projection Luminaire		
Warm	L ₅₀	L ₇₀
25°C	100,000+	48,000
50°C	75,000	34,500
Cool	L ₅₀	L ₇₀
25°C	100,000+	72,000
50°C	75,000	34,500
Full	L ₅₀	L ₇₀
25°C	100,000+	46,000
50°C	75,000	26,000

Questions for Manufacturers

- How does manufacturer define lifetime? How is it measured?
- Does the quoted lifetime include the electronics and other components needed to drive the LED source?
- Are all the photometrics measured by 3rd party, certified test lab? Do the measurements comply with IESNA LM-79-08?
- What is the maximum ambient temperature under which the fixture can operate and achieve rated life?
- Does the fixture have any special features for heat sinking / thermal management
- What warranty is offered by the manufacturer?
- If multiple white light fixtures are used on a project, are color points among them adequately matched?
- How do optics affect system efficiency?
- Does the proposal for my job include all of the necessary components to operate the LED fixtures?

Standards: Lifetime of LEDs vs. Traditional Lighting

- Reliability of the system is what matters
 - LEDs are likely not the limiting device
- High reliability systems result from:
 - Design
 - Fabrication / Assembly
 - Test / Burn-In
 - Field (RMA)
 - Testing Testing Testing
- Test beyond limits. Test. Test. Test. DVT.
 - Thermally cycle for weeks and mont
 - HALT testing
 - Leak tests
 - Vibration testing
 - Power disturbance, ESD etc



Standards: System Efficacy

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TECH NEWS - STRAIGHT FROM ASIA

Tech-On!

Updated: March 18, 2008 19:15 (Tokyo)

SCREEN

New Scrub

[HOME](#) > Nichia Unveils White LED with 150 lm/W Luminous Ef...

Nichia Unveils White LED with 150 lm/W Luminous Efficiency

Dec 21, 2006 16:39

Satoshi Ookubo, Nikkei Electronics

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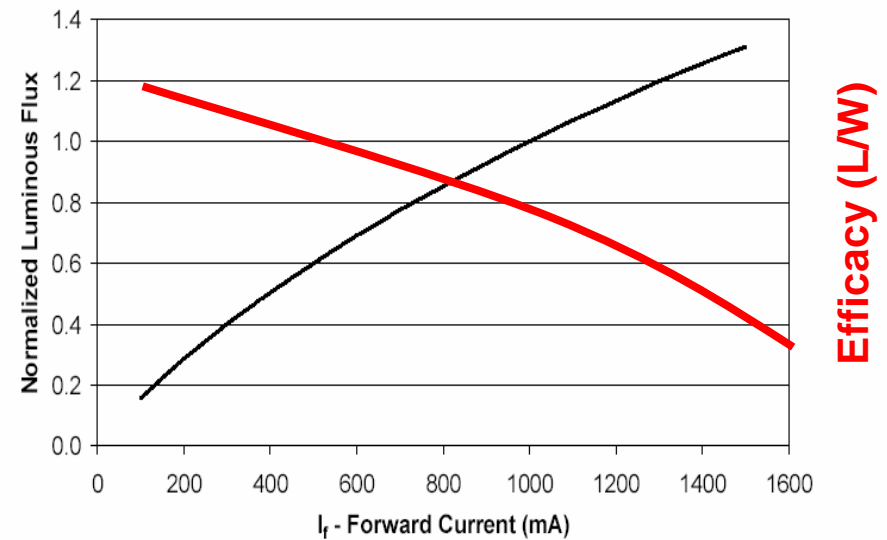
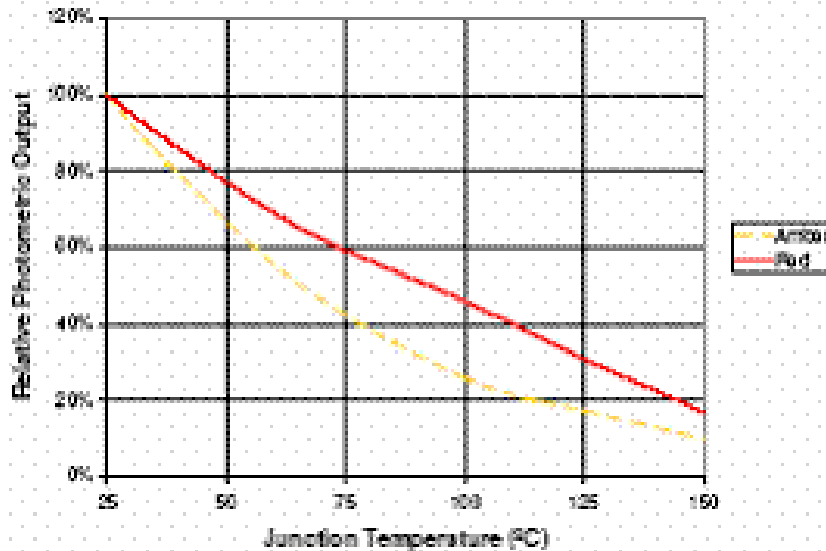
[del.icio.us](#)



Demonstration using nine pieces of the latest white LEDs: a luminous flux of 90 lm was achieved at an

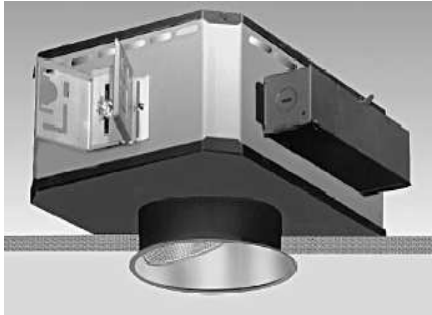
Standards: System Efficacy

- Performance is published at 25°C
- LEDs lose output with increasing temperature or current



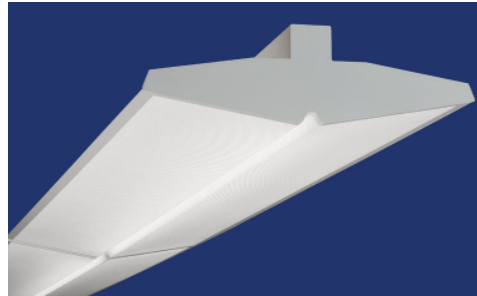
Standards: System Efficacy

Recessed Downlight



Input lpw: 72
 Losses: 67%
Output lpw: 24

Direct/Indirect Pendant



Input lpw: 74
 Losses: 20%
Output lpw: 59

LED Downlight



Input lpw: 66
 Losses: 49%
Output lpw: 34

Indirect Troffer



Input lpw: 68
 Losses: 25%
Output lpw: 51

Source: Independent Testing

Asymmetric Wall Wash



Input lpw: 80
 Losses: 62%
Output lpw: 30.2

Standards: System Efficiency

US DOE's CALIPER Testing

Table 1. Pilot Round Test Partial Results¹

Photometrics based on LM-79 for <ul style="list-style-type: none"> • Complete luminaires • 25° C ambient temperature 	Light Output (lumens)	Luminaire Efficacy (lm/W)	Correlated Color Temperature (K)	Color Rendering Index
CPTP 06-01 Downlight² (manufacturer published LED luminous efficacy = 40 lm/W)	193	12.82	3012	70
CPTP 06-02 Under-cabinet Light (manufacturer published LED luminous efficacy = 55 lm/W)	166	16.07	<i>See note³</i>	
CPTP 06-03 Downlight (manufacturer published LED luminous efficacy = 45 lm/W)	298	19.3	2724	67.3
CPTP 06-04 Task Light (manufacturer published LED luminous efficacy = 36 lm/W)	114	11.6	<i>See note³</i>	
CPTP 07-35 Downlight (manufacturer's Published luminous efficacy = 40* lm/W)	553	36	3442	81
CPTP 07-36 Downlight (manufacturer's Published luminous efficacy = 28.6* lm/W)	133	30.5	2767	70

*Alpha samples

Standards: Light Quality

- Lighting Artifacts
 - Socket shadows
 - Fringing
 - Color variations & poor CRI
 - Striations



Standards: Light Quality

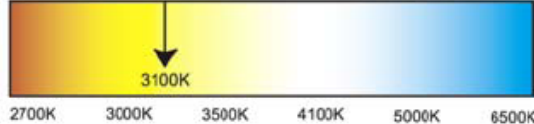
- New SSL Standards for CCT
 - ANSI C78.377
 - Required for Energy Star

- LED Manufacturers Energy Star
 - Cree
 - Nichia
 - Philips Lumileds
 - Osram

ANSI / Energy Star CCTs	
<u>Nominal CCT⁽¹⁾</u>	<u>CCT (K)</u>
2700 K	2725 ± 145
3000 K	3045 ± 175
3500 K	3465 ± 245
4000 K	3985 ± 275
4500 K	4503 ± 243
5000 K	5028 ± 283
5700 K	5665 ± 355
6500 K	6530 ± 510

Standards: Light Quality

- NGLIA / DOE Product Quality
 - Proposed for 2009
 - To Prevent market mistakes made with CFLi
 - Lighting facts label
- <http://www.lighting-facts.com/>
 - For more information

Lighting Facts™	
Solid State Lighting Luminaire	
Lumens	840 lm
Lumens per Watt	93 lpw
Watts at 120VAC	9W
Color	
Correlated Color Temperature (CCT)	3100K
Color Rendering Index (CRI, R _a)	87
	
<small>Efficacy and lumen output are reported according to IESNA LM-79-2008</small>	

The Lighting Facts label, designed to go on the product, packaging, or literature, provides a simple summary of product performance data.

Factors to Consider

LED Myths....and Realities

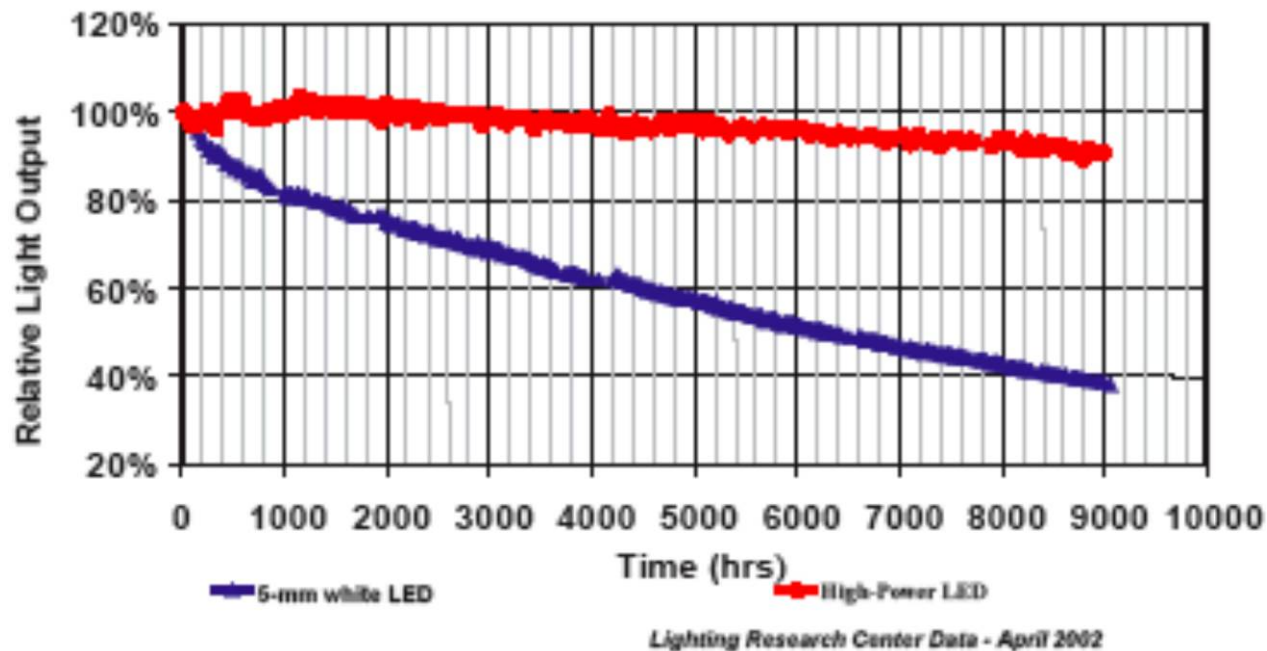
Myth 1: LEDs last forever



100,000 HOUR
SUPER LONG LIFE
SAVES ENERGY

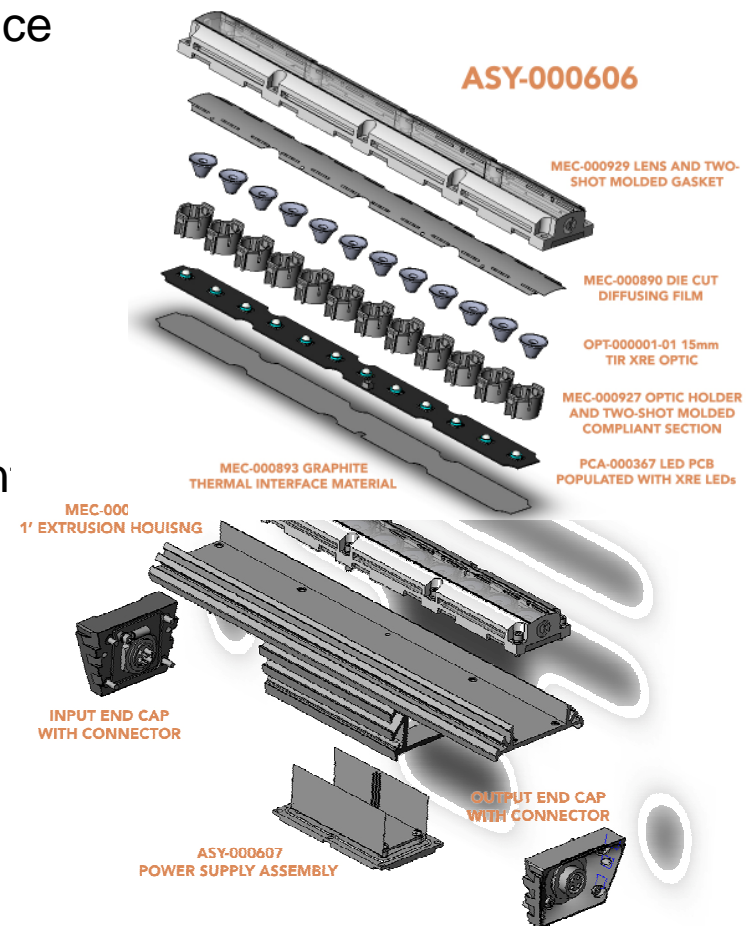
Fact 1: LEDs do NOT last forever

- LEDs do fade over time (Lumen Maintenance)
- How is Lifetime defined?
 - New standard, LM-79, out now



Fact 1: Reliability is a System Thing

- Reliability of the system is what matters
 - LEDs are likely not the limiting device
- High reliability systems result from:
 - Design
 - Fabrication / Assembly
 - Test / Burn-In
 - Field (RMA)
 - Testing Testing Testing
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Myth 2: LEDs generate no heat

Hotel "Kemi Showcastle", Finland

"...virtually no heat..."

"...almost no heat generated..."

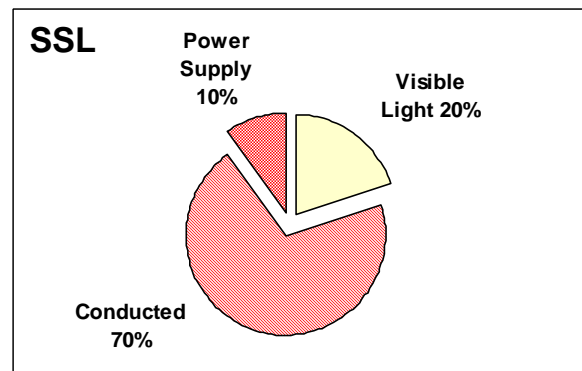
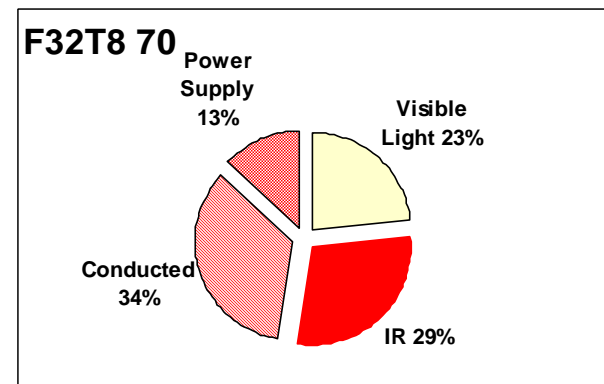
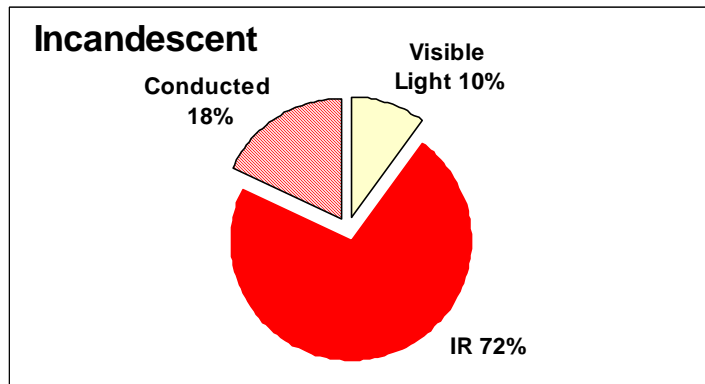
"...your safety and comfort are ensured since the light's LEDs bulbs produce no heat..."



"...LEDs give off virtually no heat so they are ideal for use in small confined areas..."

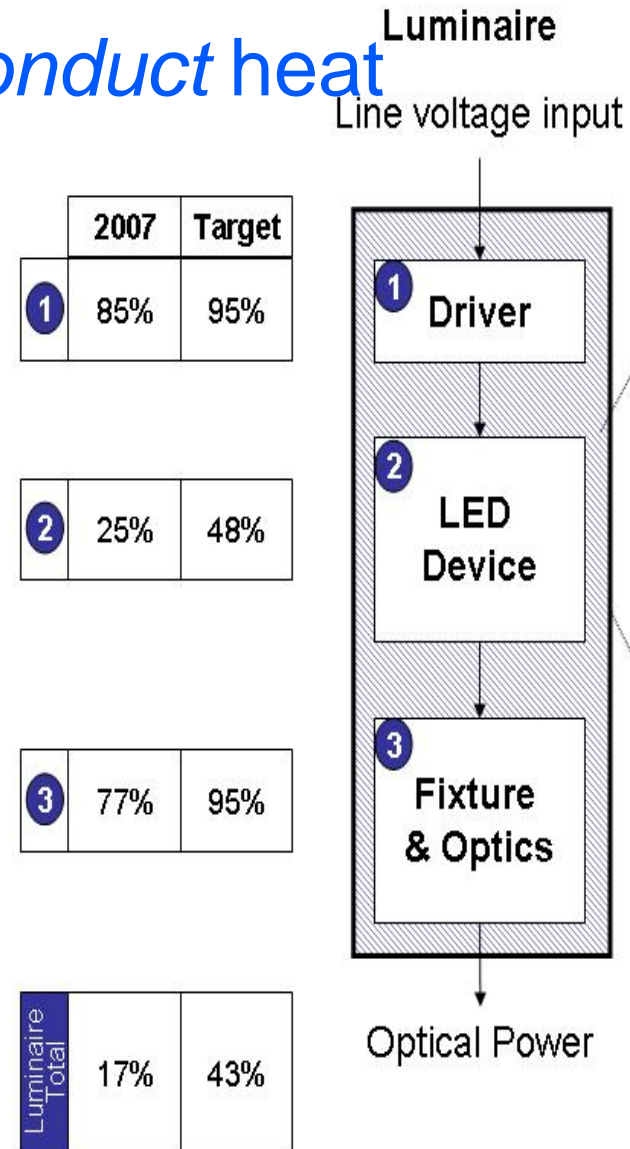
Fact 2: LEDs Generate Heat but do not Radiate Heat

- LEDs and the system are not 100% efficient
- There is little heat in the beam of light from the LED
 - LEDs only radiate energy in the visible spectrum



Fact 2: LED Systems *conduct* heat

- LED systems are not 100% efficient
- System Efficacy =
 $\text{Power Supply} \times \text{LED} \times \text{Optic}$
 $90\% \times 27\% \times 80\% = 20\%$
- For a 10W System:
 $10\text{W} \times 20\% =$
 2 Watts Optical
 8W thermal losses

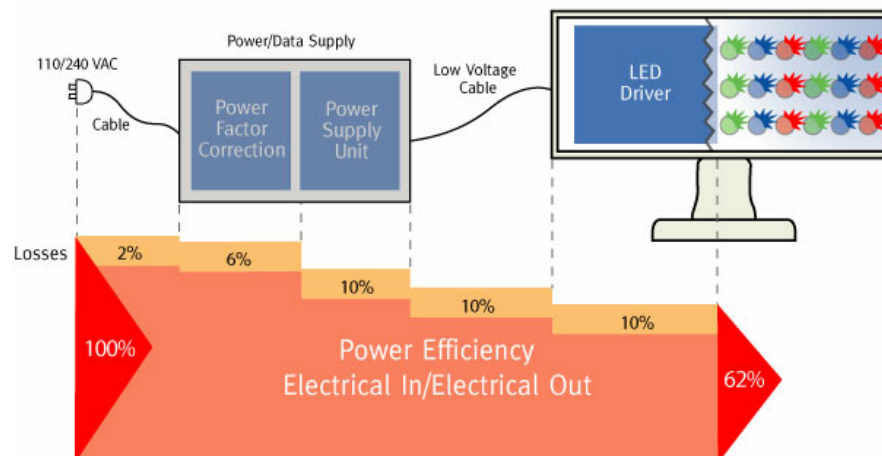


Fact 2: LEDs do generate heat

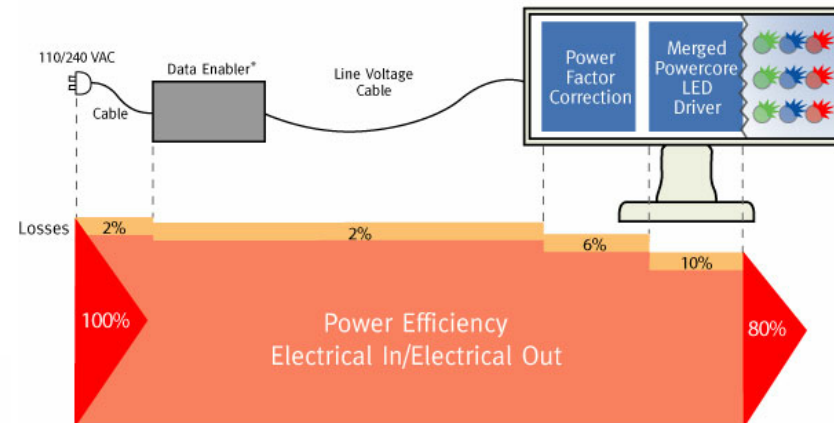
Systems need to be optimized for efficacy

- Thermal
- Power
 - Line Voltage
 - No off-state power

Low Voltage System



Powercore System



*Minimum communications electronics fixed overhead not included.

Myth 3: White LEDs produce 150LPW so the system must be 150LPW!

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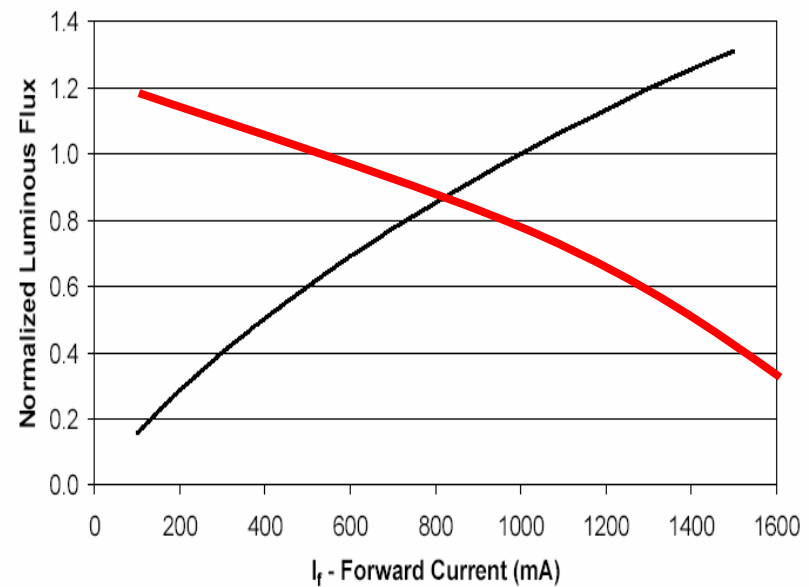
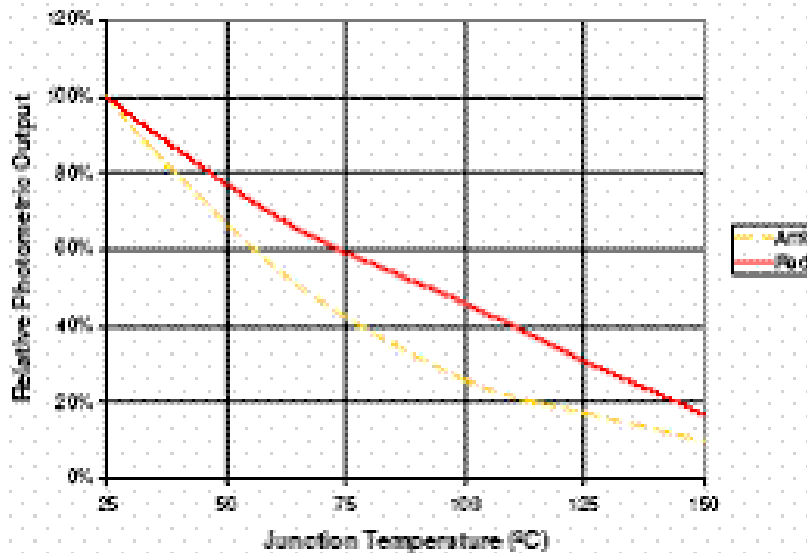
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Demonstration using nine pieces of the latest white LEDs: a luminous flux of 90 lm was achieved at an

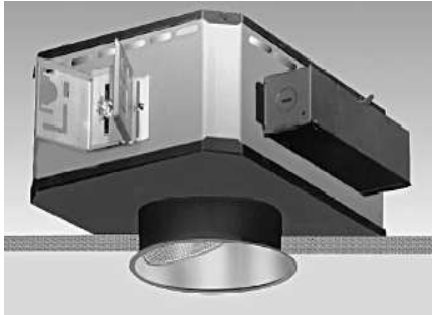
Fact 3: LEDs Lose Efficacy

- Performance is published at 25°C
- LEDs lose output with increasing temperature or current



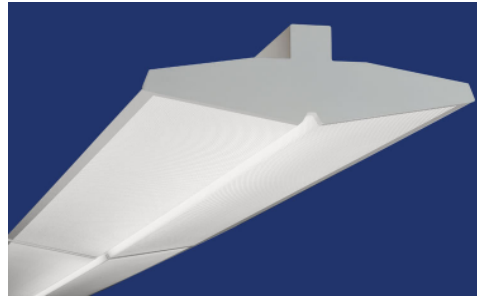
Fact 3: All Systems have Losses

Recessed Downlight



Input lpw: 72
 Losses: 67%
Output lpw: 24

Direct/Indirect Pendant



Input lpw: 74
 Losses: 20%
Output lpw: 59

eW Downlight



Input lpw: 66
 Losses: 49%
Output lpw: 34

Indirect Troffer



Input lpw: 68
 Losses: 25%
Output lpw: 51

Source: Independent Testing

Asymmetric Wall Wash



Input lpw: 80
 Losses: 62%
Output lpw: 30.2

Myth 4: 3W LEDs are Brighter than 1W LEDs

Light Wave LX^{WHT}

Technical Specifications



HOUSING:

- Aluminum
- Powder coat grey finish
- IP66 rating (Dry, Wet, Damp)

UNIT DIMENSIONS (L X W X H):

- 137mm (5.39") x 178mm (7.00") x 239mm (9.39")

UNIT WEIGHT:

- 3.50kg (7.71 lbs)

LEADER CABLE:

- 1.83 m (6.0 ft)
- High voltage, plenum rated

SOURCE:

- Selected High Performance 3-watt LED

LIFE EXPECTANCY:

- 75,000+ hours

BEAM SPREADS:

- 8, 24, 48 and 120 degree

LENS:

- Clear Lexan® lens

COLOR TEMPERATURE:

- 3200°K White (Warm White)
- 5500°K White (Cool White)

FIXTURE POWER REQUIREMENTS:

- 24VDC

FIXTURE OUTPUT:

- 108W

POWER CONSUMPTION:

- 119W

POWER SUPPLY (SOLD SEPARATELY):

- 1.83 m (6.0 ft)

- High voltage, plenum rated

SOURCE:

- Selected High Performance 3-watt LED

LIFE EXPECTANCY:

- 75,000+ hours

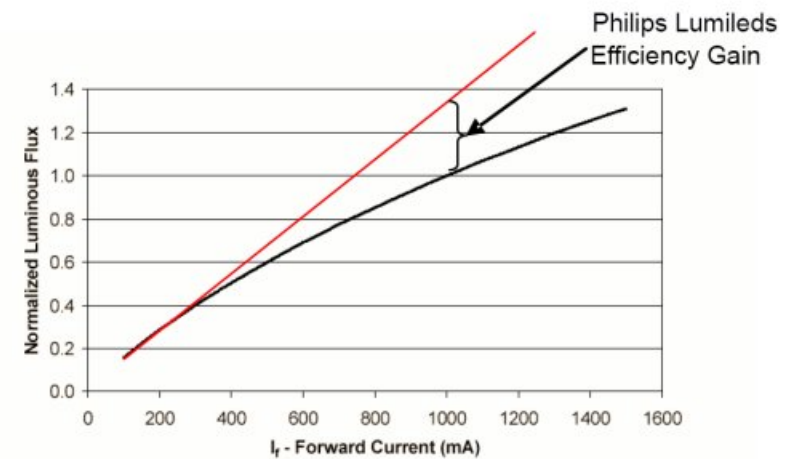
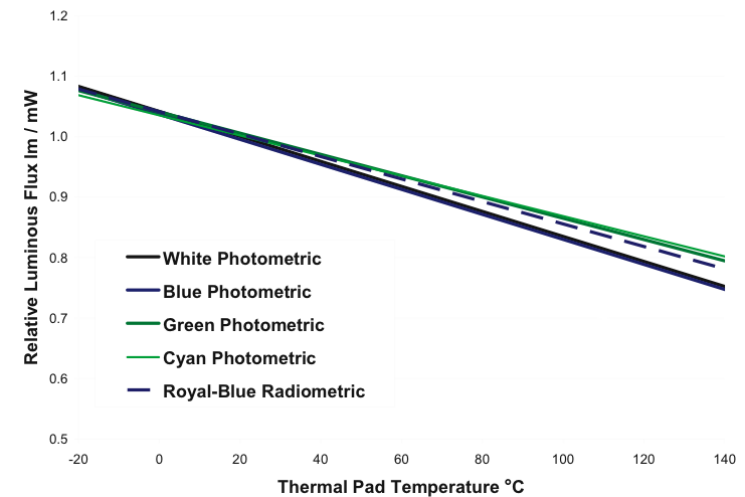
BEAM SPREADS:

- 8, 24, 48 and 120 degree

Fact 4: Light Output is not about LED power ratings

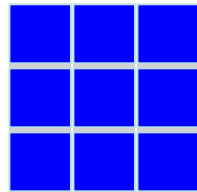
- More power ► more heat ► less light
- Good design hits the “sweet” spot of output, efficacy, and initial cost
- Six ½ watt LEDs may produce far more light output than a single 3 watt LED

Cool-White, Neutral-White, Warm-White, Green, Cyan, Blue and Royal-Blue at Test Current.



Fact 4: Light output is not about LED power ratings

- Higher power package ► higher efficiency and output *if the system is designed correctly*
- *System* includes drivers, optics, thermal, mechanics and LEDs



$V = 31.5V$
 Drive: $31.5V @ 110mA \approx 3.5W$
 Driver efficiency: 94%

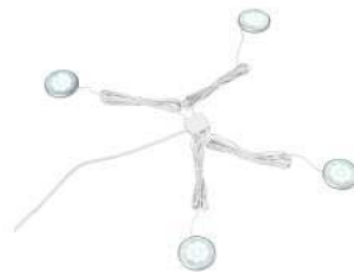
Vs.



$V = 3.5V$
 Drive: $3.5V @ 1A = 3.5W$
 Driver efficiency: 80%

Myth 5: LEDs are not Bright Enough for Illumination

IKEA® UNITED STATES



DIODER

Multipurpose lighting

color
white

Price reflects the options selected above

\$39.99
/ 4 pack

Product information

Key Features

- * Emits low heat; can be used in small spaces, like inside a cabinet or behind a wall-mounted TV.
- * Built-in light diodes with 50 times longer life than normal bulbs; no need to buy separately.

Designer:

IKEA of Sweden

Product Dimensions

Diameter: 2 "
Package quantity: 4 pack

Diameter: 5.8 cm
Package quantity: 4 pack

Good To Know

Light diodes are not replaceable; diode life approx. 50,000 hours.
Transformer electronic, fixed plug-in.
Light diodes are integrated into each light disc.
Mounting screws and double-sided tape included.
Includes: 4 light disc (dia. 2 1/4") with wires (length 2.5 yds) for connection between light disc and junction box, 1 junction box and 1 connection cord (length 2.5 yds).

Product Description & Measurements

Polycarbonate plastic

Fact 5: LED Systems are Suitable for Illumination

Case Study – MIT’s Health Services Center, Boston, MA

- Application: Alcove Lighting
- Install date: 2-08
- Traditional Lighting: Cold cathode
- New Lighting: LED Cove
- Energy Savings:
 - Cold cathode: 12W/ft
 - SSL 4.5W/ft
 - Savings 7.5W/ft (62.5%)



Fact 5: LED Systems are Suitable for Illumination

Case Study – Old North Church, Boston, MA

- Application: Niche / Cove
- Lighting Designer: Lana Nathe, Light Insight
- Install date: 2-08
- Traditional Lighting: Linear Incandescent
- New Lighting: LED Cove
- Energy Savings:

– Linear Incandescent	30 W/ft
– SSL	<u>4.5 W/ft</u>
– Savings	25.4 W/ft (85%)



Case Study: LED Systems for Illumination

Case Study – Boathouse Row, Philadelphia

- Application: Architectural
- Install date: 6-05
- Traditional Lighting: Incandescent
- New Lighting: iColor Flex SL
- Energy Savings:
 - Incandescent: \$8000/yr
 - SSL \$1000/yr
 - Savings \$7000/yr (87%)

- Maintenance Savings: \$50K/yr



Photo Credit:
© Jacques-Jean Tiziou www.jjtiziou.net

Case Study: LED Systems for Illumination

Case Study – LAX Airport, Los Angeles, CA

- Application: Architectural
- Install date: 3-06
- Traditional Lighting: HID
- New Lighting: ColorBlast
- Energy Savings:
 - HID: \$73K/yr
 - SSL \$18K/yr
 - Savings \$55K/yr (75%)
- Maintenance Savings: \$980K over the life of the system



Kinetic Light Installation by Artist Paul Tzanetopoulos
 Photo Credit: Los Angeles World Airports

New Applications are Emerging

- Office Lighting
 - Downlights
 - Pendants

- Lamp Replacements
 - MR16s, GU10s
 - PARs

- Outdoor Lighting
 - Street / Parking Lot
 - Bollards
 - Parking Garage

Daywave – office luminaire



LED Downlight Case Study for Emerging Applications



LED Downlight Product

- The product was developed to compete against surface mount compact fluorescent downlights



Diskus



Surface Circlet



CFL Lamp-X-Baffle



LiteForms



BAFLUX



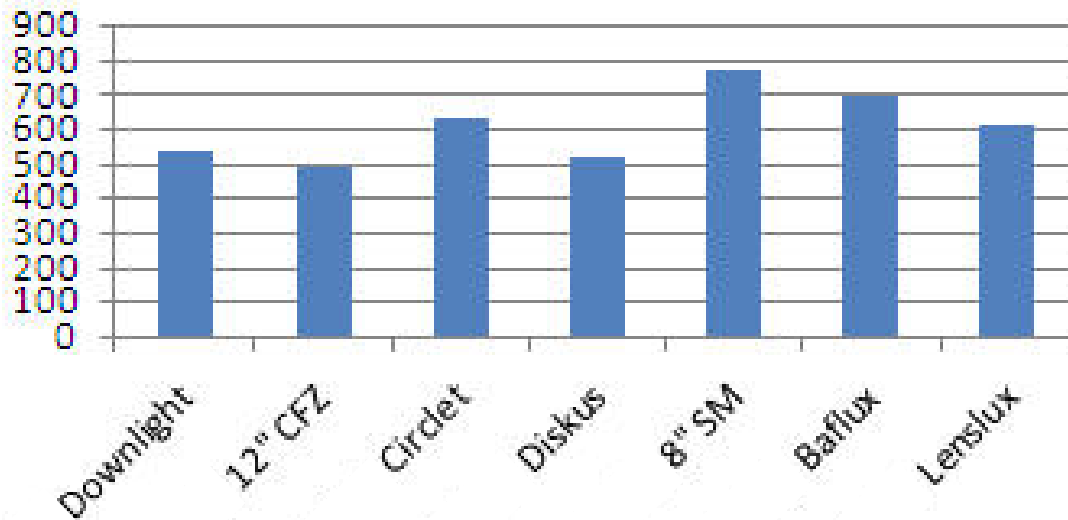
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Performance Comparison - Results

Product	Average FC	Max FC
Baflux	12	15
LED Downlight 65-deg. 4000K	12	17
LED Downlight 65-deg. 2700K	10	15
CFL Downlight <6" apperture (NLPIP)	12	12
CFL Downlight 6-7" apperture (NLPIP)	12	12

Performance Comparison

Fixture Lumen Output



- Average output is 605 lm
- LED Downlight 65-deg. 4000K is 539 lm

Luminance versus Illuminance

- Lumens measure the perceived power or light emitted from a fixture. This is spec'd for the lamp.
- Foot-candles (lux) are a measure of illuminance, or the useful light incident on a surface. This is spec'd for the luminaire given a specific lamp.
- The IESNA has established guidelines for illuminance levels for specific applications
- eW Downlight 65 degree is suitable for Illuminance Category B
- eW Downlight 30 degree is suitable for Illuminance Category C

Performance Comparison

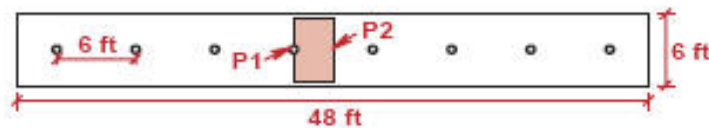


Specifier Reports

CFL Downlights

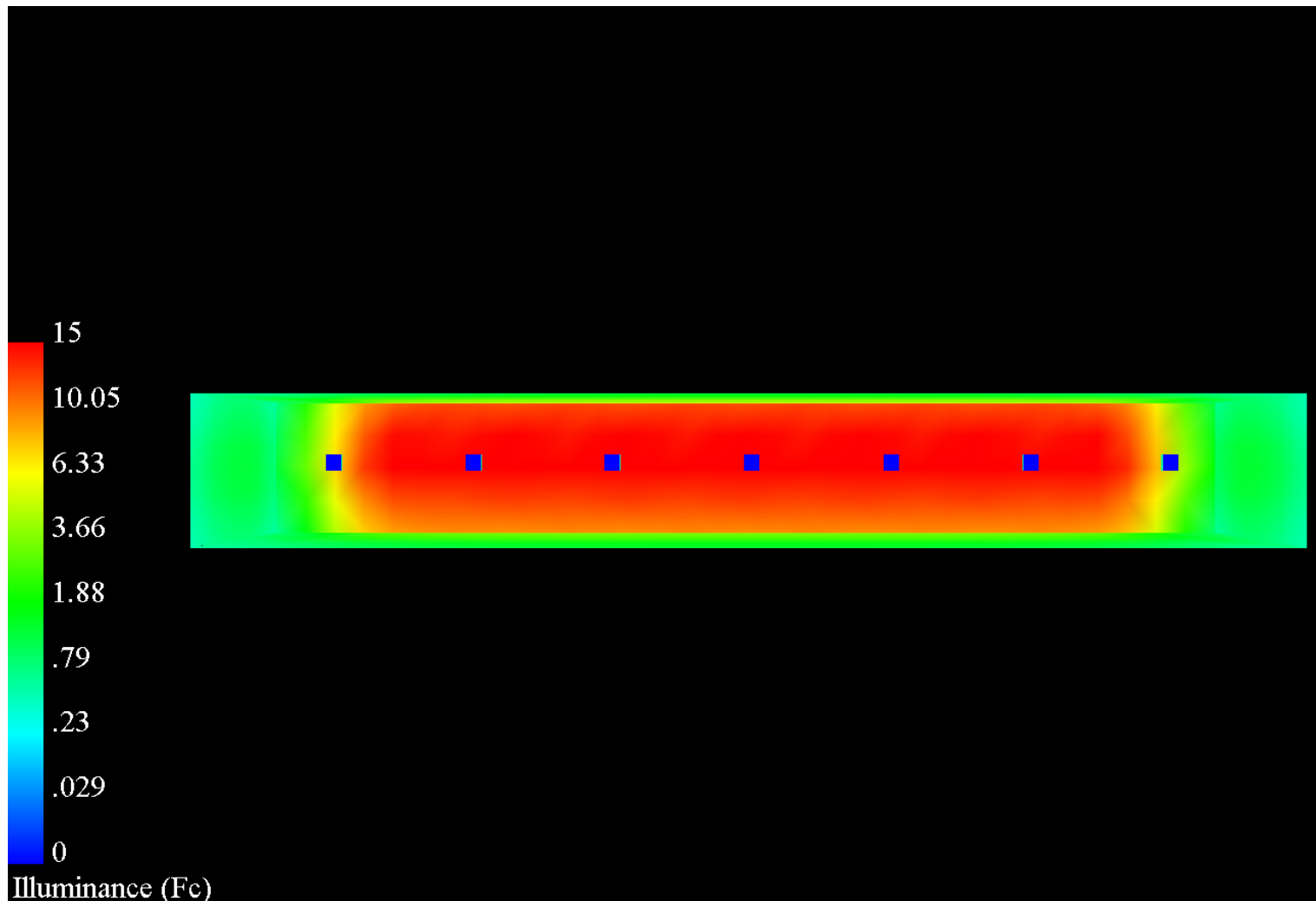
Downlight luminaires designed for compact fluorescent lamps

Figure 3. Luminaire Layout for Corridor

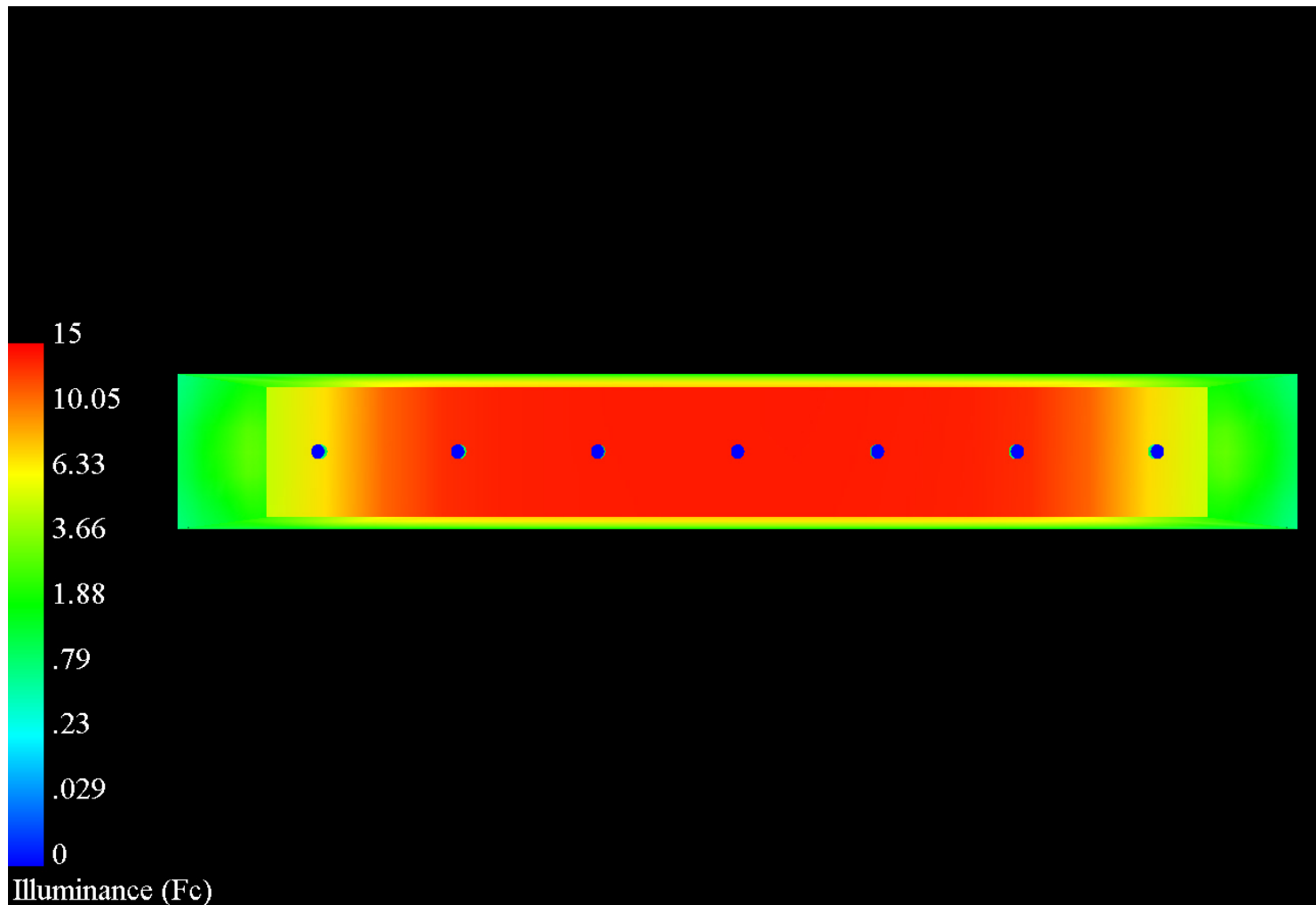


- luminaire location
- P1 and P2 points at which illuminance was calculated
- area used to calculate average illuminance (E_{avg})
- V viewing location and direction for VCP calculations

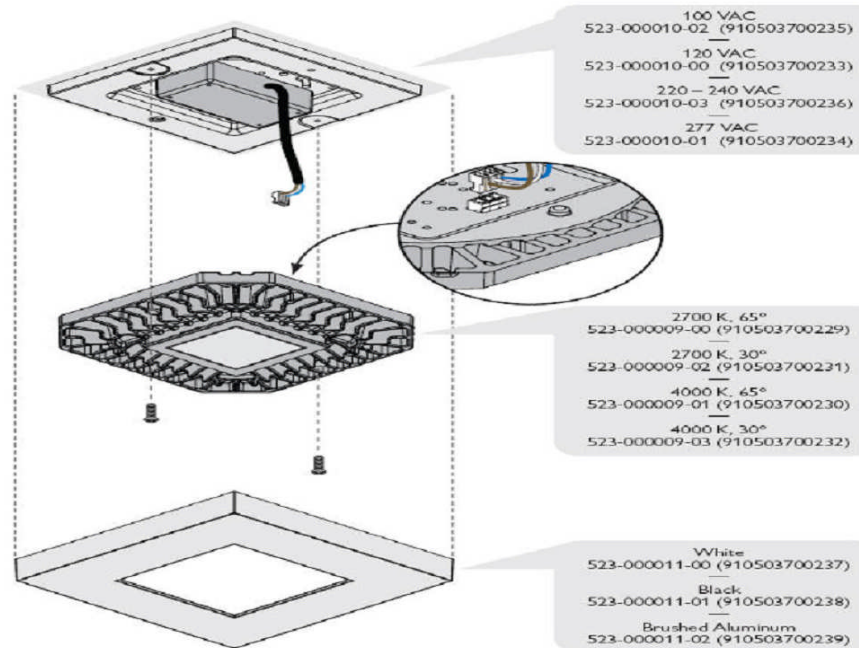
Performance Comparison – LED Downlight



Performance Comparison – Baflux



Is it relampable?



LED undercabinet



LED undercabinet

Question	Response
Low lumen output (157 & 185 lm/ft.)	<ul style="list-style-type: none"> •Delivered light matters •30 foot-candles at 2 feet
Point source reflection & shadowing	<ul style="list-style-type: none"> •Comparable to click-strip and xenon
First cost	<ul style="list-style-type: none"> •Lifetime cost is competitive
Output of similar T5 at 2 ft	<ul style="list-style-type: none"> • 1350 lm (675 lm/ft)

GENERAL CHARACTERISTICS

Lamp Type LED - Undercab

Wattage 10

Voltage 110 - 130 V

Rated Life 50,000 hrs*

PHOTOMETRIC CHARACTERISTICS

CRI 82

Initial Lumens 275

LPW- 27.5

Color Temperature 2800 K

GENERAL CHARACTERISTICS

Lamp Type T5 2'

Wattage 14

Voltage 110 - 127 V

Rated Life 35,000 hrs*

PHOTOMETRIC CHARACTERISTICS

CRI 85

Initial Lumens 1350

LPW 91

Color Temperature 3000 K

Luminance versus Illuminance

- Typical under counter application is 18" above workspace
- Same argument as with downlight, useful light matters
- Ew Profile 4000K @ 50 fc meets Category E
 - Kitchen counter critical seeing (e.g. cutting)
 - Casino high activity areas
 - Educational facility science laboratories
 - Food service displays
 - Hotel front desk
 - Industrial fine material processing, detail work
 - Industrial maintenance work

Luminance versus Illuminance

- Ew Profile 2700K @ 40 fc meets Category D
 - Health care facility general work areas, nursing stations
 - Hotel bathrooms
 - Library circulation desk, cataloguing, reading stacks
 - Merchandising sales transaction areas
 - Museum exhibit cases
 - General kitchen lighting
 - Industrial wrapping, packing and labeling
 - Ship navigation, control and switchboard areas
 - Baggage checking areas

LED undercabinet replaces T8's?



- Relampable? ROHS compliant...

LED Cove



LED Cove

Figure 2: Leader Cable and Terminator Attachment

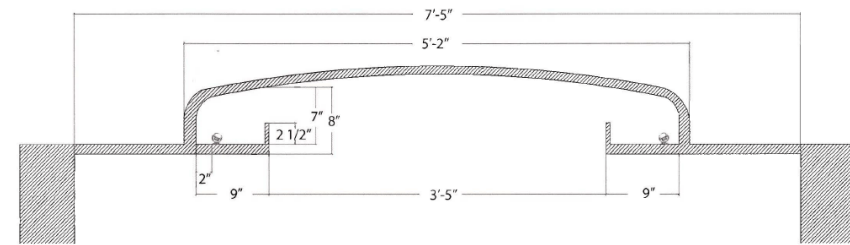
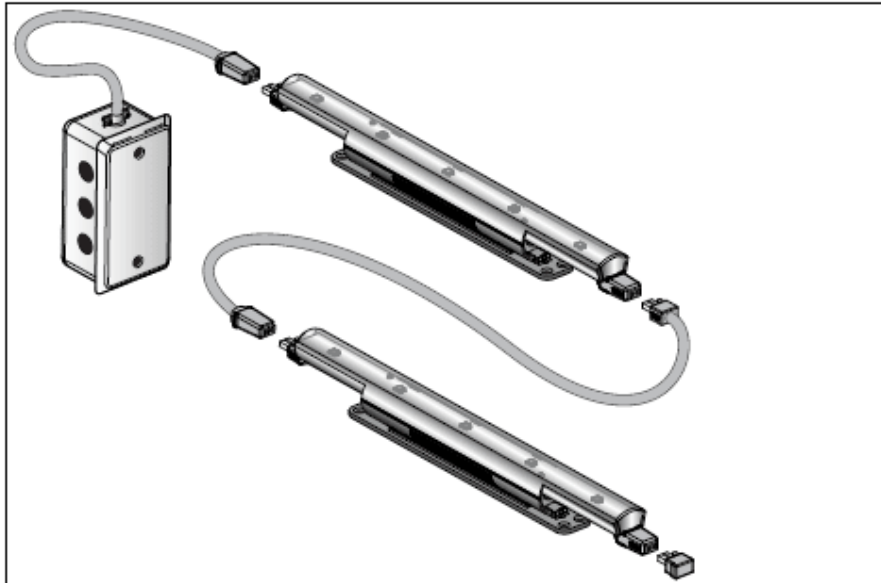
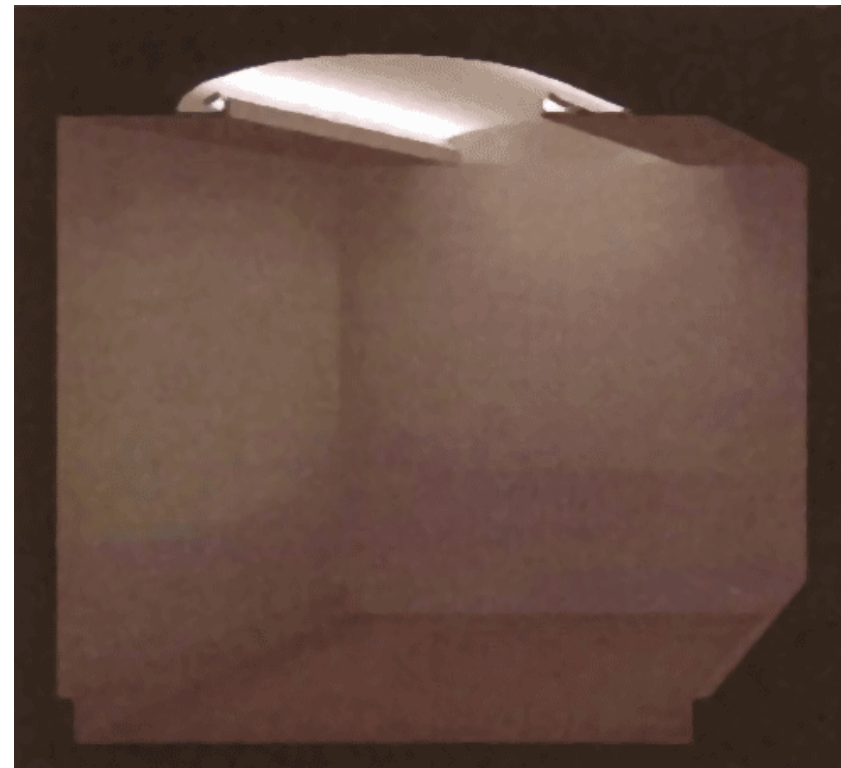
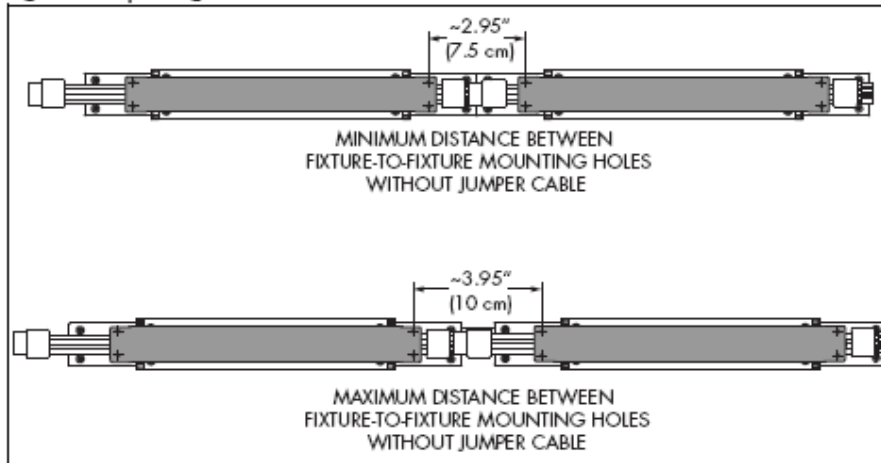


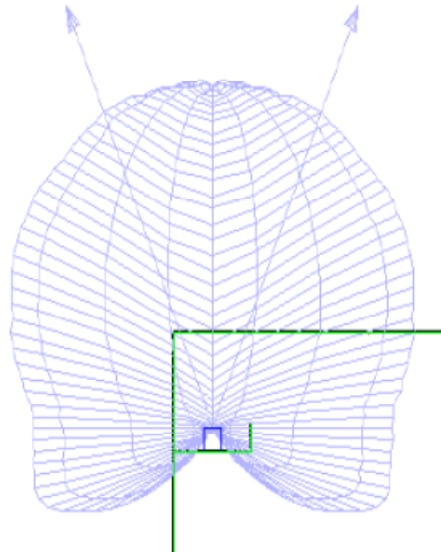
Figure 3: Spacing Between Interconnected Fixtures



Cove comparison of T8 to LED Cove

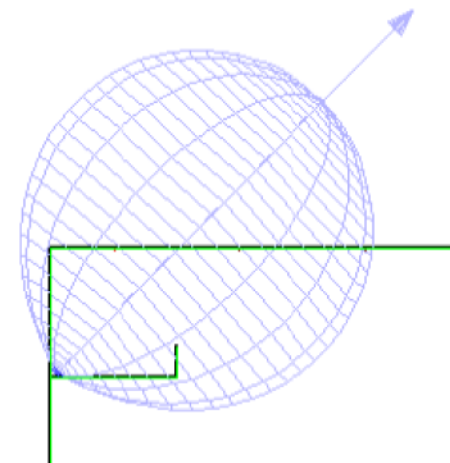
F32T8 Lamp

- 2800 lm lamp, 4 ft. length
- 700 lm/ft.
- Radiates 360 degrees
- Including all losses typically only ~85% of lumens leave fixture: $700 \times 0.85 = 595$ lm
- Throws light in all directions, a 120-deg. Slice would emit ~200 lm



LED Cove

- 177 lm fixture, 1 ft. length
- 177 lm/ft.
- Radiates 120 degrees
- If this fixture radiated 360 degrees, like fluorescent: $177 \times 3 = 531$ lm
- Rotatable housing puts light where it's needed



Projection Luminaires



Competitive Comparison for LED Projection Luminaire

Grade Mount Application

All fixtures aimed at a 5' x 35' wall at an 18 degree tilt with a surface reflectance of 0.8 and a 3' setback

Fixture	eW Blast Powercore 4000K Clear	Hydrell 7000 35CMT6	Kim Flood A	Kim Flood B	Lithonia Flood A	Lithonia Flood B
Power Consumption	50W	60W	50W	100W	25W	100W
Lumen Output	1,750	3,400	3,060	5,600	3,400	9,600
Average FC	8.8	7.2	6.4	6.5	6.5	13.7
Max FC	27.2	45	28.6	51.2	24.6	69.3

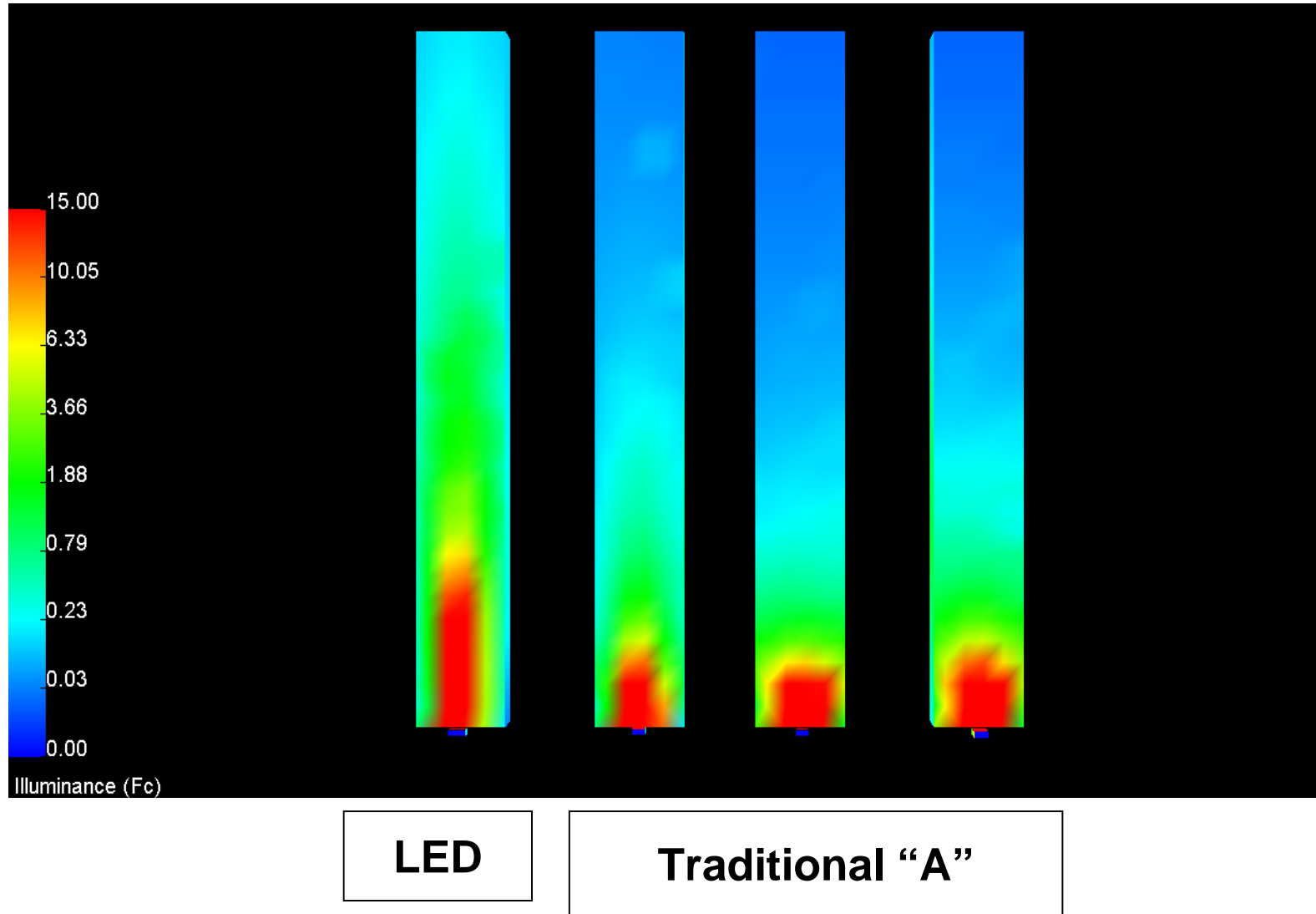
Wall Mount Application

All fixtures mounted at top of wall, aimed at a 5' x 35' wall at a 1 degree tilt with a surface reflectance of 0.8 and a 0' setback

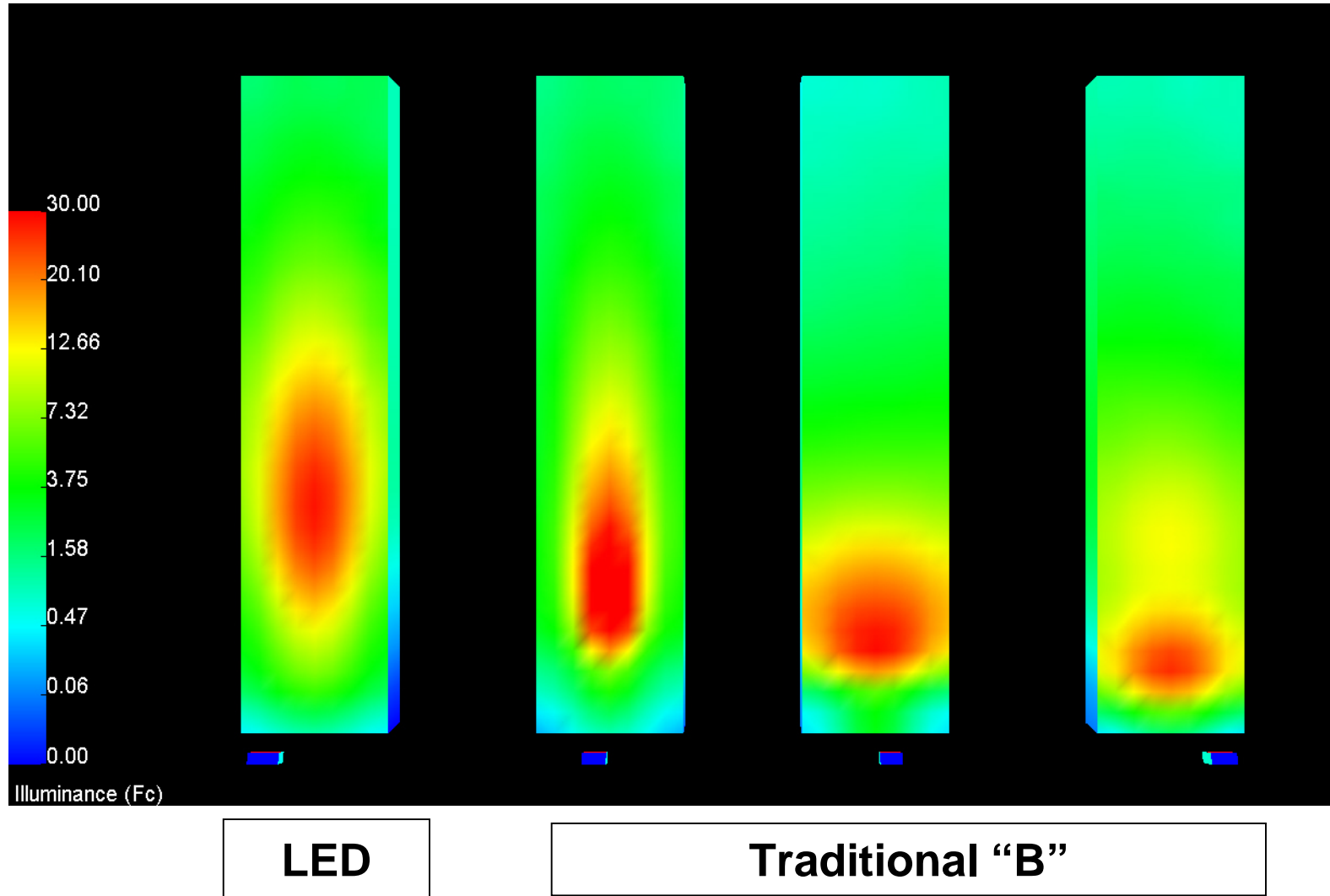
Fixture	eW Blast Powercore 4000K Frosted	Hydrell 7000 35CMT6	Kim Flood A	Kim Flood B	Lithonia Flood A	Lithonia Flood B
Power Consumption	50W	60W	50W	100W	25W	100W
Lumen Output	1,674	3,400	3,060	5,600	3,400	9,600
Average FC	5.2	3.8	4.95	7.9	4.8	16.2
Max FC	77.7	157	224	385	187	735

- Lumen output is lower than MH fixtures, but illuminance is comparable

Competitive Comparison



Competitive Comparison



Recent Installation – Customs House Tower, Boston

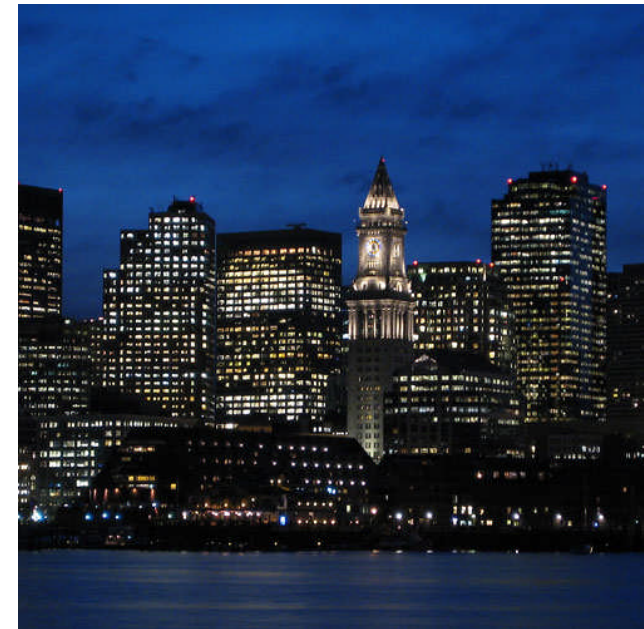
- 125 LED projection luminaires
- Tower had been dark for 20 years due to cost and maintenance related to conventional lighting alternatives



Before



After



After

Hotel Mock-up with LED projection Luminaire



Before

After

- LED fixtures deliver a white light glazing the property wall accenting the architectural features. The light is focused, so it washes the columns and does not illuminate the guest windows.
- 6x 50W LED luminaires replaced 3x 275W luminaires (i.e. 250W lamp + 25W ballast)
- It's the effect and not just the Lumens

Hotel Mock-up with Projected LED



Before



After

- Long Life
- Energy Savings
 - 6x 50W LED units replaced 3x 275W luminaires (i.e. 250W lamp + 25W ballast)
- Significantly less light pollution on guest windows
- More dramatic lighting effect (not just lumen comparison)

Competitive Comparison



GENERAL CHARACTERISTICS

Lamp Type Proj Lum.

Wattage 50

Voltage 110 – 240V

Rated Life 70,000 hrs*

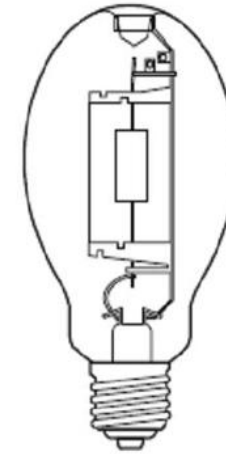
PHOTOMETRIC CHARACTERISTICS

CRI 82

Initial Lumens 1750

LPW 35

Color Temperature 2800 K



GENERAL CHARACTERISTICS

Lamp Type 150 w CMH

Wattage 150

Voltage 110 - 130 V

Rated Life hrs 20,000*

PHOTOMETRIC CHARACTERISTICS

CRI 85

- Initial Lumens 9375 avg
- LPW 62.5
- Color Temperature 3000 K

True Socket replacements



MR16's



GENERAL CHARACTERISTICS

Lamp Type LED MR16

Wattage 5

Voltage 12 VAC

Rated Life 50,000 hrs*

PHOTOMETRIC CHARACTERISTICS

CRI 70-76

Initial Lumens 40

LPW- 5

Color Temperature 2800 or 4200 K



GENERAL CHARACTERISTICS

Lamp Type MR16

Wattage 20

Voltage 12 VAC

Rated Life 3000 hrs*

PHOTOMETRIC CHARACTERISTICS

Initial Lumens 240

LPW- 12

Color Temperature 3000 K

PAR 20 and LED “replacement”

GENERAL CHARACTERISTICS

Lamp Type - PAR20 Halogen

Base Medium

Wattage 50

Voltage 110 - 130 V

Rated Life 3000

PHOTOMETRIC CHARACTERISTICS

Initial Lumens 520

LPW 10.5

Center Beam Candlepower (CBCP) 4000

Color Temperature 2700 K



GENERAL CHARACTERISTICS

Lamp Type LED - PAR Bulb PAR20

Base Medium

Wattage 7

Voltage 110 - 127 V

Rated Life 20,000 hrs*

PHOTOMETRIC CHARACTERISTICS

Initial Lumens 200

LPW 28.5

Center Beam Candlepower (CBCP) 1200

Color Temperature 3000 K



Ban the Bulb

Prototype PAR38

- 700+ lumens
- 90+ CRI
- 25° FWHM Beam
- 70+ lpw **system**
- **Available 2009**



Energy Independence & Security Act of 2007

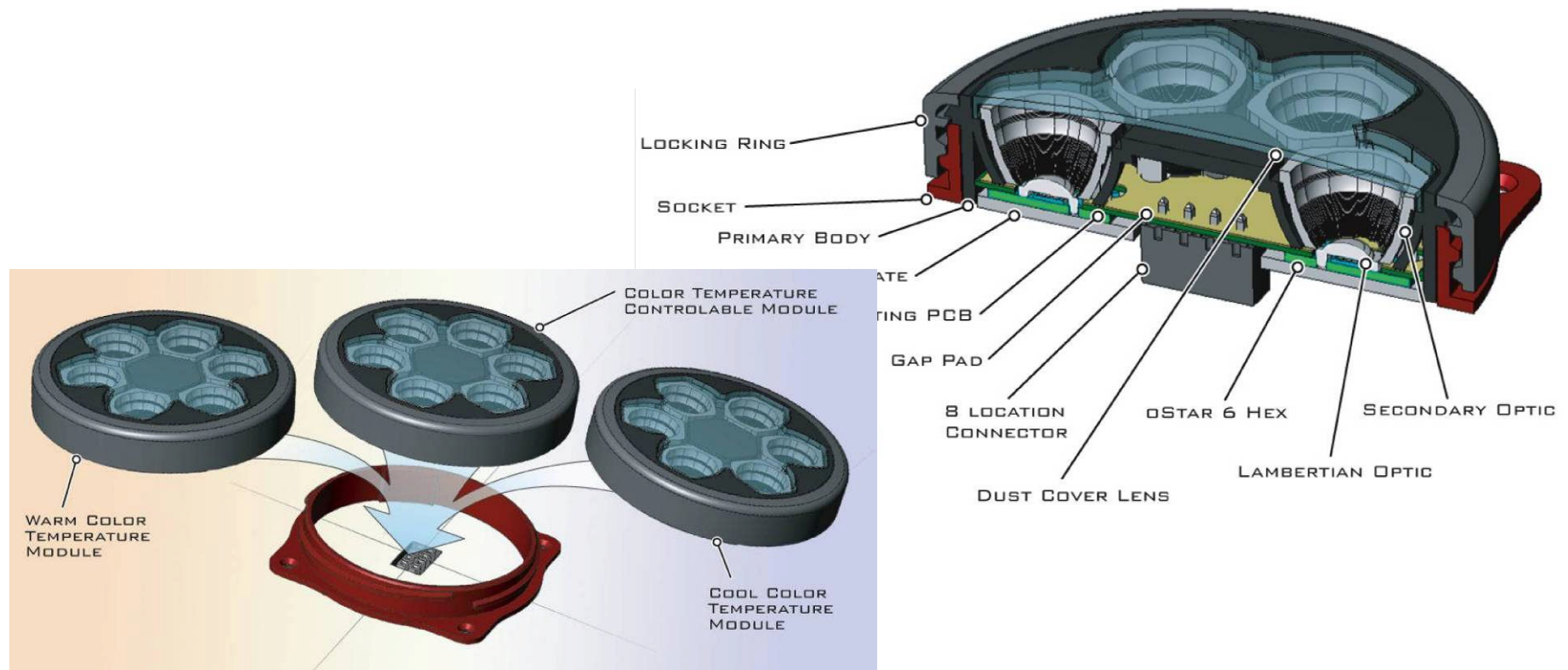
L[•]PRIZE™

- Bright Tomorrow Competition
 - DOE Sponsored
 - 60W Incandescent Replacement
 - \$10 Mil. Prize
 - Requirements:
 - 900 Lumens / 10W (90 LPW), \geq 90 CRI
 - 2000 Units
 - PAR 38
 - \$5 Mil Prize
 - Requirements:
 - 1350 lumens / 11W (123 LPW), \geq 90 CRI
 - 2000 Units



Fact 8: Replacement Options are in Discussion

- LEDs and component replacement
- Several fixtures designed already for serviceability
- Standards now being formed around replacement interconnects



PHILIPS

sense **and** simplicity