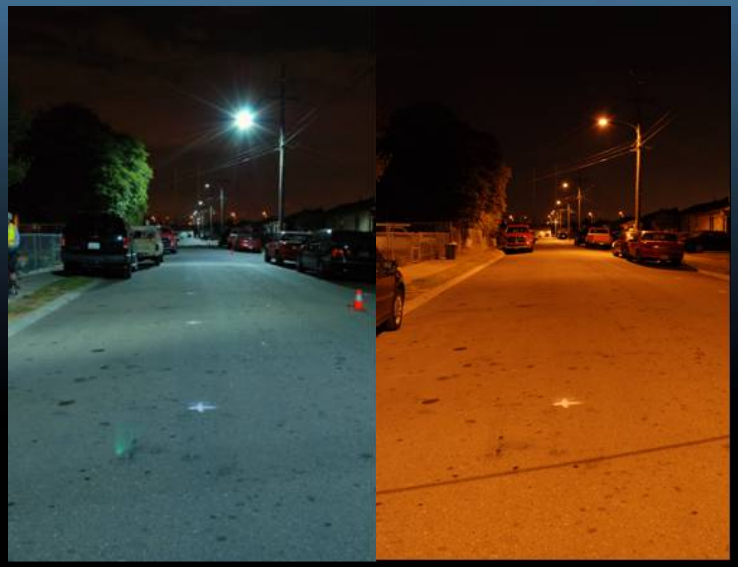
High Brightness White LEDs for General Illumination



THE EDGE™

Eric Haugaard
Director of Product Technology
Beta Lighting
www.BetaLED.com

High Efficiency White Light Sources Existing Technologies

- Most Popular Choices
  - Metal Halide (including Ceramic MH)
  - Fluorescent

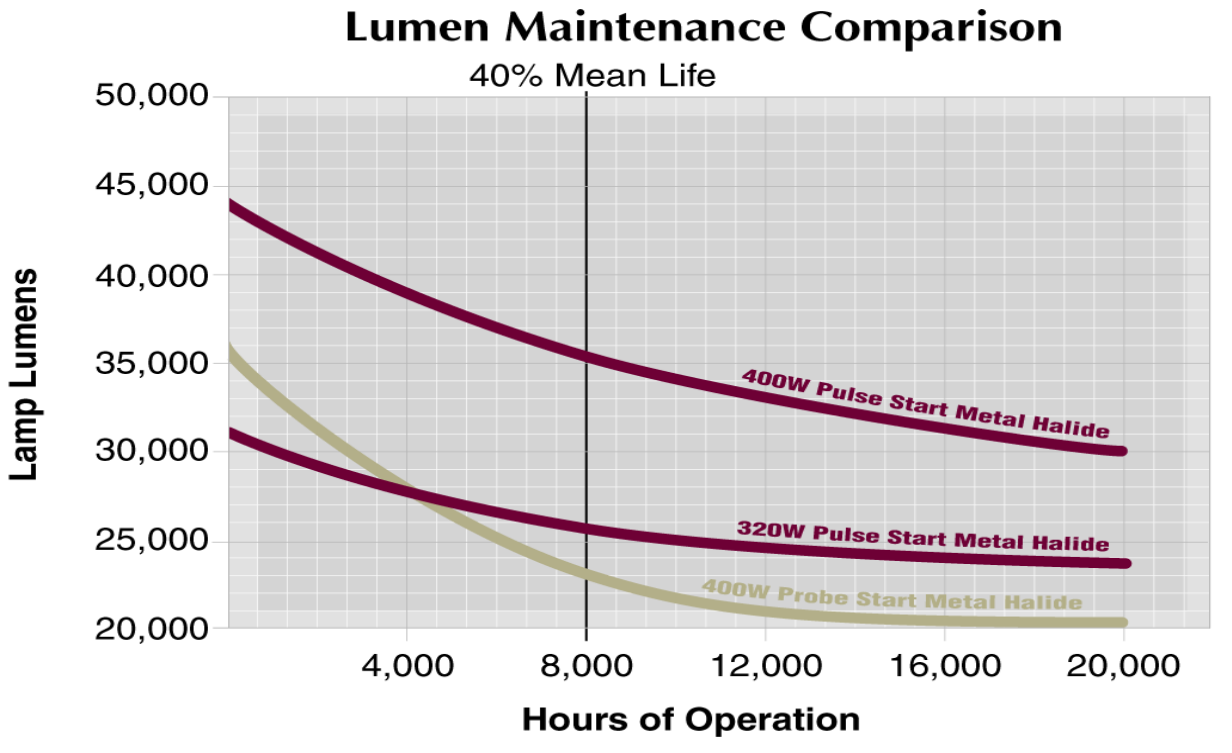
Metal Halide
General Characteristics

- High Efficacy (High Lumens per Watt)
- Relatively Thermally Insensitive
- Relatively High Heat Generation
- Good Opportunity for Optical Control
- Long Life
- Significant Lumen Depreciation Over Life
- Long Start-up and Re-strike Time
- Contains Mercury
- UV

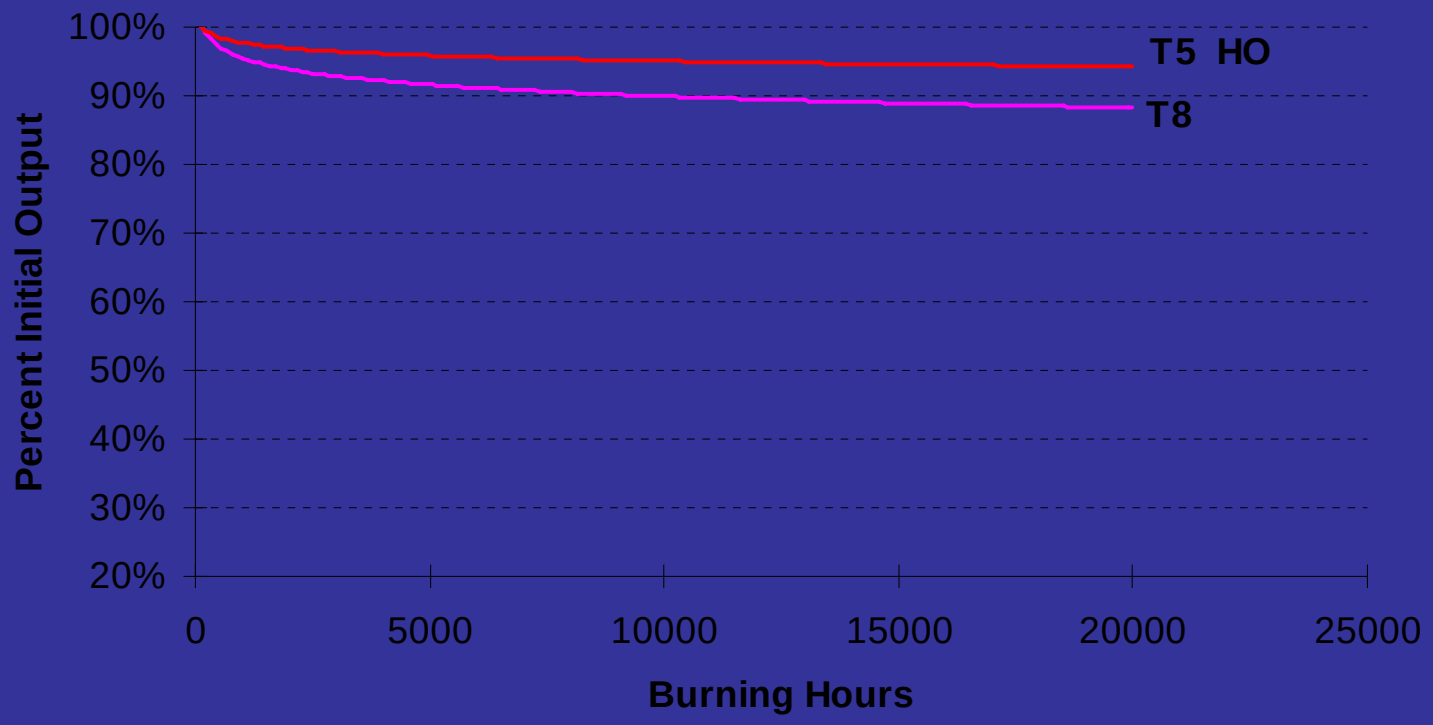
Fluorescent
General Characteristics

- High Efficacy
- Relatively Low Heat Generation
- Thermally Sensitive
- Optical Control Challenges
- Long Life
- Relatively Low Lumen Depreciation Over Life
- Instant On / Instant Re-strike
- Contains Mercury
- UV

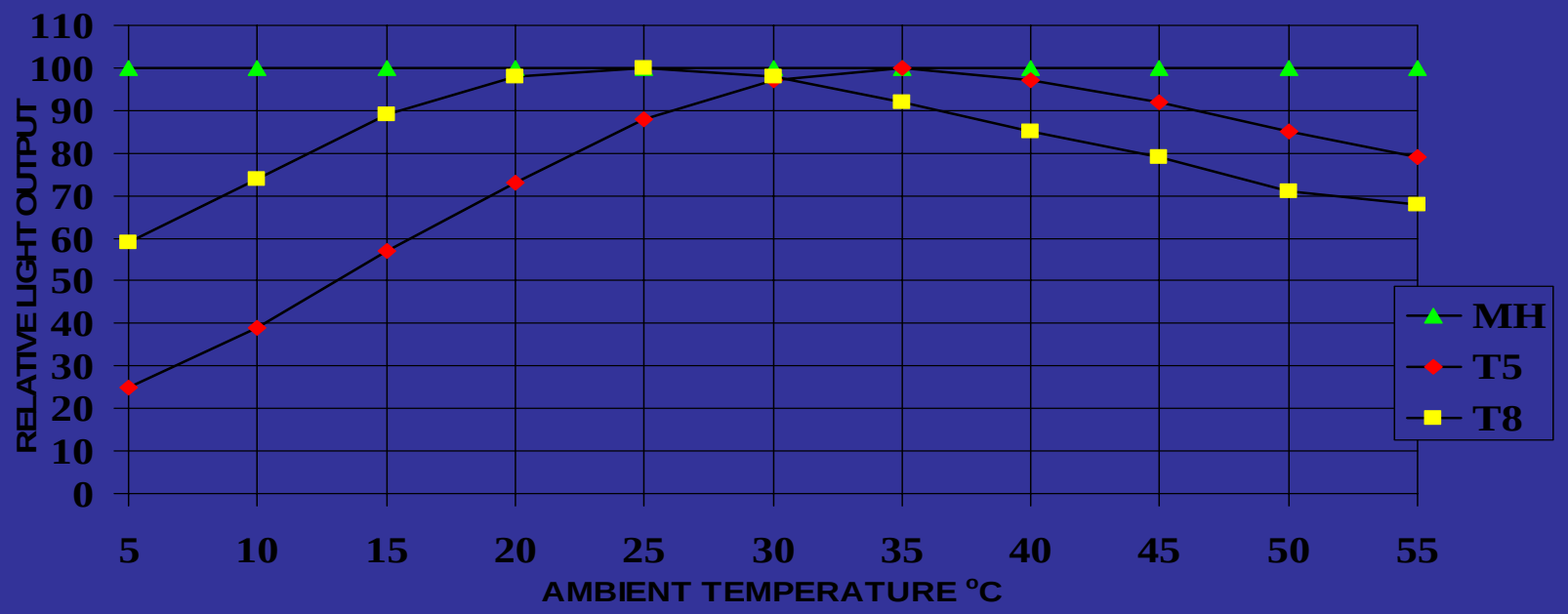
Metal Halide Lumen Maintenance



Linear Fluorescent T5 HO and T8 Lumen Maintenance



Temperature vs.. Output
T5 and T8 Fluorescent



Lighting Application Maintenance Factors *(Approximate)*

- Pulse Start Metal Halide (PSMH)
  - 0.75
    - Re-Lamp at 25% Lumen Depreciation

❖ *Requires Re-Lamping at 40% of Mean Life*

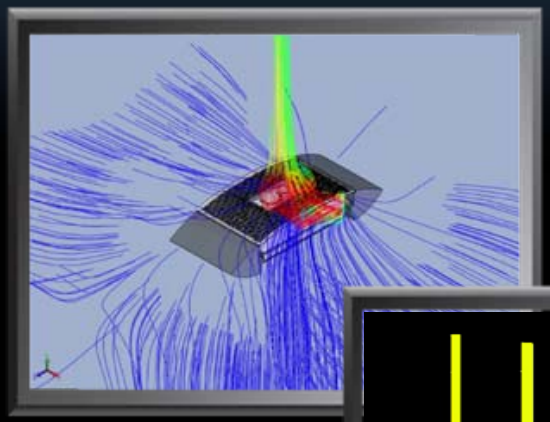
- ~ **8,000** Hours

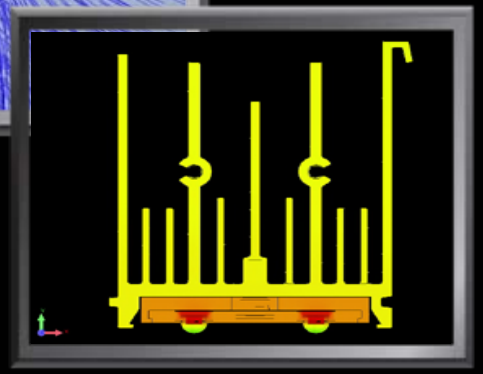
High Brightness White LED General Characteristics

- Good Efficacy and Getting Better
- Thermally Sensitive / Thermal Management Challenges
- Excellent Optical Control Opportunities
- Excellent Opportunity for Long Life
- Excellent Opportunity for Low Lumen Depreciation (High Lumen Maintenance) Over Life
- Instant On / Instant Re-strike
- Vibration and Shock Resistance
- No UV Emission
- Very Little Forward Heat
- No Mercury, Heavy Metals, etc.

Optimizing Integration for Fixture Design and Applications

Thermal Management



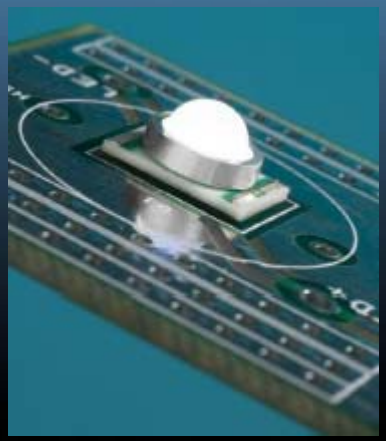


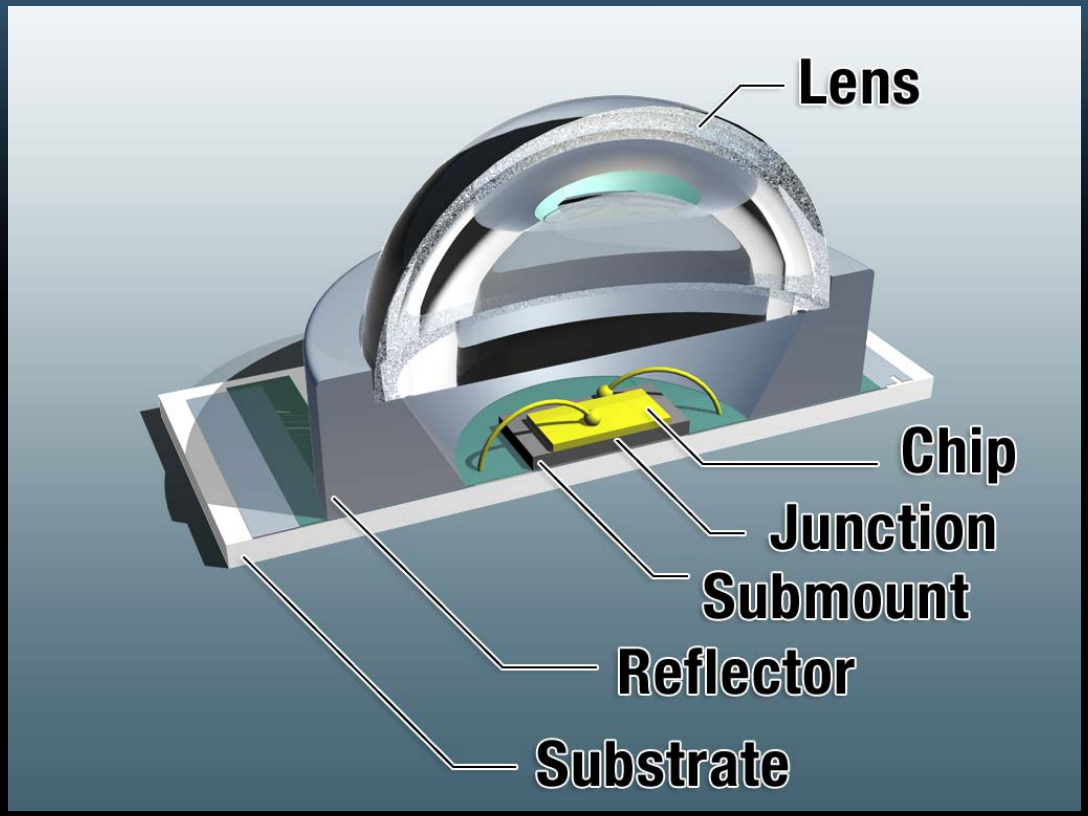
Optical Control

Thermal Management

- Key System Optimization Attribute
  - Dramatic Effects On:
    - Initial System Efficacy
    - Lumen Depreciation / Lumen Maintenance

Understanding the Effects of Junction Temperature



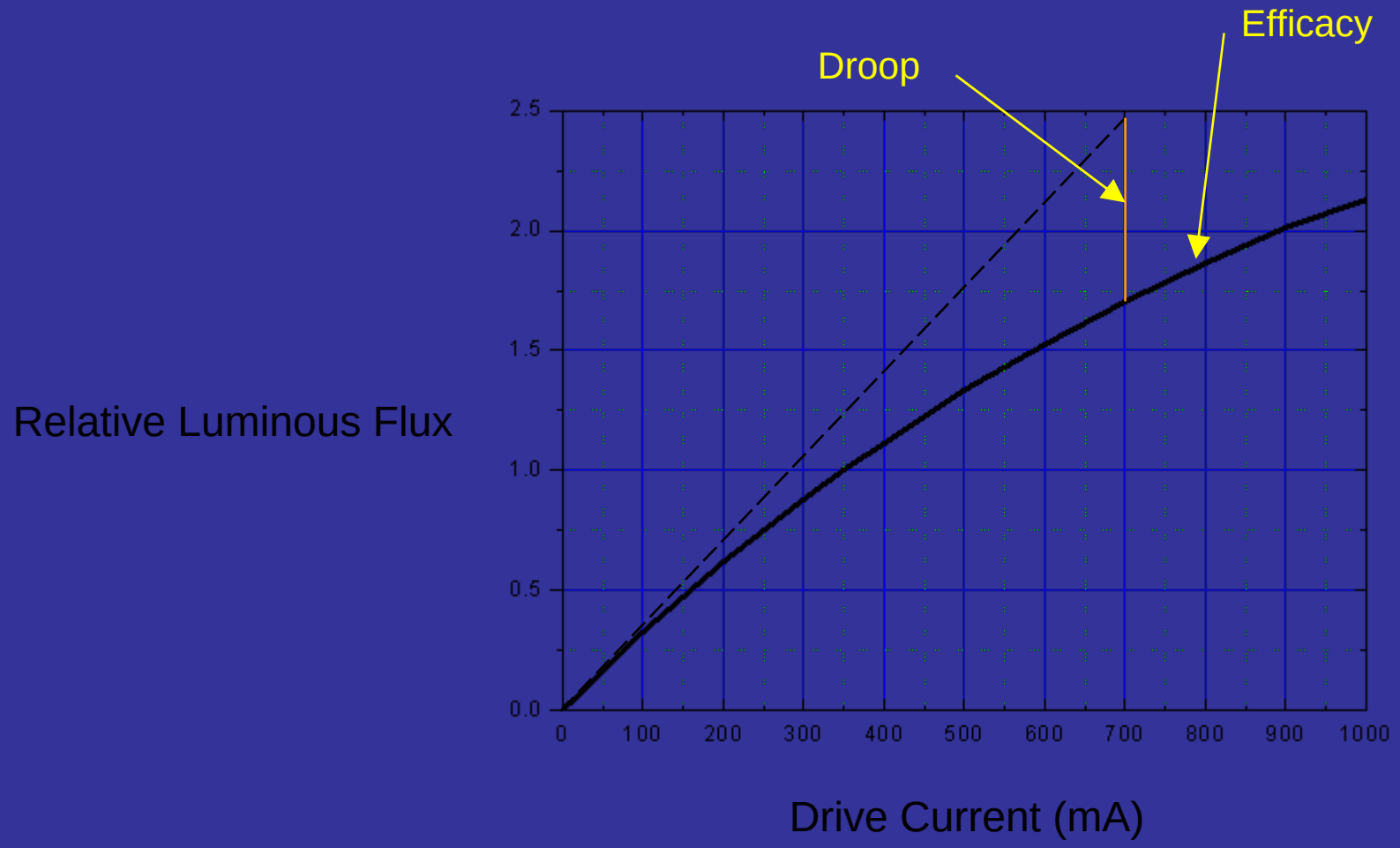


HB White LED Source Efficacy

- Example
  - 90+ Lumens/Watt
    - Measured at 25°C
      - ~25 Millisecond Time Duration
      - 350 mA Drive Current
    - ~6000 K Correlated Color Temperature (CCT)
      - Limited Indoor Applications
      - Appropriate for Many Outdoor Applications

HB White LED
Relative Initial Source Efficacy

- At Constant Time and Junction Temperature
  - Drive Current Varies



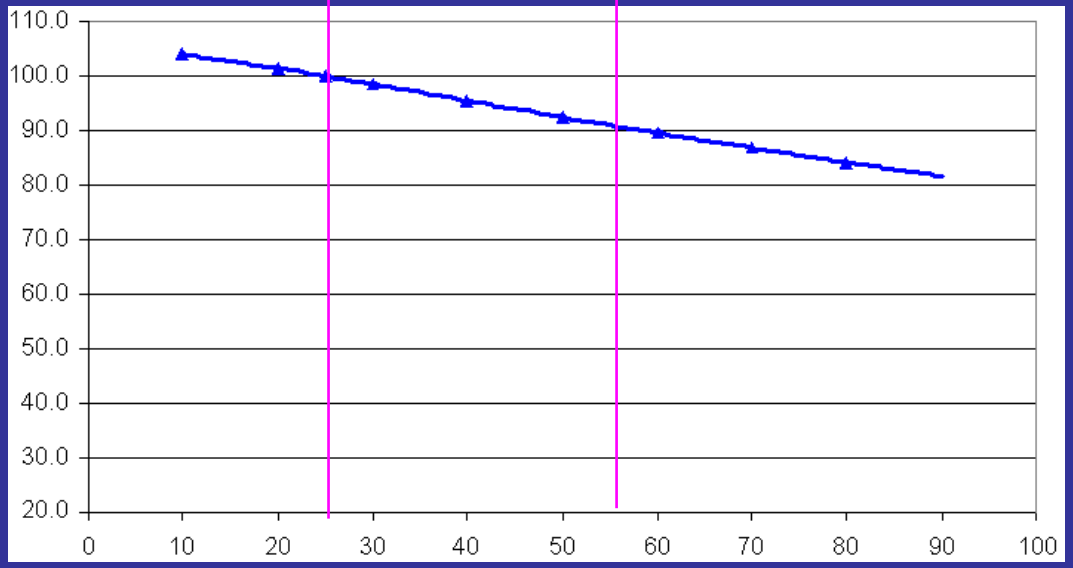
HB White LED
Relative Initial Source Efficacy

- At Constant Time and Drive Current
  - Junction Temperature (T_j) Varies

100 % Rated Value
@25ºC

+ 30ºC From Rated Value
⇨~10% Reduction

% Relative Luminous Flux



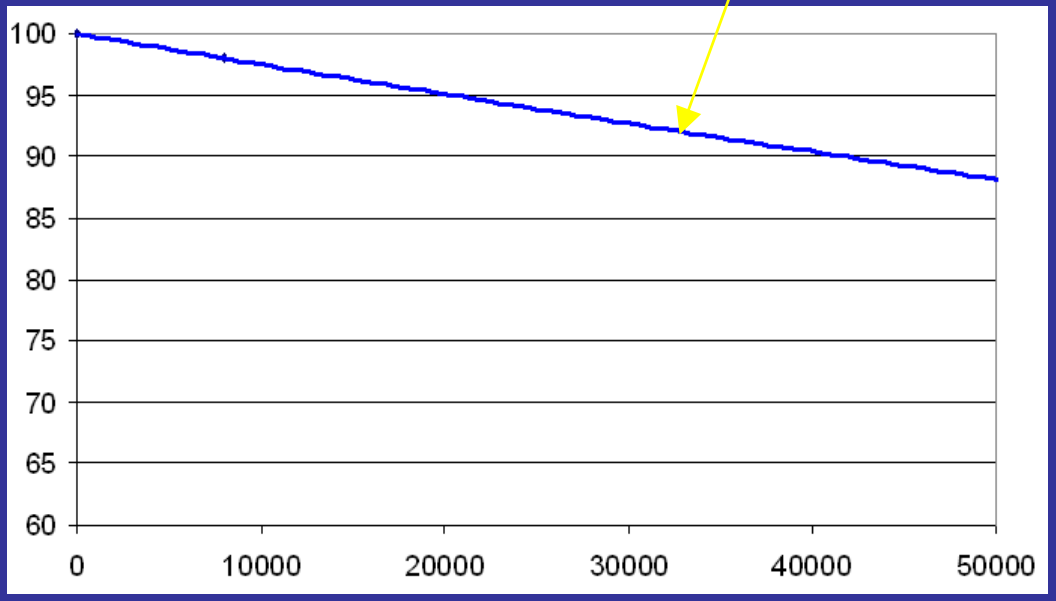
Junction Temperature T_j

HB White LED
Source Efficacy <u>Over Time</u>

- At Constant Junction Temperature (T_j) and Drive Current
  - Example: Stabilized LED System
  - Time Varies
    - *Defines Lumen Maintenance*

Example: For T_j of ~55°C
⇨~12% Reduction @ 50,000 Hrs

% Relative Luminous Flux



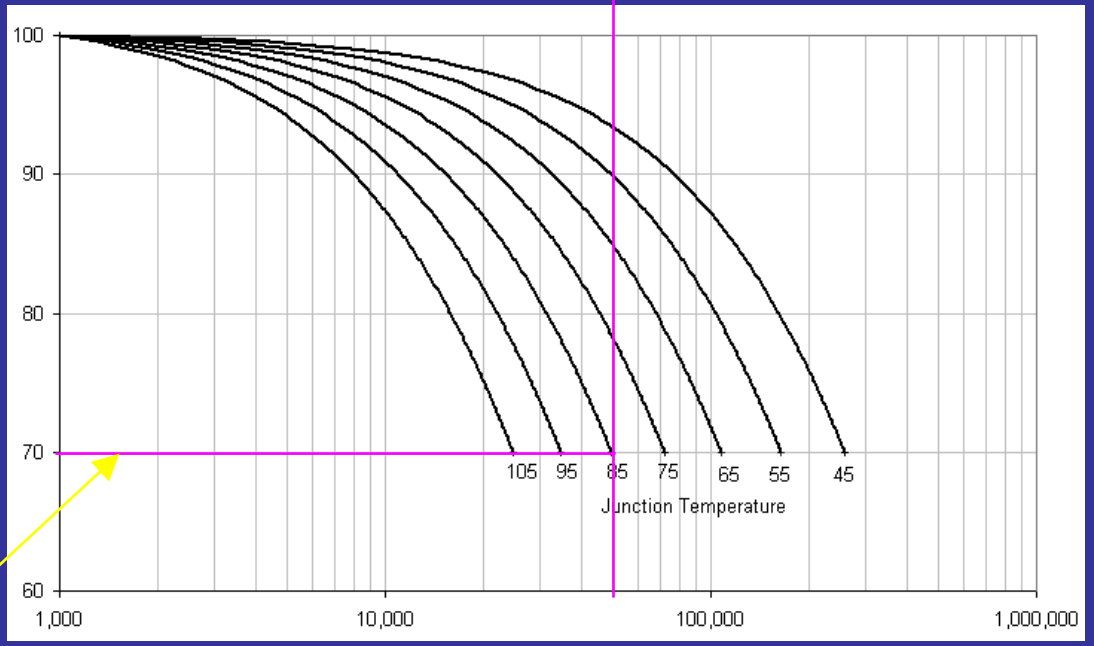
Time (Hours)

HB White LED
Source Efficacy Over Time
(Lumen Depreciation)

- At Constant Junction Temperature (Tj) and Drive Current
  - Example: Stabilized LED System
  - Multiple (Tj) Examples
  - Time Varies

For T_j of ~85°C
⇨~30% Reduction @ 50,000 Hrs

% Relative Luminous Flux

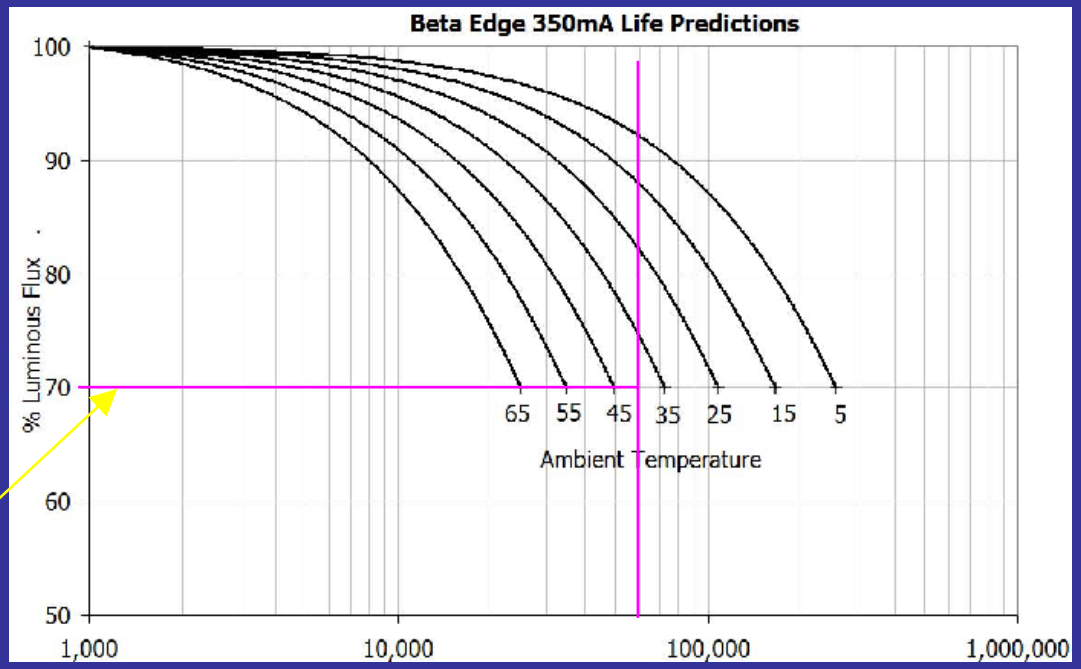


L_{70}

Time (Hours)

Beta EDGE™ Lumen Depreciation for Various Average Operating Ambient Conditions

% Relative Luminous Flux



L_{70}

Time (Hours)

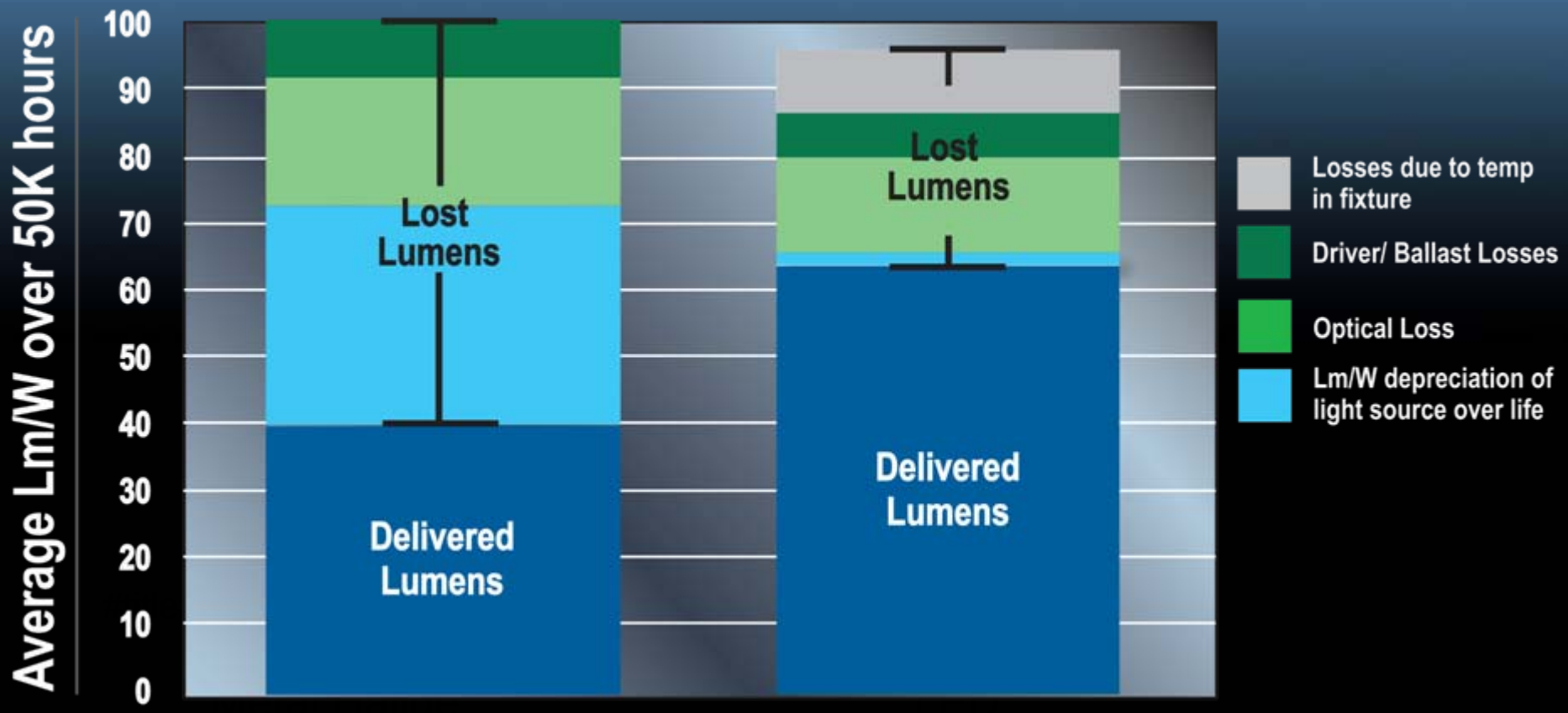
Important Points

- Thermal Management Will Determine Lumen Depreciation
- Thermal Management Will Directly Impact Initial System Efficacy
  - Complete System Must Be Tested
    - Requires Absolute Photometry

Better Day BP Gas Station

Basic System Comparison

- 100 Lumen/Watt Metal Halide
- 97 Lumen/Watt LED



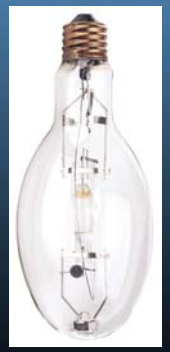
Optical Control Opportunities

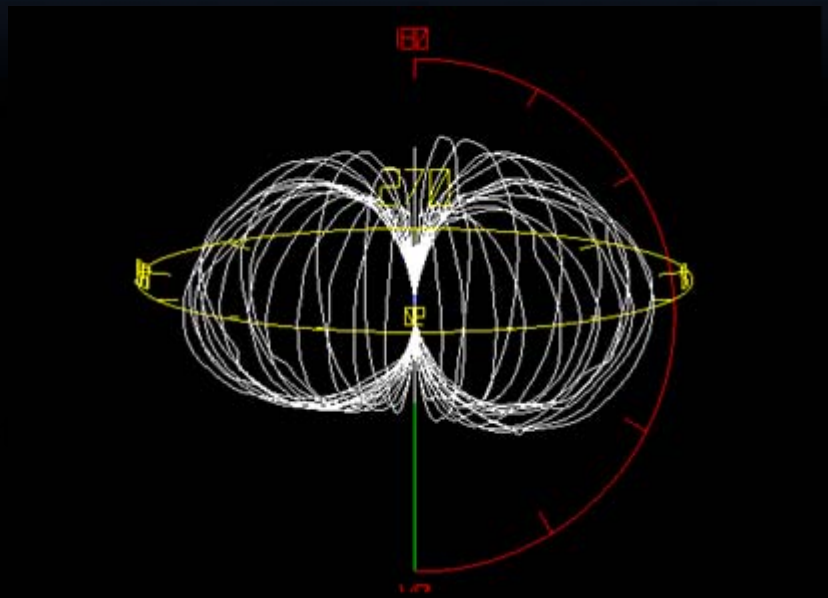
Bare Source Emission Characteristics

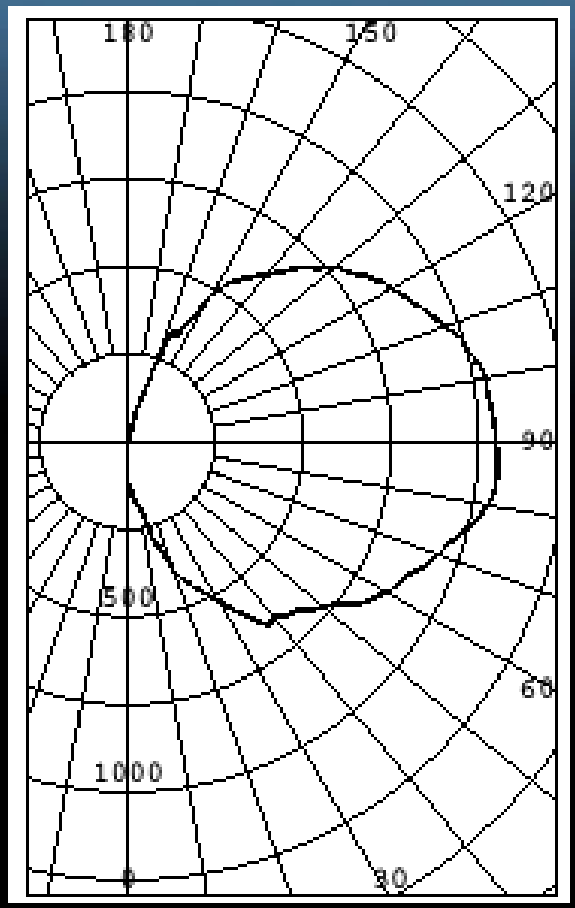
HID vs. LED

HID Bare Source Photometry

Commercially Available MH Lamp
Polar Candela Plot

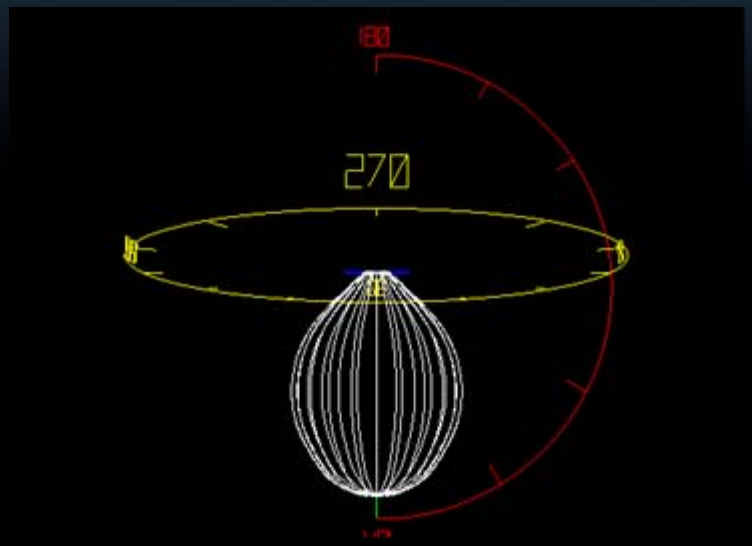


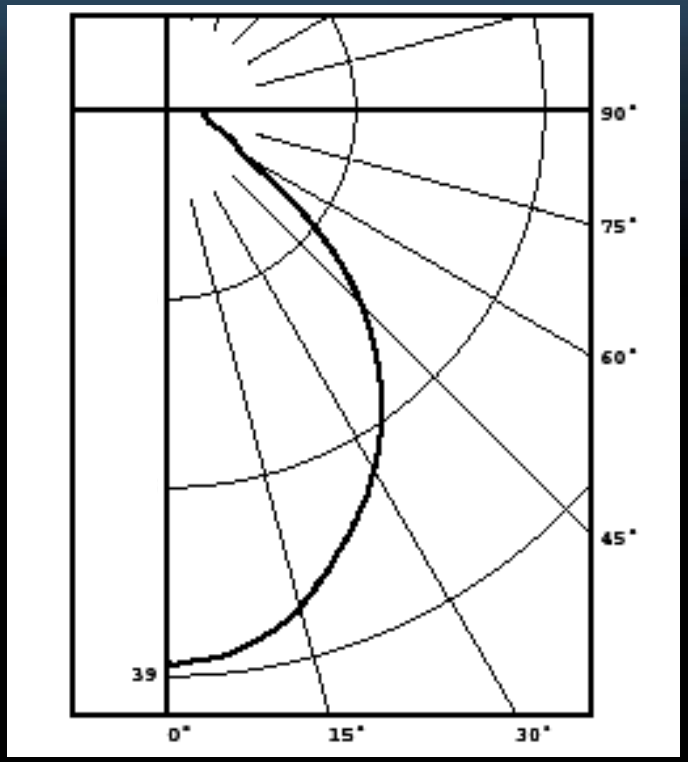




LED Bare Source Photometry

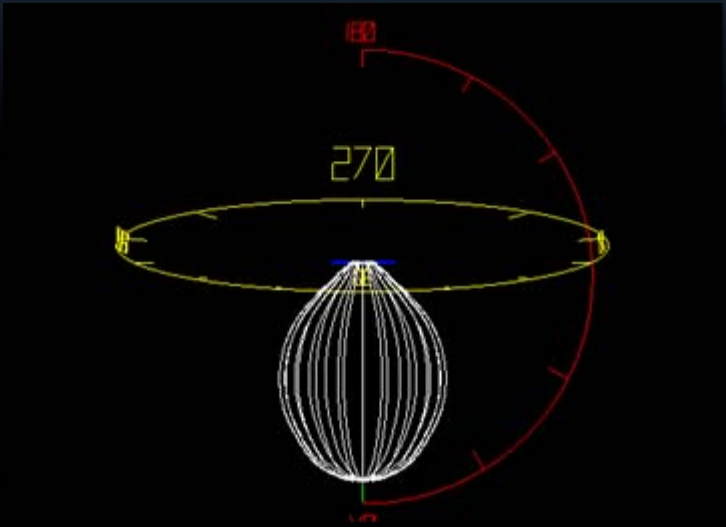
Commercially Available HB
White LED
Polar Candela Plot





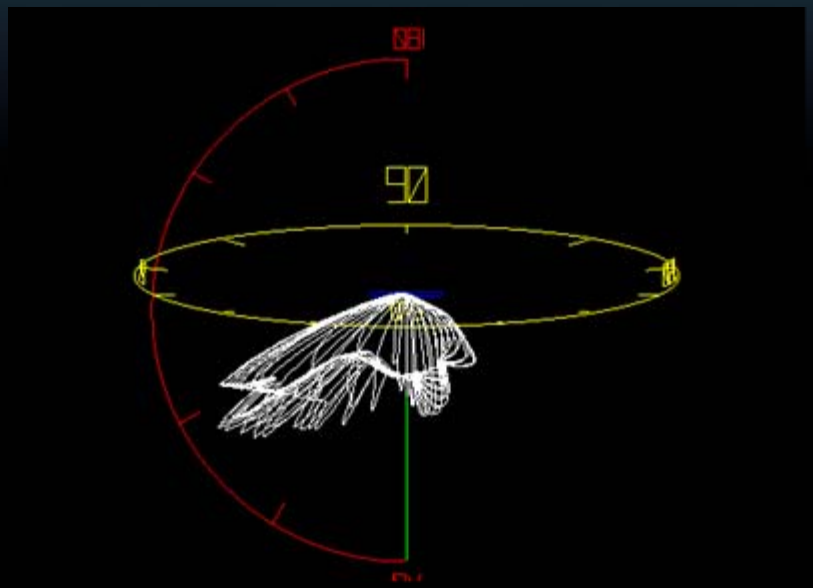
Optical Control

- Bare LED Package Illustration

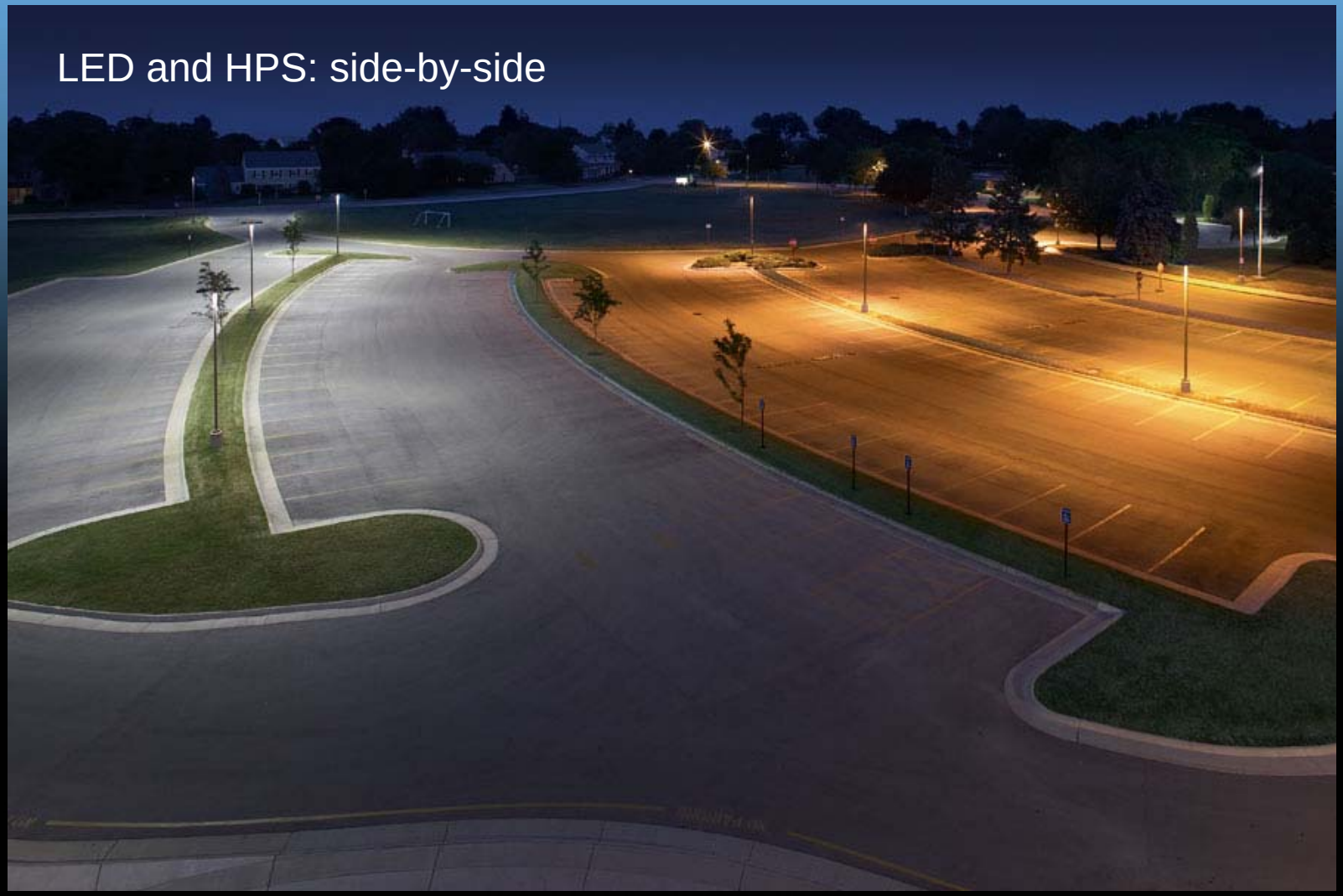


Optical Control

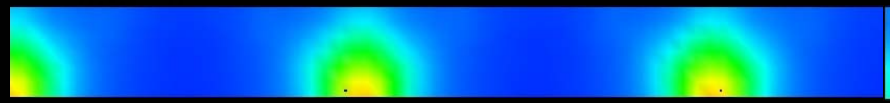
Illustration of Altered Distribution
(Secondary Optic Added)



GovEnergy 2008

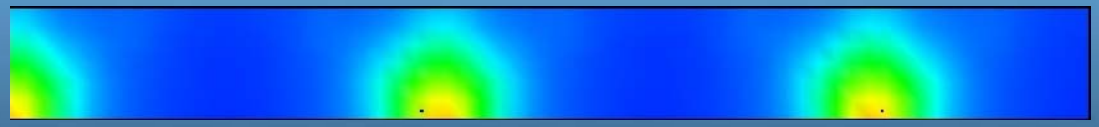


City of Oakland, CA – Street Lights

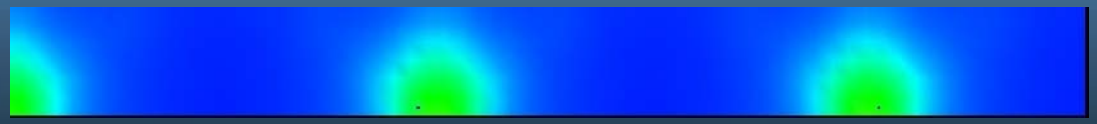


GovEnergy 2008

100 Watt HPS



70 Watt HPS



60 LED Type 3

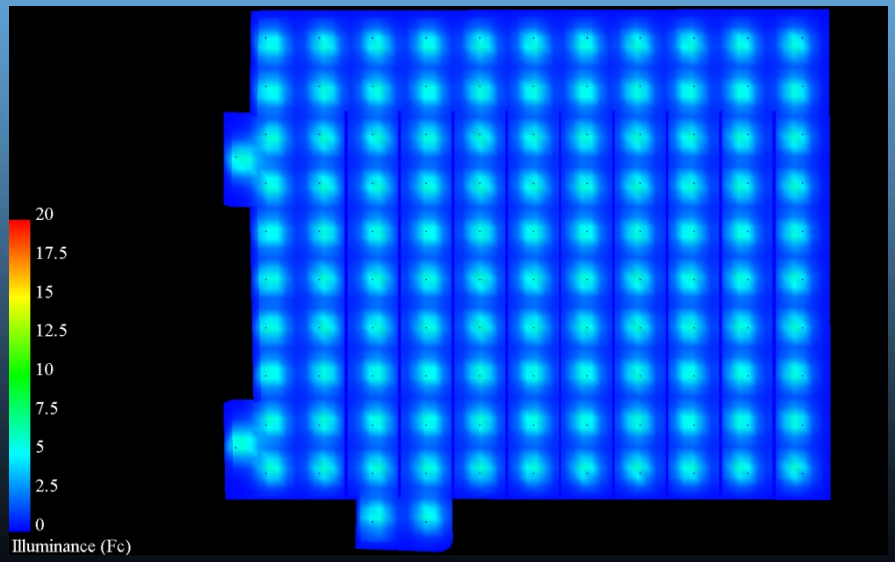
60 LED Type 2

40 LED Type 2

By the Numbers

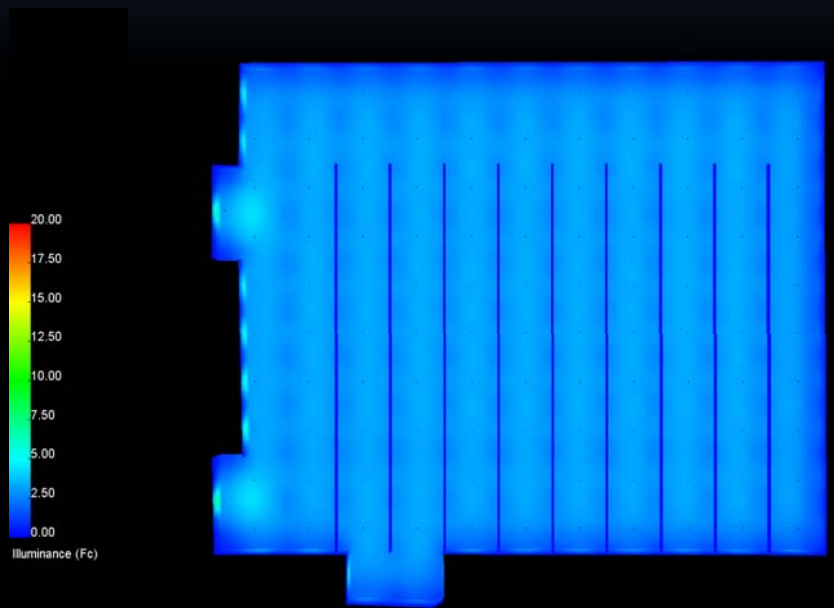
Illuminance Comparisons 150' spacing					
	Oakland Existing Beta T3 60 LED	Beta T2 40 LED	Beta T2 60 LED	70 w HPS	100 w HPS
average	0.34	0.31	0.47	0.33	0.49
max	0.87	0.62	0.93	1.68	2.49
min	0.08	0.13	0.20	0.09	0.13
avg:min	4.25	2.38	2.35	3.67	3.77
max:min	10.88	4.77	4.65	18.67	19.15
lumens	4468	3400	5100	4512	6698
energy consumption	77.7	55	79	86	115
luminaire efficacy (LPW)	57.5	61.8	64.6	52.5	58.2

Application Comparison



LED Solution A

AVG	2.70
MAX	12.5
MIN	0.2
MAX/MIN	63:1
LLF	0.7 (@ 50,000 Hrs. Use)
Power	78W



LED Solution B

AVG	3.03
MAX	4.6
MIN	0.9
MAX/MIN	5:1
LLF	0.95 (@ 50,000 Hrs.Use)
Power	55W

What is Needed for a Fair Comparison?

- Certified Photometric Report From an Independent Testing Agency (per IESNA LM-79)
  - LED System
  - Competing Systems
- Life Data (Lumen Depreciation Value) for the LED System (per IESNA LM-80)
  - Based On the Life of the Application
    - L_{70} = end of life limit
- Appropriate Maintenance Factors for the Competing Systems
- Understanding of Costs

❖ Side-by-Side Performance Evaluation

Other Factors of Comparison

- Complete System Life
- Reliability
- Warranty
- Serviceability and Maintenance
- Chromaticity Selection
- Chromaticity Variation
- Environmental Impact Factors
  - Disposal / Recyclability / etc.
- Etc.

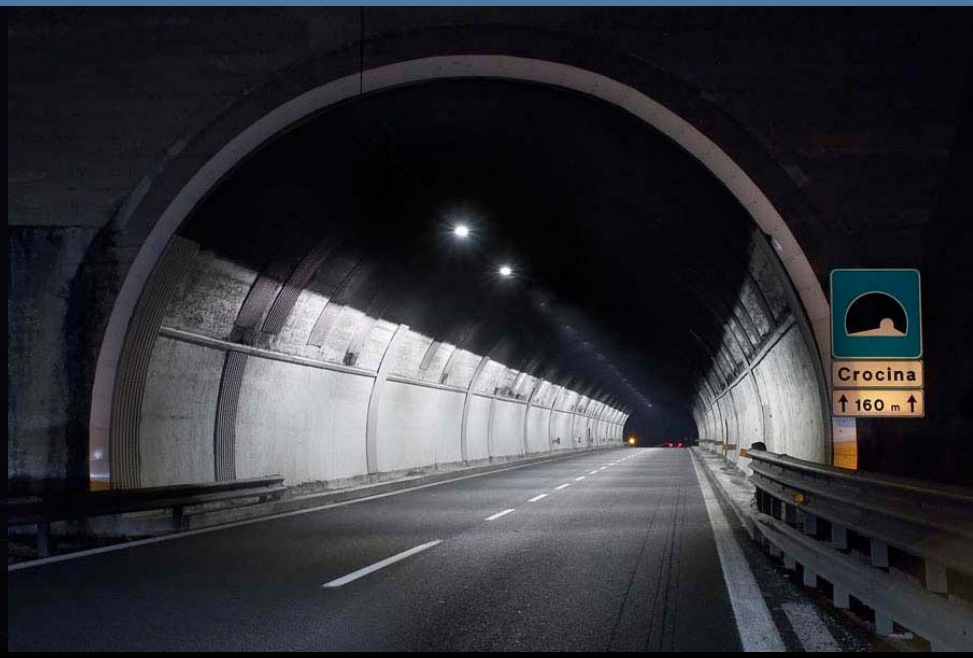
Ongoing LED Improvements

- Increased Efficacy
  - Across all Chromaticity Ranges
- Optical Design
- Thermal Management
  - Materials / Heat-sinking
  - Packaging
- Reduced Chromaticity Variation
- Standards (Updates and Refinements)
  - Test / Measurement / Application
- Driver and Control Technology
- Costs
- Etc.

Crocina Tunnel, Arezzo, Italy

Before Retrofit to LED

After Retrofit to LED



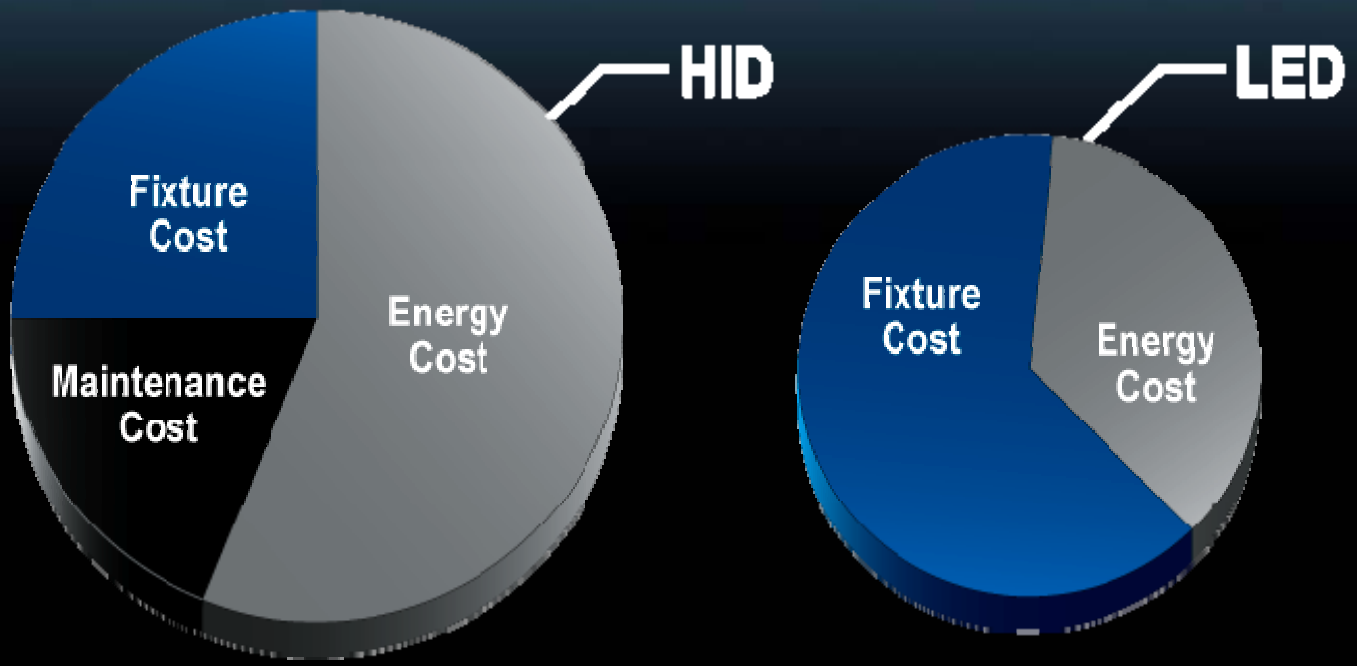
Sentry Equipment - Parking Lot

Parking Structures

Interior Applications are Here!

Value Analysis

Total Cost of Ownership Illustration



Thank You!

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