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I&M – LED Intro

August 1st, 2017

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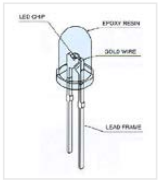
Lighting Basics

Generations of Roadway Lighting

IMAGE											
MONOGRAM				GENERAL ELECTRIC	GENERAL ELECTRIC						
TEXT	GAS LANTERNS	OPEN ARC LAMP FIXTURE	GE LIGHTS 1ST MAJOR LEAGUE BASEBALL GAME @ CROSLEY FIELD	GE LIGHTING SYSTEMS Moves to NORTH CAROLINA	FIRST INTEGRATED SYSTEM (HOUSING, RELECTOR, REFRACTOR, LAMP & BALLAST)	GE – NICK HOLONYAK, JR. CREATES FIRST PRACTICAL VISIABLE SPECTRUM LED	GE – PIONEERED HIGH PRESSURE SODIUM BALLAST TECHNOLOGY	GE – PATENTED VERSABEAM OPTICAL	GE – PATENTED ULTRASPORT STADIUM LIGHTING	GE LAUNCHED STREET DREAMS	LED LUMINAIRE TECHNOLOGY
YEAR	EARLY 1800	LATE 1800	1935	1955	1959	1962	1969	1994	1994	2005	2008

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HID Street Lighting




- **Primary Fixture Type: The Cobrahead**
  - First introduced in ~1957
  - Resembled a cobra's flared neck when viewed from the ground
- **HID Lamp Types**
  - Mercury Vapor
    - "White light" with a bluish green hue
    - Originally popular for Street Lighting but also Landscape Lighting
  - High Pressure Sodium
    - Initially disliked because of the "orange glow"
    - Became the predominant light source for Street Lighting in the 80's
  - Metal Halide
    - True "white light"
    - More efficient than Mercury Vapor but shorter life

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Optical Types




- **Non-cutoff:**
  - These lamps distribute light in all directions. A major problem is created by the light pollution and glare, as they shoot their light upwards into trees and towards the sky rather than towards the ground. Non-cutoff fixtures are rarely found on roadways because they tend to blind the driver.
- **Semi-cutoff:**
  - This is the most popular street lighting optic
  - Most of the light can be emitted below 90 degrees, but as much as 5% of the light can also be emitted above 90 degrees
- **Cutoff:**
  - These optics give more light control than semi-cutoffs
  - Less than 2.5% of the light can leave the fixture above 90 degrees
- **Full-cutoff**:
  - No light above 90 degrees
  - Full-cutoffs distribute their light in a defined pattern, potentially providing more light on the ground at lower power consumption
  - In recent years, cutoff-type lights have gained popularity due to IDA

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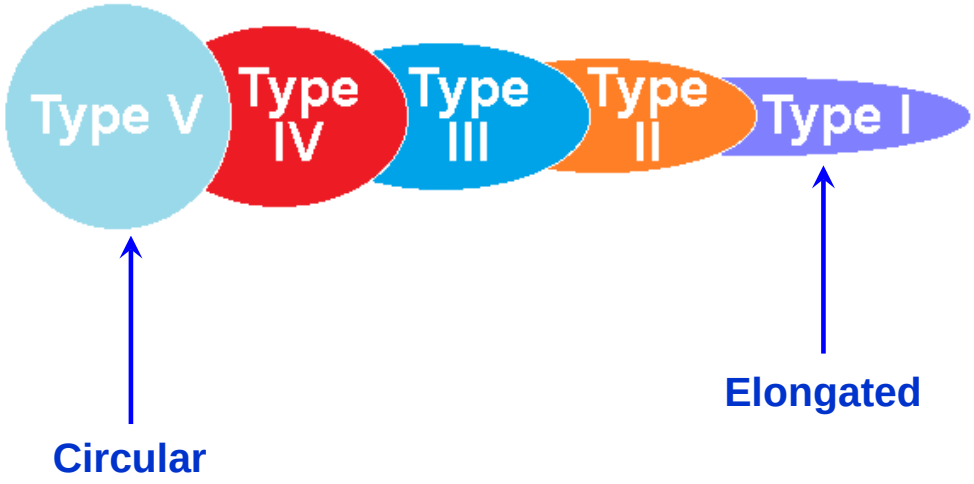
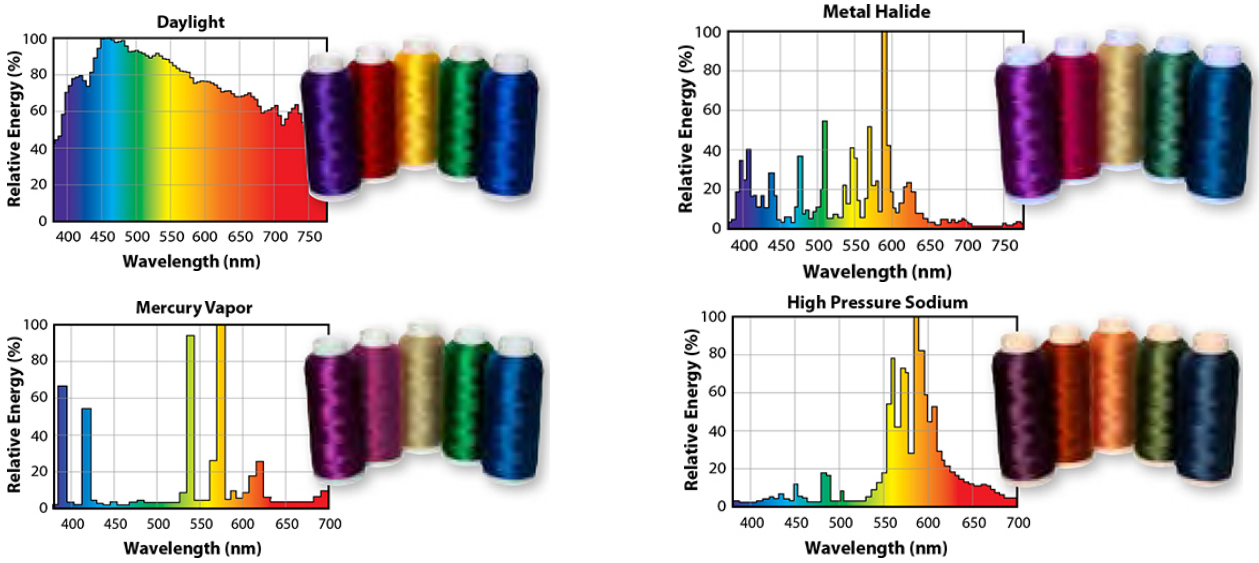
Street Light Distribution Patterns



CRI (Color Rendering Index)



The eye sees all objects in the form of reflected light. All of the colors contained in the object must also be present the beam of light to accurately reproduce the image in reflected light. The Color Rendering Index is a numerical scale from zero to one hundred used to rate the accuracy at which a light source will render colors. A value of 100 CRI indicates perfect color rendering. There is, however, another factor to consider in the color equation... the amount of light. Low light levels make an object lack color and look dull, or grayish.

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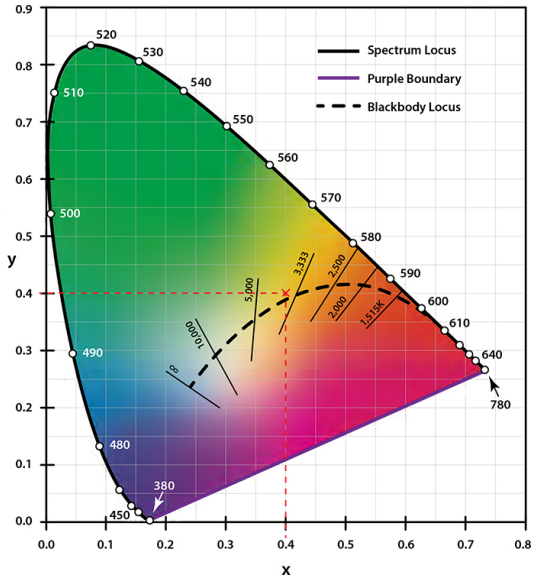
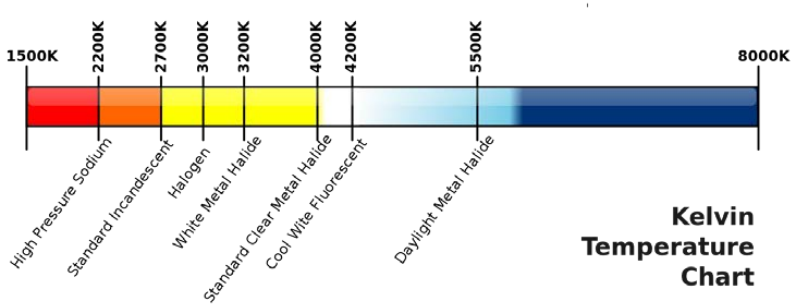
CCT (Correlated Color Temperature)





There are a number of color combinations that can be used to create White Light, or a particular Color Temperature. The Chromaticity Chart is used to qualify the color of the light that is produced by a lamp. This is called a lamp's Color Temperature. This can be seen on the Chromaticity chart. Color temperature is specified in degrees Kelvin (°K)*.

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LED Basics

What are LED's

LED (light-emitting diode) is a type of solid-state lighting that uses a semiconductor to convert electricity into light and offers the following benefits:

- Greater energy efficiency – uses ~half the watts of HPS
- Longer life – Reduced Maintenance
- Better quality of light
  - White Light = Improved visual acuity (safety / security)
  - Ability to focus light directionally = Increased uniformity
- Environmental Impact
  - Lower carbon footprint / reduced CO2 emissions
  - No Lead or Mercury content
- Compact size, light weight

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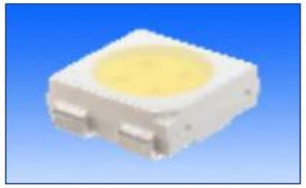
LED Durability

LED Features:

- No filament failures, no cathode failures, no glass to break…

LED Benefit:

- Rugged vs. Traditional Lamps
- Vibration resistance



imagination at work

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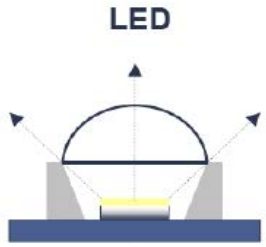
LED Photometric Control

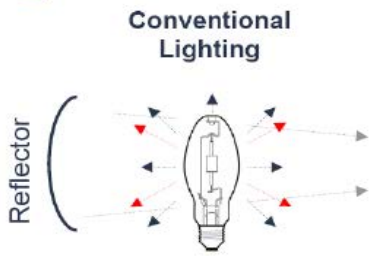
LED Features:

- Multiple Light Source Emitter
  - **Directional Source**
  - **360 deg. Lamp**
- Individually Controllable

LED Benefit:

- Color Consistency – Unit To Unit
- Greater Optical Control – Light where desired
- Improved Fixture Efficiency – Fewer Fixtures / Lower Watts
- Improved Control Of Spill Light – Less Light Pollution / Light Trespass





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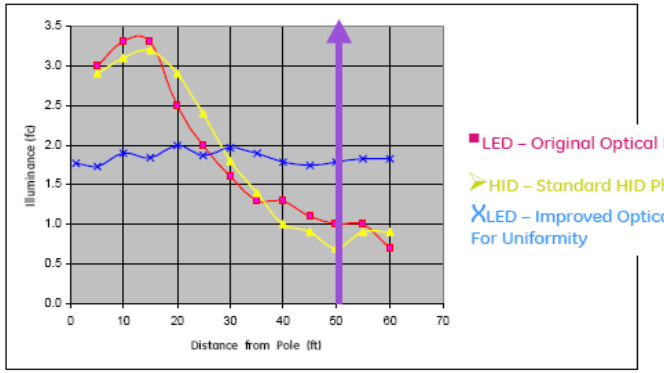
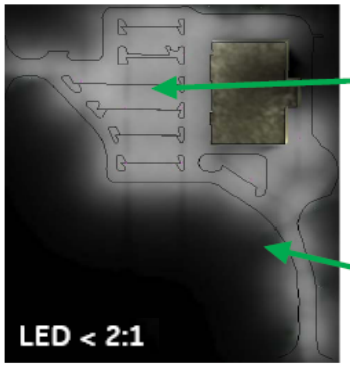
LED Photometric Control



- LED – Original Optical Design (Match HID)
- HID – Standard HID Photometry
- LED – Improved Optical Design – Optimized For Uniformity

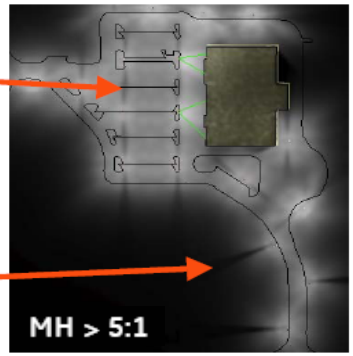
LED Area Light



Smoother gradient demonstrates improved uniformity

Improved light control provides for less light trespass – more light where desired

400W HID Area Light



Parking Lot Design: Plan View

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LED vs HPS

Reduce Your Sodium

It's a lot easier to see that making the upgrade from High Pressure Sodium (HPS) to LED street lights goes a long way toward user visibility, operator savings and energy efficiency.

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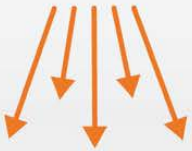
Light Distribution



LED lamps distribute light at a sharp, defined angle

HPS lamps have a nondirectional, less controlled light distribution

LEDs Offer Improved Visibility Through:

Better color rendering

Better light distribution, eliminating dark areas between poles

Improved contrast visibility for drivers

LEDs Provide Noon Daylight Color Temperature

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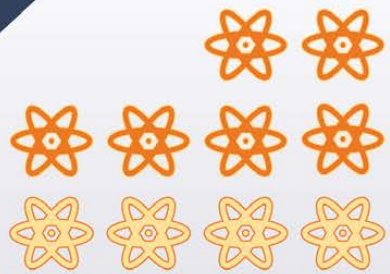
With Optimized Application Design, LEDs Can Deliver:

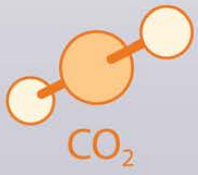


40–80% Energy Savings

• AND •

50–75% Relamping and Maintenance Savings

	Usable Power	Power Distribution	Emissions
LED	125 watts	456 kWh per year	Plus, LEDs emit **less CO_2** as a result of **energy use** than HPS
HPS	290 watts	1,065 kWh per year	



LED vs HPS

- **"Source" vs "system" efficiency**
  - **30% of the lamp lumens are "trapped" in the HID luminaire and never make it out of the fixture**
- **LED's are directional light sources**
- **White light vs yellow light**

100 Watt HPS

- 9,500 Initial Lumens
  - Less 30% to account for "trapped" lumens that never make it out of the HID = 6.650 Lumens
- 8,000 Means Lumens (Lumen output at 10,000 hours)
  - Less 30% to account for "trapped" lumens that never make it out of the HID = 5,600 Lumens
- 7,125 Lumens at end of life (24,000 hours)
  - Less 30% to account for "trapped" lumens that never make it out of the HID = ~5,000 Lumens

53 Watt GE LED

- ~6,000 Initial Lumens
- Lumen output after 50,000 hours = ~5,500 Lumens

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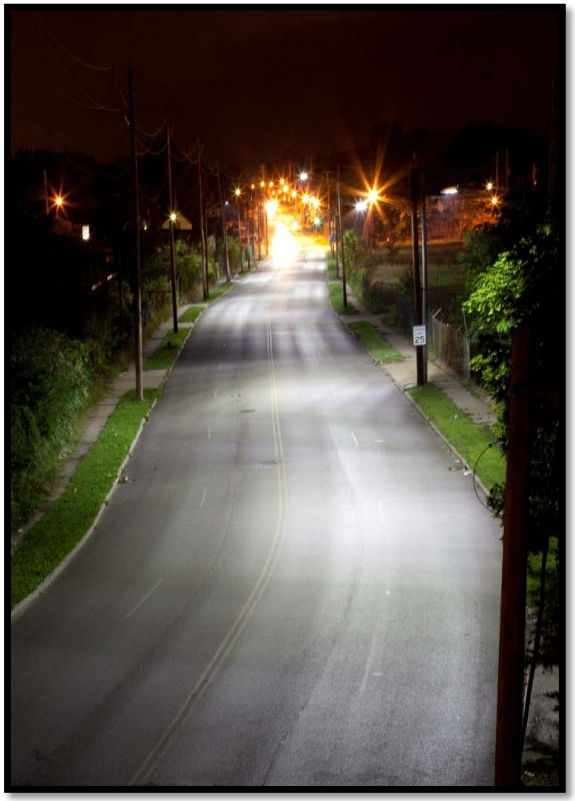
Application Photo

Before:
290W HPS



After:
143W LED

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Industry Trends

Lighting Regulations and Standards Are Becoming More Aggressive

	Trend	Influencing Bodies
Lighting Power Density (LPD)	↓	
Uplight	↓	
Trespass Light	↓	
Light Levels	↓	
Glare	↓	
Lumens / Watt (LPW)	↑	

Lighting Solutions Need To Meet These Requirements

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IES Study – LED LDD

Luminaire Dirt Depreciation (LDD) has the potential to negatively affect the performance of a Luminaire. Not only does LDD affect the overall light output of the Luminaire but can also impact the pattern of light distribution.

Manufacture	LED Optic	Dirt Depreciation Rate
GE Evolve	Flat Glass	1.0% per year
Tested Product A	Individually Molded Acrylic	1.8% per year
Tested Product B	Molded Glass	2.2% per year
Tested Product C	Individually Molded Acrylic With No Outer Optic	3.0% per year
Tested Product D	Large Individually Molded Acrylic	3.8% per year

Source: Illuminating Engineering Society, RES-1-16 Measure and Report Luminaire Dirt Depreciation (LDD) in LED Luminaires for Street and Roadway Lighting Applications; Gibbons, Palmer, Meyer, Terry

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IES Study – LED LDD

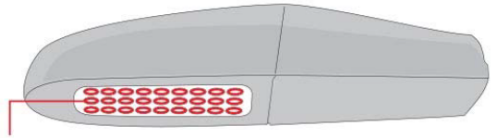
Dust and Dirt Migration

The Evolve fixture houses the LEDs and reflectors in a dirt- and dust-free cavity with an IP65/IP66-rated optical enclosure and a tempered glass lens to minimize the effects of dirt. This design approach provides consistent light distribution over the life of the product.

GE

Flat, tempered glass lens protects the LED optical enclosure. Lens surface is smooth and flat which is less prone to dirt accumulation.

COMPETITION



Designs that have exposed refractive optics have more crevices (or surfaces, edges, pockets) prone to dirt accumulation that could adversely affect the beam distribution pattern.

A recent Illuminating Engineering Society report* on LDD stated:

"LED luminaires with flat glass optics were less susceptible to average dirt depreciation than luminaires with exposed inner optics.....With exposed optics, especially the individually molded acrylic, the surface of the optic is much more complex, has significantly more leeward edges, and significantly more surface area. These features will cause much more turbulence over the exposed optics, enabling dirt to accumulate on each individual optic and likely leading to more dirt sticking."

*Source: Illuminating Engineering Society, RES-1-16 Measure and Report Luminaire Dirt Depreciation (LDD) in LED Luminaires for Street and Roadway Lighting Applications; page 71, Gibbons, Palmer, Meyer, Terry

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AMA Challenges Blue Content of LED's

- The AMA recommends 3K CCT for all applications
  - 3K CCT or lower is not an appropriate solution for all applications
  - The use of 3K CCT or lower may compromise the ability of the lighting system to meet all critical design criteria for each unique application

- The DOE reports "there is nothing inherently different about the blue light emitted by LEDs
  - At the same power and wavelength, electromagnetic energy is the same, regardless of source type

- DOE report concludes:
  - "According to current international standards, no light source that emits white light and is used in general lighting applications is considered hazardous to the retina for healthy adults."

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AMA Challenges Blue Content of LED's

- Resources
  - AMA Article
    - http://www.ama-assn.org/ama/pub/news/news/2016/2016-06-14-community-guidance-street-lighting.page
  - DOE Response
    - http://energy.gov/eere/ssl/articles/get-facts-led-street-lighting
  - NEMA Response
    - https://www.nema.org/news/Pages/NEMA-Comments-on-American-Medical-Association-Community-Guidance-Advocating-and-Support-for-Light-Pollution-Control-Efforts.aspx
  - LRC (Lighting Research Center) Response
    - http://www.lrc.rpi.edu/resources/newsroom/AMA.pdf

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Roadway Product Portfolio

differentiating factors

- optical design
- mechanical design
- electrical design
- reliability & performance
- controls capability

We've applied the science of light and our expertise in roadway fixtures to integrate application efficiency and reliability into every Evolve™ ERS fixture. The foundation of our exceptional, high-performance LED roadway lighting solution revolves around GE's custom designs.

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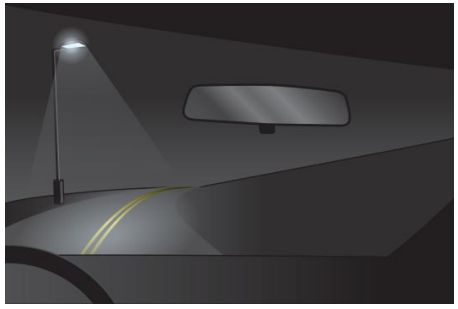
optical design

aiming to please

GE uses an advanced reflective optic design that meets RP-8 recommended practices for luminance, illuminance and small target visibility. This unique design ensures that Evolve ERS fixtures will deliver light control with significantly less waste than the other optical technologies used by many of our competitors.

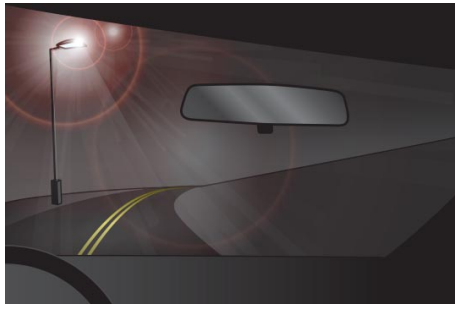
Evolve ERS fixtures have improved ratings for backlight, uplight and glare (BUG ratings) to direct more light on the road and not in neighboring properties or in the eyes of nighttime drivers – meeting tight local ordinances and International Dark-Sky (IDA) requirements.

GE



Our unique reflective technology allows us to focus light where it's needed – on the road – with less glare.

COMPETITION



The refractive technology design used by other manufacturers typically results in more wasted light trespass and glare for drivers.

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optical design

minimizing glare

GE's innovative reflective design only puts light where it is needed and minimizes direct view of the light source with a non-pixilated appearance.

GE design recesses the LED array within the optic (or reflector) to limit visibility of the LEDs from the driver's field of view, minimizing glare. Many competing optical designs use LED arrays with individual optics, making the entire array visible to the driver, resulting in a pixilated appearance with higher levels of glare and increased light trespass.

GE

Minimized visibility to LED light source, creating non-pixilated appearance to driver's field of view

COMPETITION

Visibility to every LED, creating a pixilated appearance and increased glare to driver's field of view

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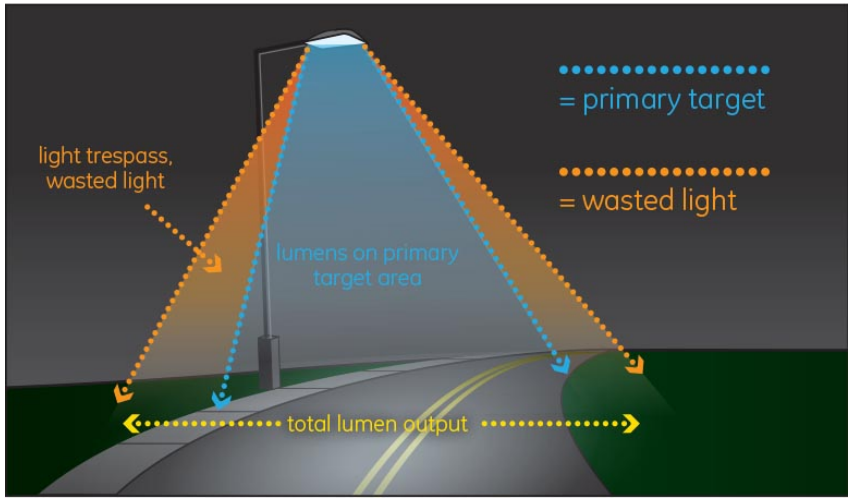
optical design

light on target: coefficient of utilization

Excellent light control aims the light directly where you need it.



Efficiency in action

- Lumens per Watt (LPW) = Total Lumen Output/Total Watts
- Coefficient of Utilization (CU) = Lumens on Primary Target Area/Total Lumen Output
- Higher the Coefficient of Utilization (CU) = Less Wasted Light

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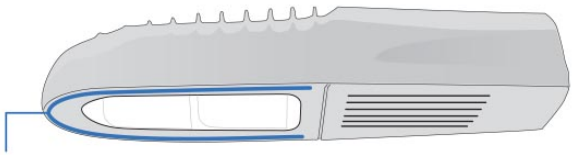
mechanical design

dust and dirt migration

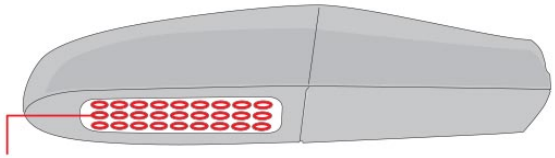
The Evolve ERS fixture houses the LEDs and reflectors in a dirt- and dust-free cavity with an IP65-rated optical enclosure and a tempered glass lens to minimize the effects of dirt. This design approach provides consistent light distribution over the life of the product.

GE



Flat, tempered glass lens protects the LED optical enclosure. Lens surface is smooth and flat which is less prone to dirt accumulation.

COMPETITION



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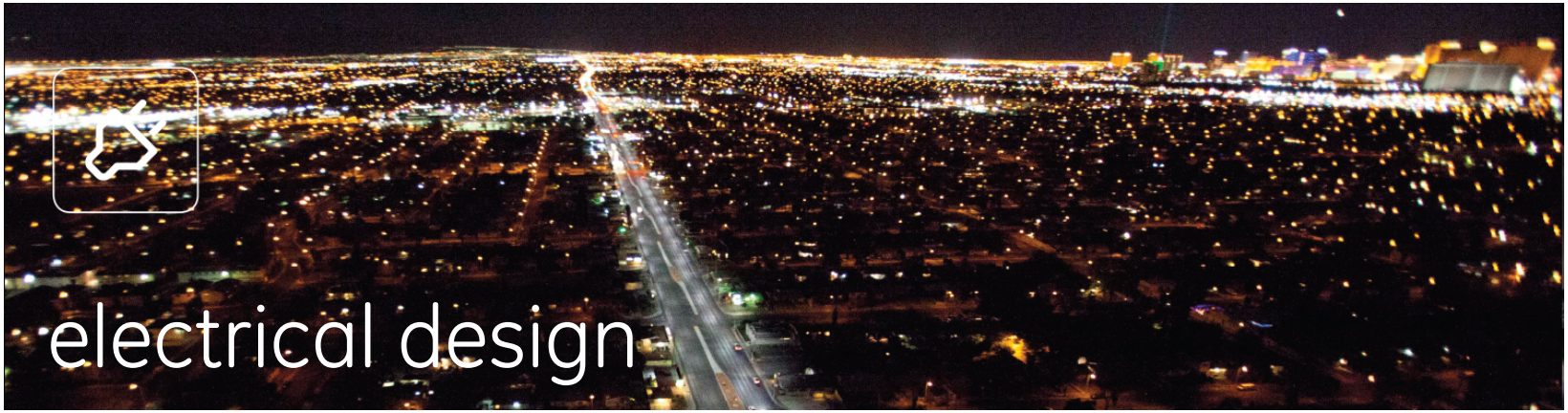

electrical design

one manufacturer of complete system

Entire system, including driver, fixture and controls are made, tested and warranted by the same manufacturer to ensure long-term system reliability.

surge protection

GE's standard transient voltage surge suppression (TVSS) exceeds the U.S. DOE Municipalities Solid State Lighting Consortium (MSSLC) specification for surge protection devices.

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surge hit tolerance comparison

	NUMBER OF STRIKES PROTECTED AGAINST
RATINGS OF MOST COMPETITOR OFFERINGS	1-30
GE STANDARD OFFERING (6kV/3kA)	120

FOR SITUATIONS REQUIRING PROTECTION AGAINST MORE POWERFUL STRIKES

GE OPTIONAL HIGH-CAPACITY OFFERING	5,000 (6kV/3kA)
	120 (10kV/5kA)

reliability & performance

extensive testing of the LED, subsystem and complete system

Rather than rely solely on test data from LED suppliers, we extensively test the complete system to validate performance.

1 million+ unit hours

16,000+ hours at +60°C ambient

Rather than rely solely on test data from LED suppliers, we extensively test the complete system, using both in-house and independent labs around the world to validate performance. GE has accumulated more than 1 million unit hours of testing and more than 16,000 hours of testing at +60°C ambient, going beyond the industry's standard level of testing to ensure our fixtures can live up to our claims.

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GE Reflective Optics

Roadway Cobrahead Product Summary

ERL1

- ✓ 100 -150W Replacement
- ✓ 2,000 -8,800 Lumens
- ✓ >L90 @ 100K hr (02-05)
  >L84 @100K Hr (06-07)
  >L67 @100K Hr (08)
- ✓ 98 to 130+ LPW
- ✓ Reflective Optics
- ✓ Temperature rated at –40° to 50°C
- ✓ 12-15 lbs
- ✓ 3000K and 4000K
- ✓ IP65 rated
- ✓ 4 Bolt Slipfitter option
- ✓ Coastal Finish Option

ERLH

- ✓ 200 -250W Replacement
- ✓ 10,000 -15,000 Lumens
- ✓ >L90 @ 100K hr (10-11)
  >L74 @100K Hr (13-15)
- ✓ 93 to 111 LPW
- ✓ Reflective Optics
- ✓ 40° to 50°C (10-11)
  40° to 40°C (13-15)
- ✓ 15-16 lbs
- ✓ 3000K and 4000K
- ✓ IP65 rated
- ✓ 4 Bolt Slipfitter option
- ✓ Coastal Finish Option

ERS2

- ✓ 400W Replacement
- ✓ 15,700 -28,000 Lumens
- ✓ >L90 @ 100K hr (16-23)
  >L72 @100K Hr (24-28)
- ✓ 98 to 122LPW
- ✓ Reflective Optics
- ✓ 40° to 50°C (16-23)
  40° to 40°C (24-28)
- ✓ 25-29 lbs
- ✓ 3000K and 4000K
- ✓ IP66 rated
- ✓ 4 Bolt Slipfitter option
- ✓ Coastal Finish Option

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Roadway "Simplified" Product Strategy

- **All products are Made in America**
  - Assembled in Hendersonville, NC
- **Reflective Optics**
  - Minimizes glare
  - Puts light on task
- **Excellent Backlight Control**
  - Minimize light trespass
- **Reversible Optics**
  - Where additional backlight is required
- **Wireless Controls ready / ANSI 7-Pin**
  - Standard on LED Cobraheads
- **10kv/5kA Surge**
  - Standard on LED Cobraheads > 7K Lumens
- **Warranty**
  - Five Year Standard / 10 Year Option

ERL1

2,000– 8,500 Lumens

ERLH

10,000– 15,000 Lumens

ERS2

17,000– 28,000 Lumens

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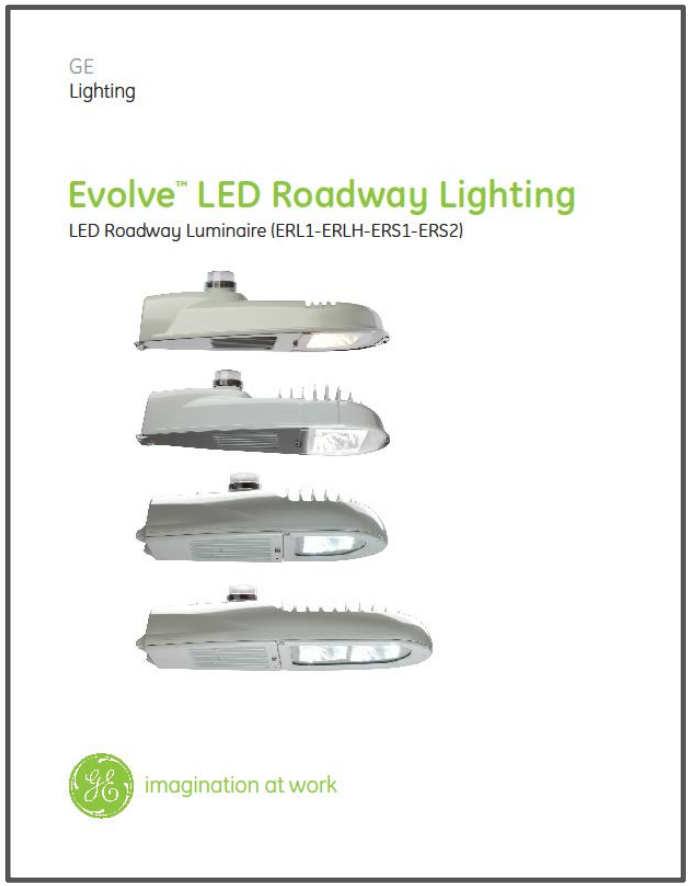
Roadway “Simplified” Product Strategy



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ERL / ERLH Exterior Product Design

Controllable
7-Pin ANSI Socket Standard
Dimmable
Light Grid Compatible

Optical Chamber
Separate Electrical Chamber
IP6X Sealed Optical Chamber

Housing
Die-Casting
Aluminum

Hinged Door
Easy Installation
No Pole Interference

Reflective Optics
Low Glare
Good Cutoff
Non-Pixelated Design
Neighbor Friendly
Dark-Sky Friendly

Glass Lens
Easy Cleaning
Flat Surface
Reduced Dirt Depreciation
No UV Degradation
Non-Yellowing

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ERL / ERLH Interior Product Design

Mounting
Adjustable for 1.25”- 2” Pipe
Stepped +/- 5° for Vertical Leveling
Stainless Steel Mounting Hardware
2 Bolt or 4 Bolt Option

Tool-Less Entry
Optional

Terminal Block
Accepts (3) #12 Cables
(3) Clamp-Type Pressure Terminals for Connections

Optional Tether
(not shown)

Wiring
#16 Stranded Wires
Silicon Rubber Insulation
105° C Rated

50 Watt GE Driver
Manufactured in Hendersonville, NC

Optional Secondary Surge Protection
10Kv/5kA

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Evolve Security Light E2SB

Product Offering & Accessories

Voltage:	120 to 277V
Lumen output:	4200 to 5900
Wattage:	42 & 57
Typical LPW:	95 -104 (@4000K)
Life :	L70 @ 100,000
CCT:	3000K, 4000K & 5000K
Optics beam:	Type III & Type V
Controls:	ANSI C136.41 7 PIN
Mounting:	Slipfitter adjustable for 1 ¼ to 2 in pipe
	Long 24 in Bracket , "L" option
Finish:	Cast Aluminum (Die Cast)
Surge Protection:	Standard: 6kV, 3kA
	Optional: 10kV, 5kA , "R" option

- #G vibration per ANSI C136.31-2010
- IP 65 rated optical enclosure
- ANSI C136.41 7 pin available
- Weight – 7.6 lbs

EFH (High Lumen Flood)

Available Now!

Product Offering & Accessories

Voltage:	120-277V & 347-480V
Lumen Output:	20k, 25k, 30k, 35k, 40k lumen
Typical LPW:	129 (119min-140max)
Wattages:	150 to 297W
Lumen Maintenance:	>L92 at 50k hrs.
CRI:	70
CCT:	3000K, 4000K & 5000K
Optics beam:	NEMA 7x7, 7x6, 6x6, 6x5
Sensors:	ANSI 7pin PE Receptacle, STANDARD
Controls:	0-10V dimming, DALI digital dimming
Surge Protection:	6kV Standard, 10kV Option
Mounting:	Trunnion, 1.9-2.3" Knuckle, & 2.3-3" Knuckle
3ft 14-3" SO Cable:	Available with Knuckle & Trunnion mount
Color:	Black, Dark Bronze, Gray, White
Temperature Rating:	-40° to 50° C
Vibration Rating:	2G w/ Knuckle mount, 3G w/ Trunnion mount
Product Dimensions:	Approximately 24" x 19" x 5" and 35lbs
IP Rating:	IP66 optical enclosure, wet location electrical

» UL/cUL certified
» DLC Listed for 120V - 480V
» RoHS compliant

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Product Story

- Replaces 400W & 1000W
- Similar housing shape ensures 1:1 replacement of HID to LED
- Key lumen packages & optics to optimize light output for most applications: General parking, school yards/sports fields, utility yards, retail, truck yards, and many commercial applications
- Premium Lumen Maintenance & LPW!
- Die cast Al housing, with innovative heat sinking
- Sealed enclosure with unique PE design allowing for -30° to +60° of aiming (off horizontal)

Transforming expectations

responsive commercial services

- world-class commercial services
- $35 million investment
- 10 days or less lead time
- 95%+ fill rate
- 24-hour online order work flow and access

Delivery delays, and design or installation uncertainties can create a domino effect on major projects. That is why we invested $35 million in our Hendersonville, N.C., plant to optimize manufacturing speed and efficiency. Guided by LEAN principles, pull replenishment and Six Sigma, we reduced order fulfillment from an industry standard of four to six weeks to 10 days or less, with a 95 percent or higher fill rate. Even faster in emergencies or out-of-stock situations, with 24-hour turnarounds possible. In addition, the new GE Customer Connect Internet-based system simplifies order management to ease inventory management and installation planning all the way down the line.

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Application Photos


Walmart
Advanced reflective optic technology
High uniformity, excellent vertical light distribution,
reduced offsite visibility & glare

Evolve™ LED Area Light Fixtures

LED address light trespass control more efficiently

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Increased Uniformity

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Why GE?

Pioneers in Lighting

- 100+ years of Roadway Lighting Expertise

Complete Roadway Portfolio

Proven & tested product line

- 1 million+ Test Hours

Products are Made in America

- Vertically Integrated

Customers are our long term partners

- Solution Provider

GE offers continuous cutting edge innovation

- LightGrid Wireless Controls
- Intelligent Cities
- https://www.youtube.com/watch?v=cAn9lNaUBsQ
- https://www.youtube.com/watch?v=rWcffadDNdM&feature=youtu.be

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