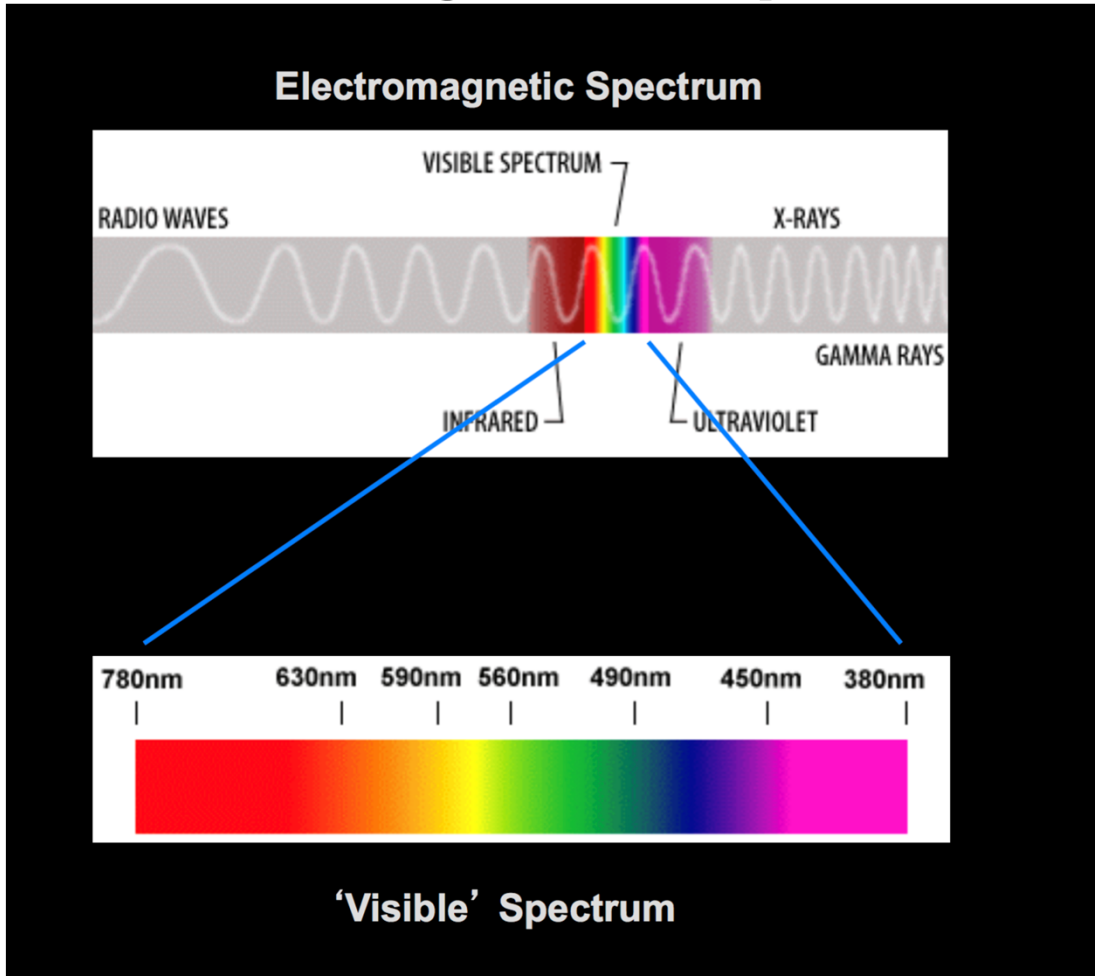
LED Lighting
Good News Today
Bad News Tomorrow??

C & W Energy Solutions
Paradise Valley, AZ 85253
Phone: 480-998-1694
email: drbobadams@gmail.com
www.cwenergyusa.com

Electromagnetic Spectrum



LED Lighting Specifications Today

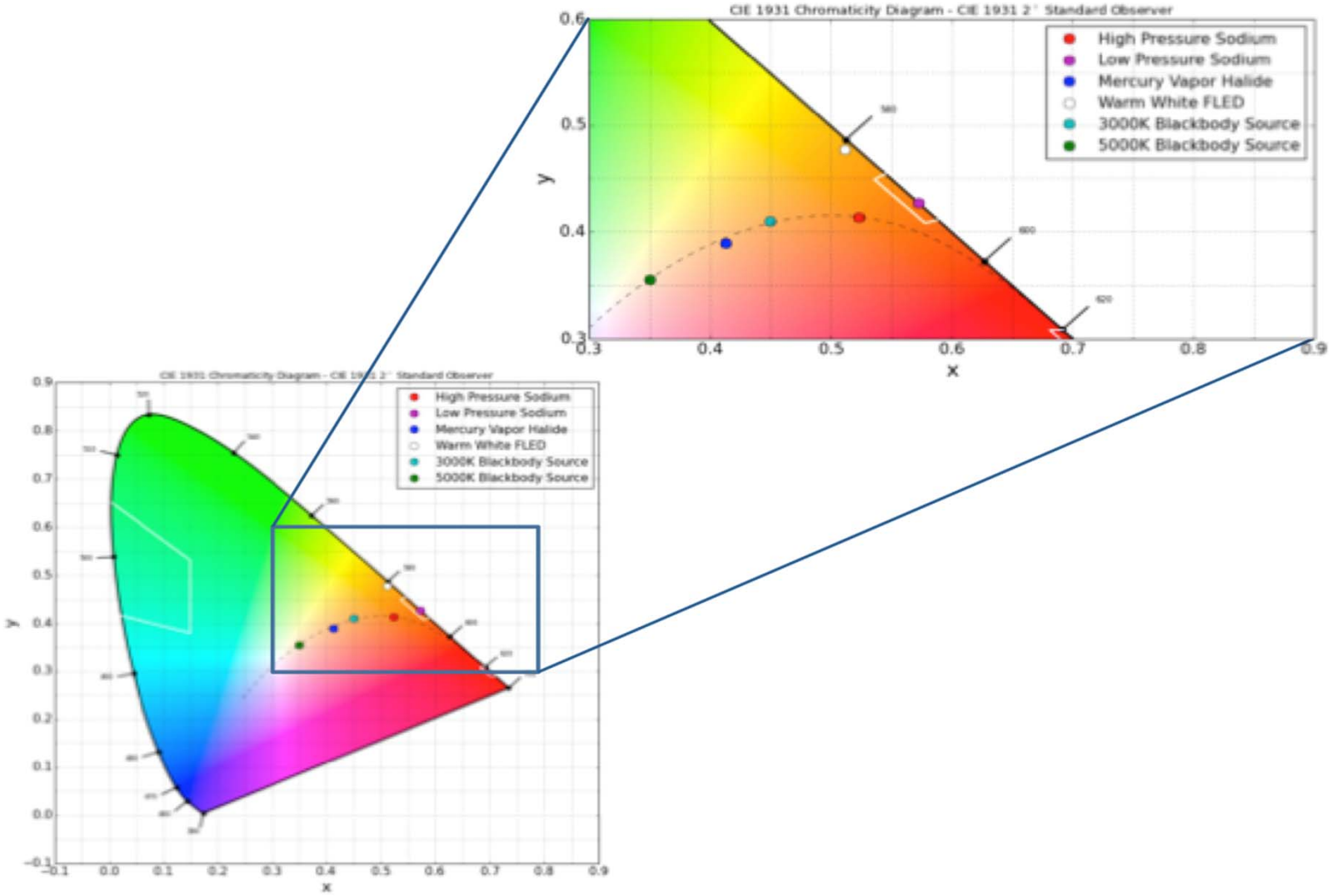
Current Definitions

- Lumen output - Lumens
- Efficacy – Lumens/Watt
- CRI
- CCT
- S/P Ratio

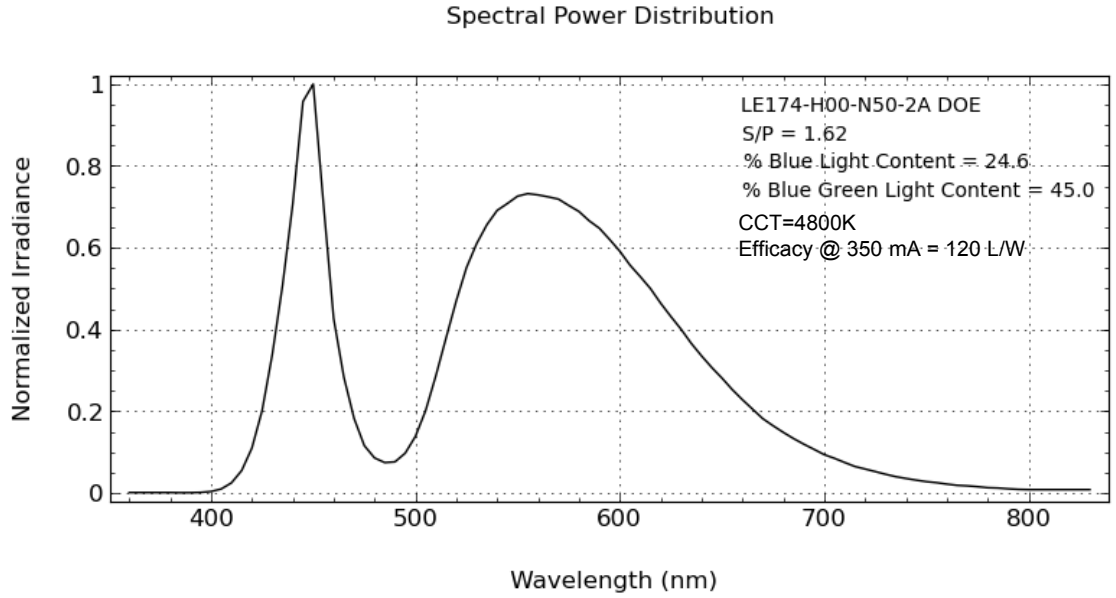
Roadway Lights – C of HI

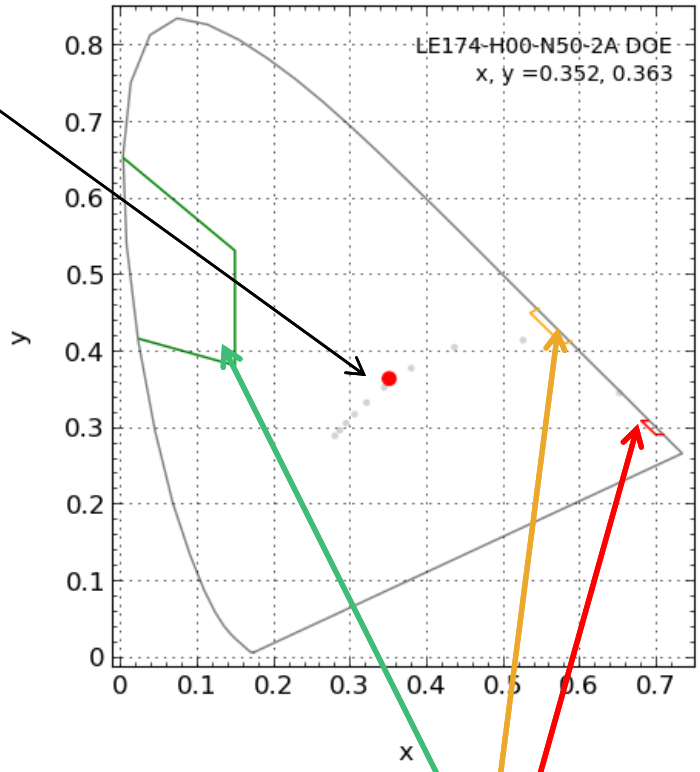
- Background CWES with C of HI
  - Street Light Conversion - 2009
    - County of Hawaii (COH) – Power costs in 2008 were $0.25 / kW-Hr and increasing each year.
    - Maintenance Costs – The cost to maintain the LPS lights was increasing as hardware aged and LPS suppliers dwindled.
  - Specifications – Want List
    - COH
      - Efficiency
      - CRI
      - Reliable
      - Outside the ITE Traffic Box
    - Observatory
      - Blue Light Content = Σ400nm:500nm/Σ400nm:700nm

CIE Color Chart - LED



Spectral Test Report: LE174-H00-**N50**-2A DOE





Planckian Curve

ITE Traffic Signal specs for x:y – G-A-R

Analysis performed with SAGE using Python;
script will be made available via a website soon.
Feb 1st, 2014

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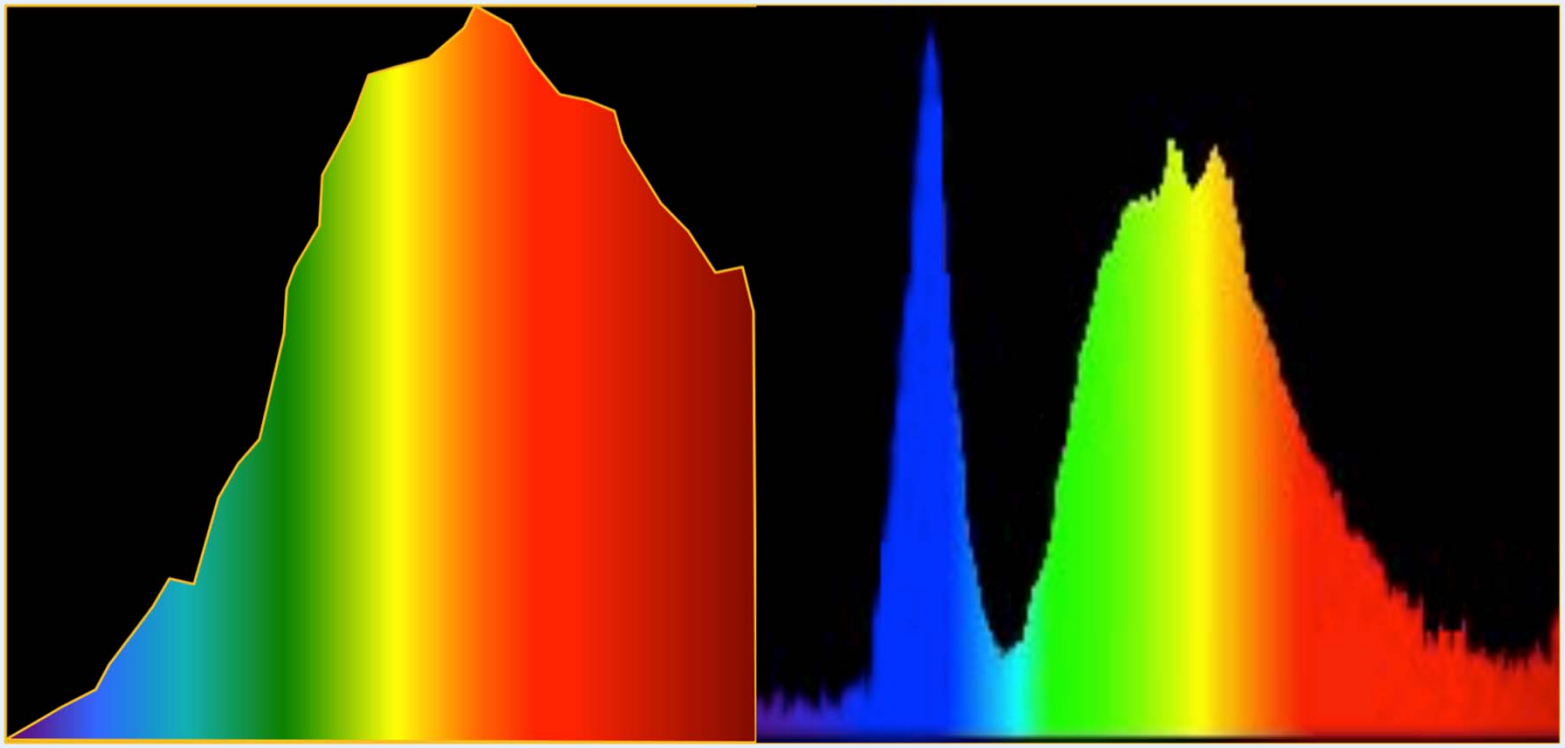
LEAAA-H00-NBB-CC-2V-CW
AAA = LE Construction; 174 for24 White LEDs; 168 for18 White LEDs
H00 = Constant Current
BB = Color Temperature; 30 for 3000K; 50 for 5000K
CC = Refers to the Optics for the Polycarbonate Cover (eg 2A)
2V = UL Approved
CW = Refers to the type ***StarFriendly***® Filter

LED Lighting Specifications Today

LED is not "natural"



Moonlight, 4125K, λ_p=610 nm

LED, 4000K, λ_p=450 nm

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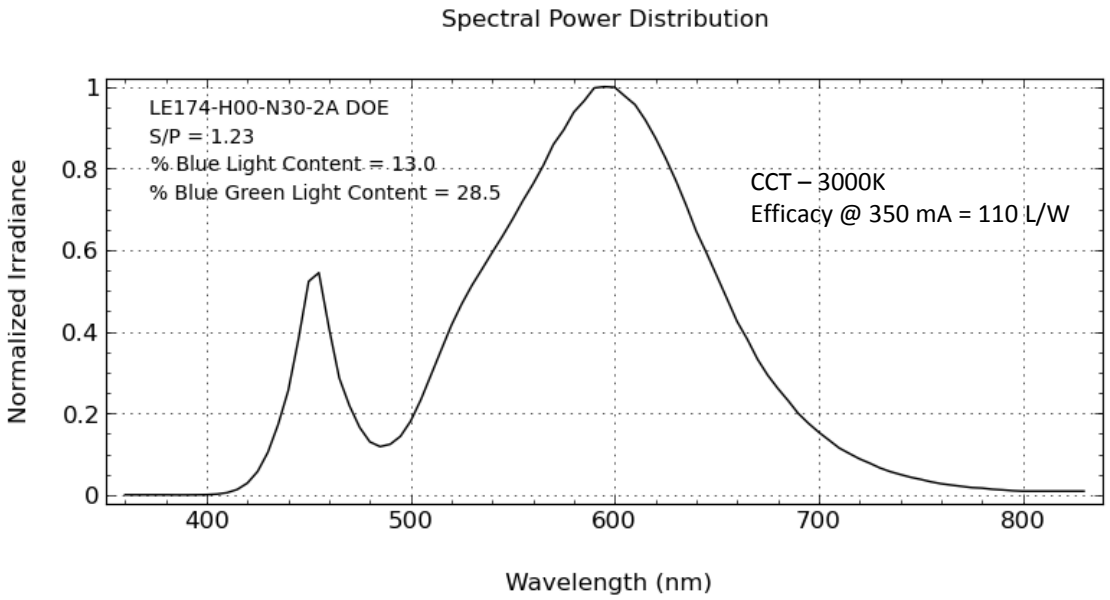

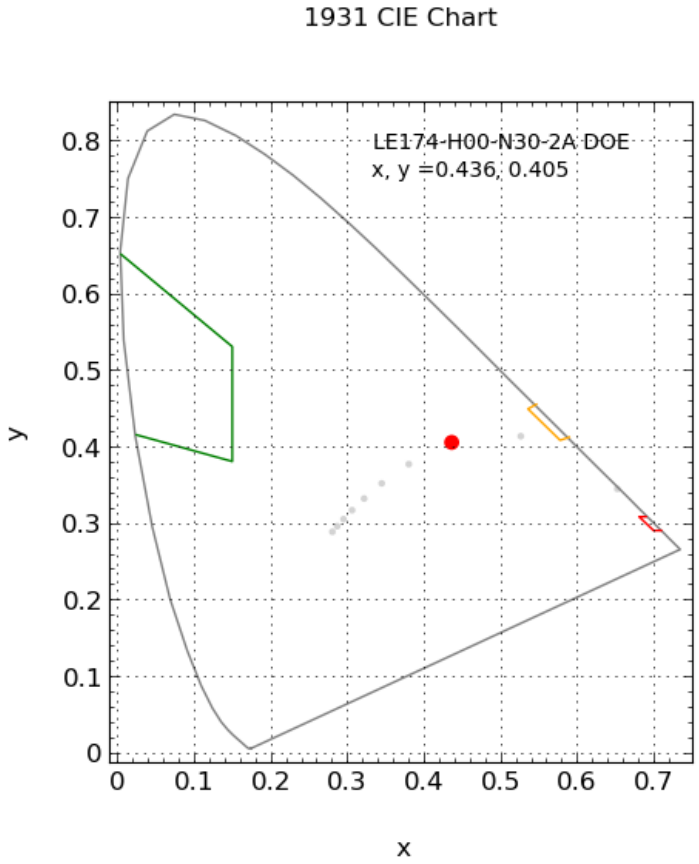

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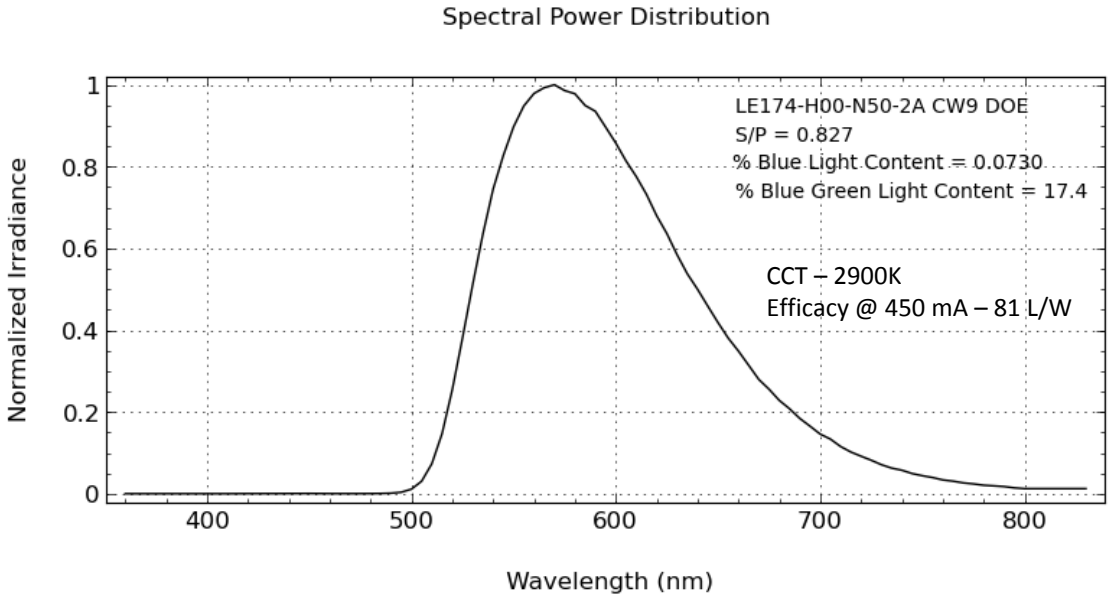
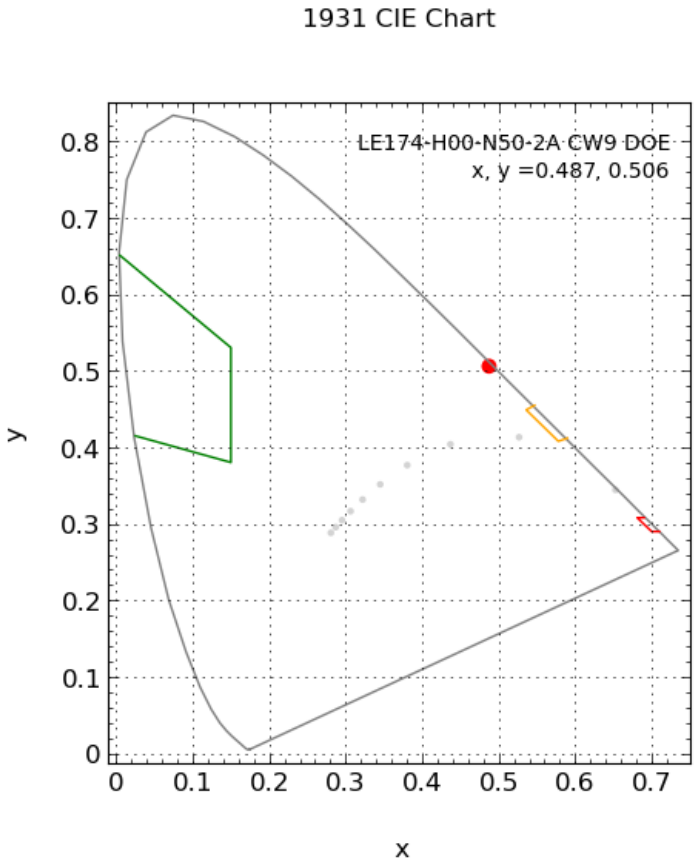
Spectral Test Report: LE174-H00-**N50**-2A **CW9** DOE





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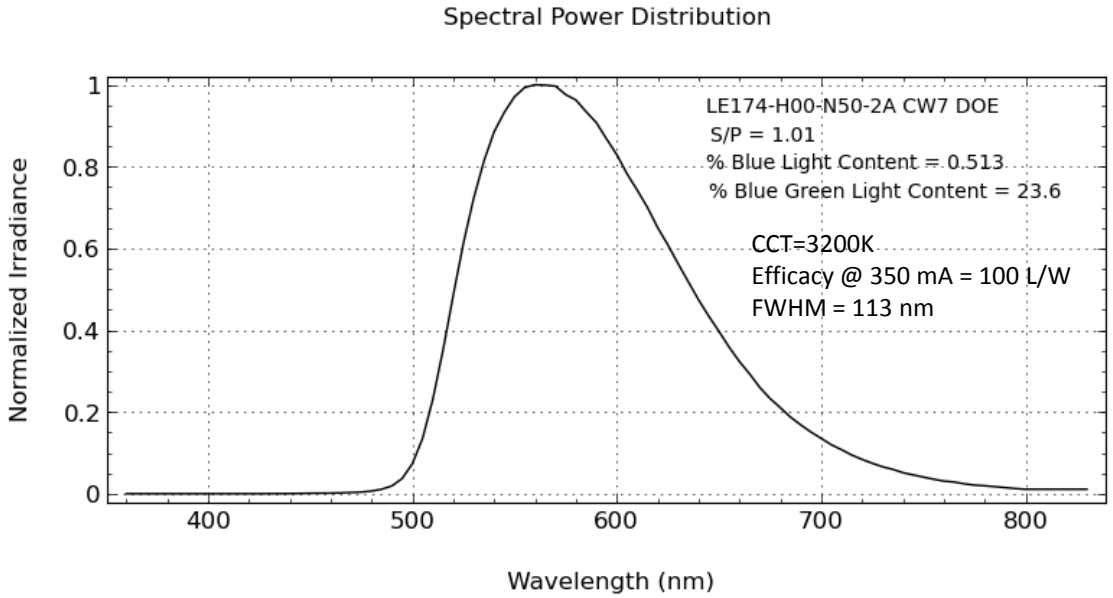

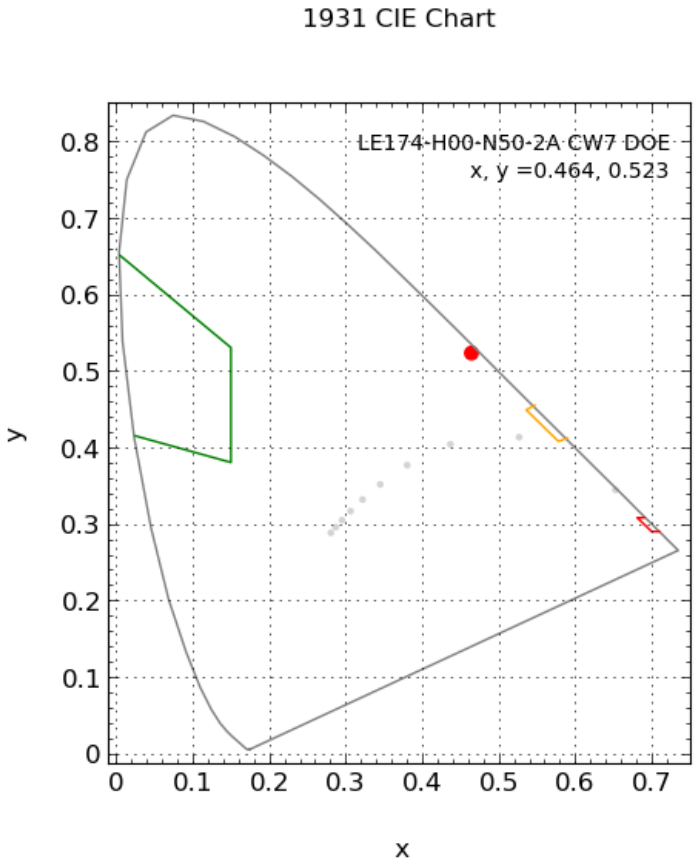

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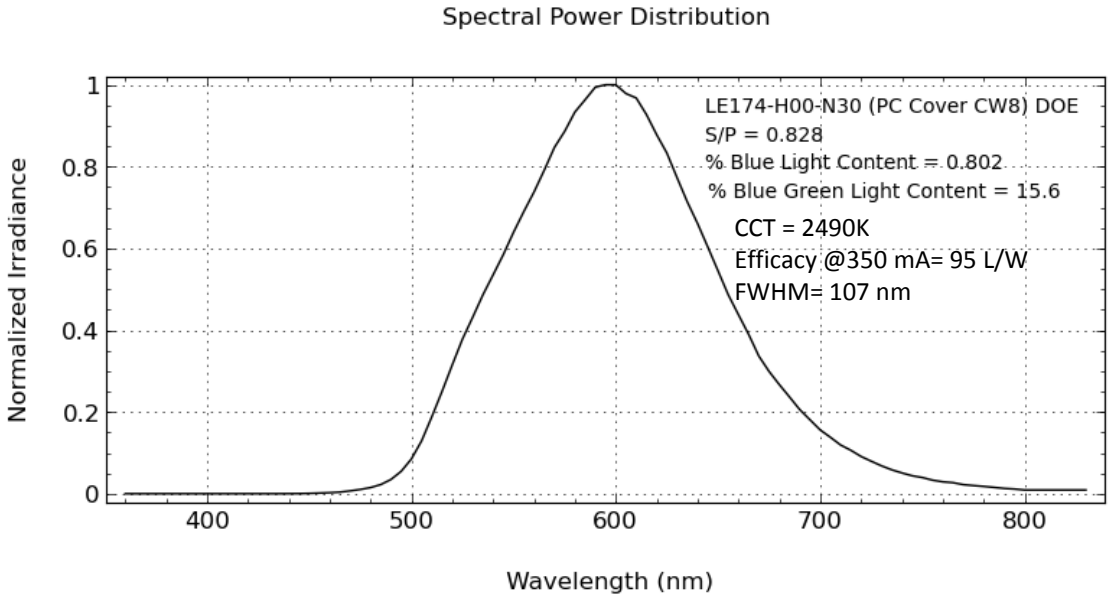
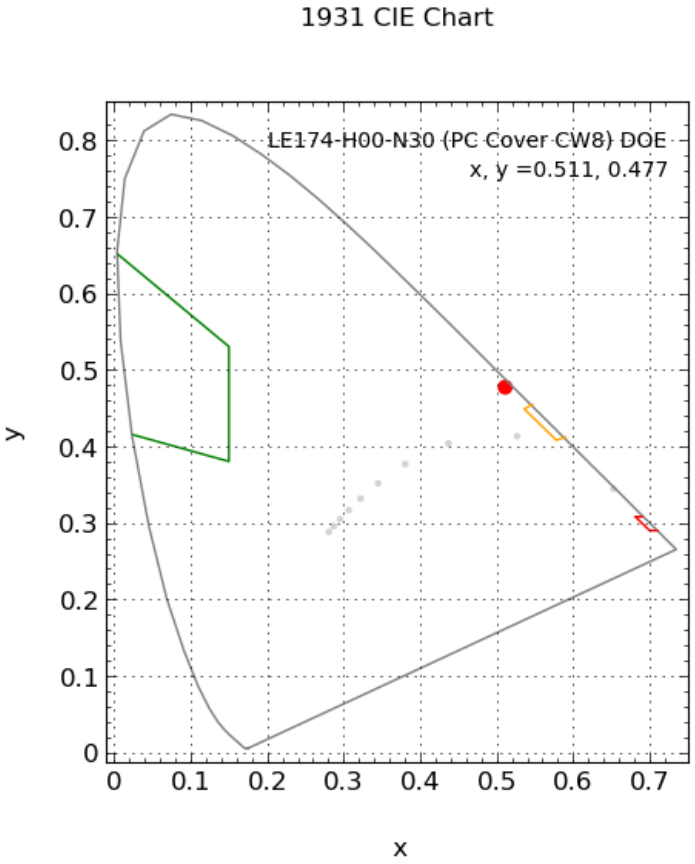
Spectral Test Report: LE174-H00-**N30** (2V **CW8**) DOE





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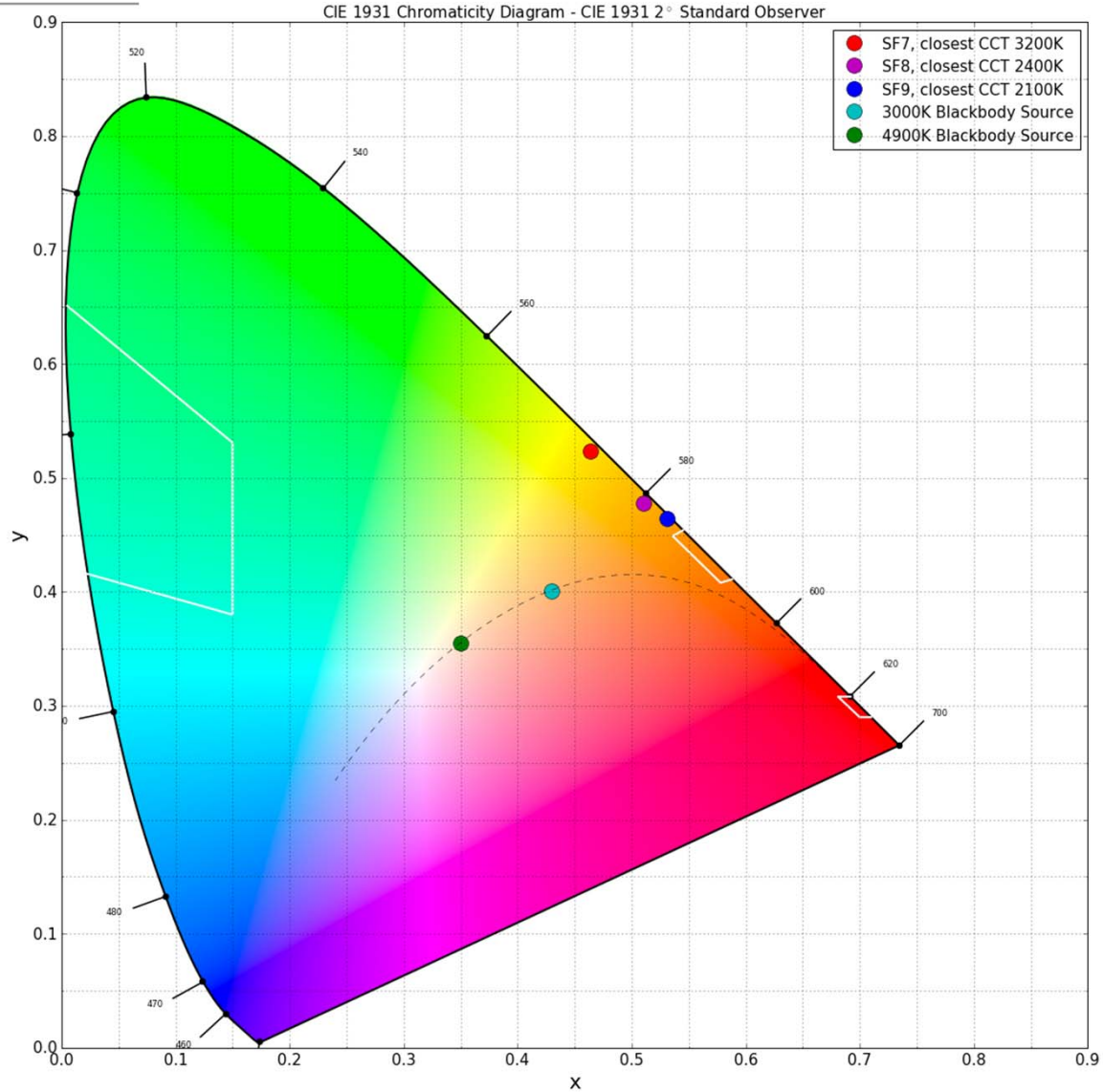
CIE 1931 Color Chart - FLED



26 W Luminaire – Replace 55 W (84W) LPS

ETL – Listing # 5002255
LE – Foxconn - > 100 patents
Fabricated in Tempe, AZ
Weight – 10 Lbs.
EPA – 0.7
Mounting Adjustment - +/- 20˚
Full Cut Off
Efficacy with Power Supply- 100 L/W
Filter RoHS Compliant
Nichia 383 LED
Warranty – 10 Years
Units in Service in HI: 13 for 6 years and 1000 for 3+ years
CWES has longest test data for LED Roadway lighting in HI
Typical Install Time with C of HI 2 man Crew – 7 minutes
Cover with Integrated Optics and Filter is Shatterproof
Unique Design – Heat Sink NOT part of Housing

LED Lighting Specifications Today

New Definitions

- Lumen output - Lumens
- Efficacy – Lumens/Watt
- CRI
- X:Y Values
- S:P Ratio - ??
- FWHM - ??
- ??

Color Simulation

February 18, 2016

Filtered LED Color Rendering Capabilities

The *Star-Friendly*® LED luminaires from C & W Energy Solutions are comprised of warm-white or cool-white LEDs and yellow filters to block blue light. The spectra are shown in FIG. 1.

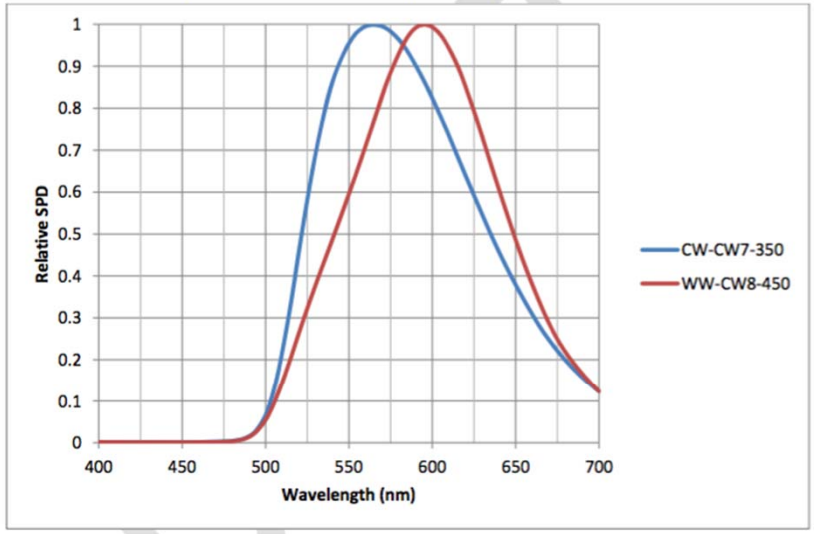


FIG. 1 – *Star Friendly* luminaire spectral power distributions

Viewed directly, the luminaire emissions appear to be strongly chromatic, as indicated by FIG. 2:

FIG. 2A – WW-CW8-350

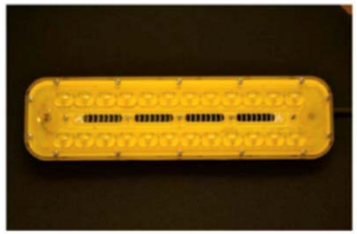


FIG. 2B – CW-CW7-350

Color Simulation

However, the perceived color of objects illuminated by these luminaires will not appear monochromatically yellow, as the human eye adapts to the dominant color of the illuminant.

This *chromatic adaptation* (see https://en.wikipedia.org/wiki/Chromatic_adaptation) is responsible for the human eye to perceive objects with approximately stable colors, regardless of the white color temperature. The same psychophysiological mechanism enables to perceive colors under strongly chromatic illuminants, albeit with sometimes drastic colors shifts.

It is possible to use one of mathematical models to predict these color shifts. The CIE Colour Rendering Indices, for example, use the century-old von Kries chromatic transformation. A more modern and accurate model is the Bradford transformation, which was used to model the color shifts from a 6500K daylight illuminant for the two *Star Friendly* luminaires.

It is also possible to render a computer-generated *GretagMacbeth ColorChecker* chart, as shown in FIG. 3:

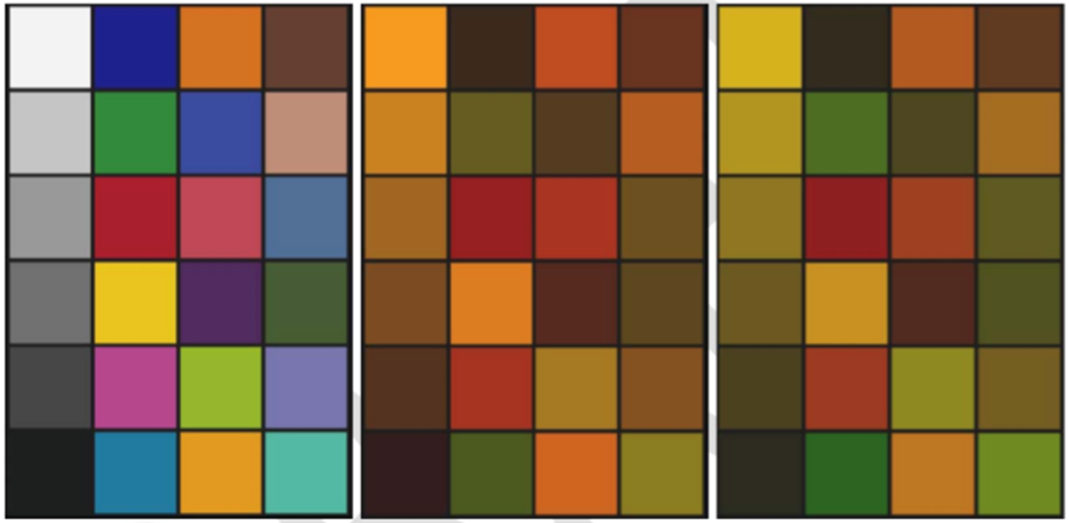


FIG. 3A – 6500K daylight FIG. 3B – WW-CW8-350 FIG. 3C – CW-CW7-350

When this document is viewed on a typical computer display with a 6500K white point, the renderings shown in FIG. 3 should reasonably approximate what an observer will perceive. These renderings are more accurate than digital photographs in that they do not rely on the spectral response of the camera CMOS sensor and its undocumented white balance algorithm.

For comparison, the Star Friendly luminaire color renderings are compared with a 2100K high-pressure sodium lamp (Venture Lighting LU150/55/D) with a CRI of 22 in FIG. 4:

Color Simulation

FIG. 4A – 2100K HPS

FIG. 4B – WW-CW8-350

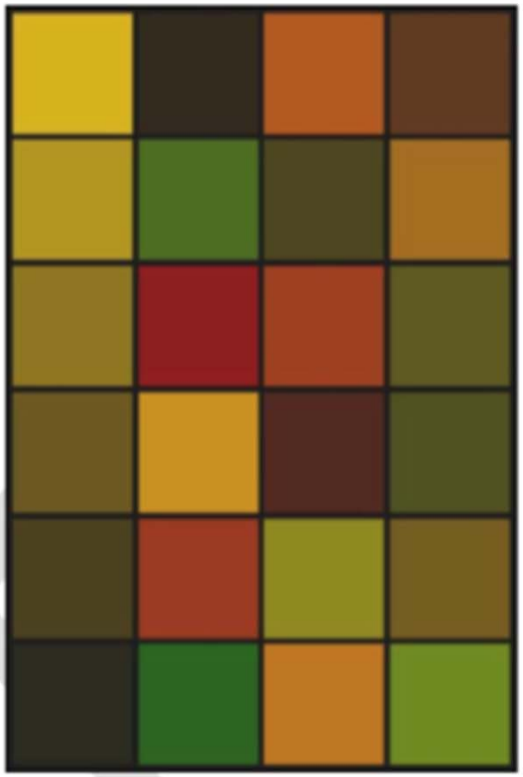


FIG. 4C – CW-CW7-350

What About Light Pollution – Sky Glow – Energy Reduction is key starting point??

Light Pollution – Sky Glow – Dark Sky

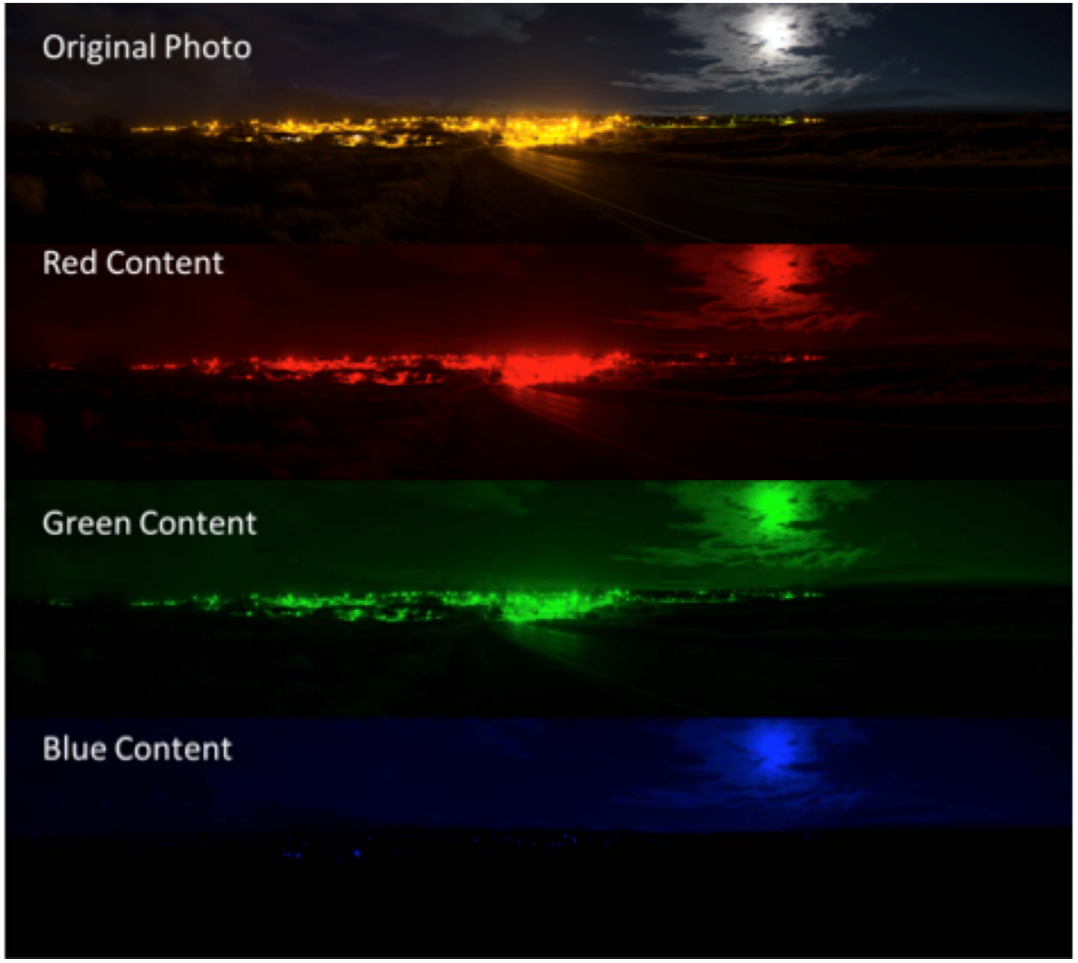
- Spectral Distribution / Light Pollution? Blue Light increase Sky Glow?
- Light Pollution: Data being collected at Waikoloa Village to quantify Light Pollution both in terms of spectra and lumen distribution and relate change to spectral data.
- Light Pollution: Hardware issue? Solution

Light Pollution – Kona Resorts

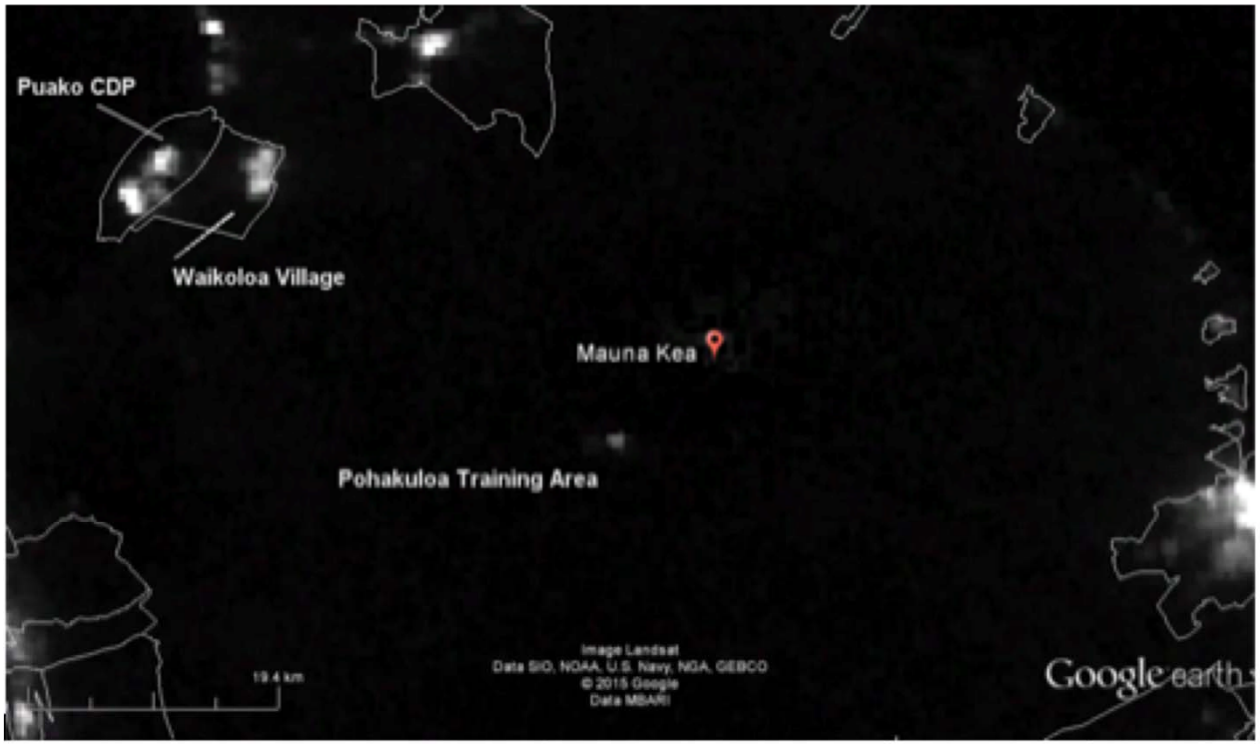
Light Pollution – Kona Resorts

Light Pollution - Study

Light Pollution - Study



Waikoloa - Before



Average satellite image from cloudless moonless nights during May 2014 (North to the top). The roads are not lit except just north of Puako, although it appears that this lighting is on the side of the road and not particularly road lighting. Hard to see in this image but there appears to be some very faint reflections off of Mauna Kea on the Eastern side particularly. This could be from the bright source at the edge of the image and another just out of the AOI to the South. The outlines are shape files for the areas. Puako is a census designated area with a population of about 429 in 2000. Pohakuloa training area for the U.S. Army for heavy weapons training. Waikoloa Village is a census-designated place in Hawaii County, Hawaii. The population was 4,806 at the 2000 census.

Waikoloa Village - Before

Waikoloa - After

Concerns in Communities

What About the Remainder of the ECO System?

•The Observatory community Is only a small portion of the overall Eco System.

•Some things with support data:

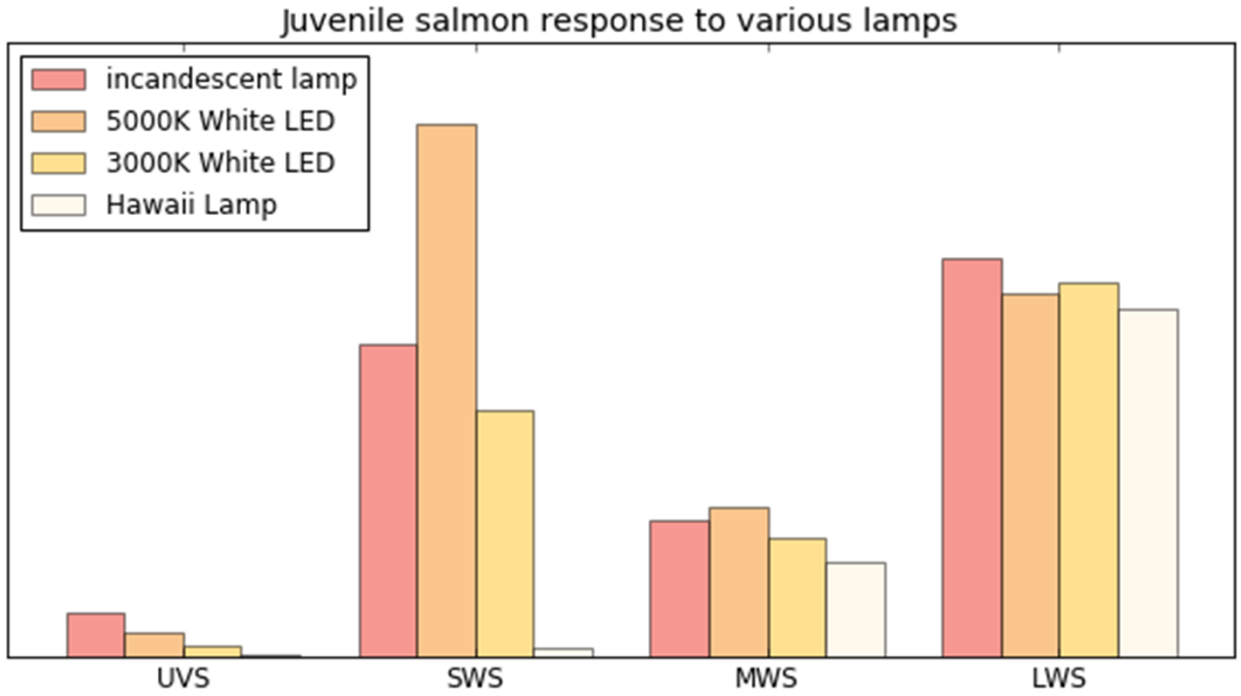
- Humans have a circadian rhythm for sleep tied to the blue light from the spectra.
- Data are available to suggest the influence of blue light on turtles

- Professor Longcore at Univ. of Southern California is studying the of the spectra on insects that are involved in the pollination of food crops.
- Attraction of birds to the offshore oil rigs can be reduced with the proper spectra.

•Some endangered species are thought to be influenced by the spectra but very limited data.

- Newall's Shear Water
- Bats
- ????

Wildlife Impacts



- The above graph compares 4 different lamps and how a juvenile salmon might respond. The salmon have 4 photoreceptors referenced herein as UVS, SWS, MWS, and LWS (UV sensitivity, Short-wave sensitivity and so on). Salmon tend to move towards lights that produce UVS and SWS detectable light. They are possibly responding to what they perceive to be bioluminescent plankton (food). Light that produces a lot of uv or blue light has damaging results to the population of juvenile salmon. This model compares a few lamps (and how much of the light from these lamps are detected by each photoreceptor) – the Hawaii light (installed in Hilo) compares VERY well to incandescent (3000K), cool white and warm white LEDs.
-

Food Chain Impacts

LED Lights

Summary

Let's Better Understand Today the Solution That We Propose To Use to Fix Problems of Tomorrow

We Do Not Want the LEDs of Today To Be the Asbestos Cases of 2040.


C&W
ENERGY SOLUTIONS

Support Data – Not For Presentation

LED Lights

Take Away

LED

Light Emitting Diodes

L – Lies

E – Exaggerations

D- Denials


C&W
ENERGY SOLUTIONS

Introductory Comments for data included.

The spectral scans in this report were done at the UL test laboratory in Phoenix, AZ and the corporate test labs at Foxconn Corporation. From these tests multiple parameters are measured (M) and from these data other specs can be calculated (C). All data in the file are based on the LE 174 unit offered by CWES and used for the roadway lighting on the Big Island of HI.

1. The PN for each unit is shown in the upper right corner. The N50 is 5000K and N30 is 3000K. The CWX represents the type of filter used.
2. Spectrum from 350 nm – 850 nm – M
3. Power at each wavelength measured in 1 nm increments – M
4. Efficacy in Lumen / Watt (L?W) of the unit with the power supply included – C
5. CCT – C
6. Full Width Half Max is reported for some filtered samples (FWHM) – C
7. Blue light content in the spectrum from 400 nm – 500 nm inclusive as a percentage of the range from 400 nm – 800 nm - C
8. Blue + Green content in the spectrum from 400 nm – 550 nm inclusive as a percentage of the range from 400nm – 800 nm – C
9. On each plot is a red dot that is the x:y coordinate for the sample measured - C
10. Each plot shows the ITE ST-052 500/AGS-PM/1105 box which is the range of x:y values allowed for the Red – Amber and Green signals – M
11. The Plankian curve (also known as the Black Body curve) is shown on each 1931 Color Chart
12. The S/P (scotopic / photopic) ratio is shown for plot – C
13. Note the location of each x:y coordinate. This normally falls on the Planckian curve but clearly does not for the FLED. This understanding is a critical feature of the technology and important for people specifying LED lighting.
14. The LED industry uses CCT to specify lights but careful study of two samples show the fallacy of the Plankian curve to specify LEDs - LE174-H00-**N50**-2A **CW9** DOE compared to LE174-H00-**N30**-2A DOE

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script will be made available via a website soon.
Feb 1st, 2014

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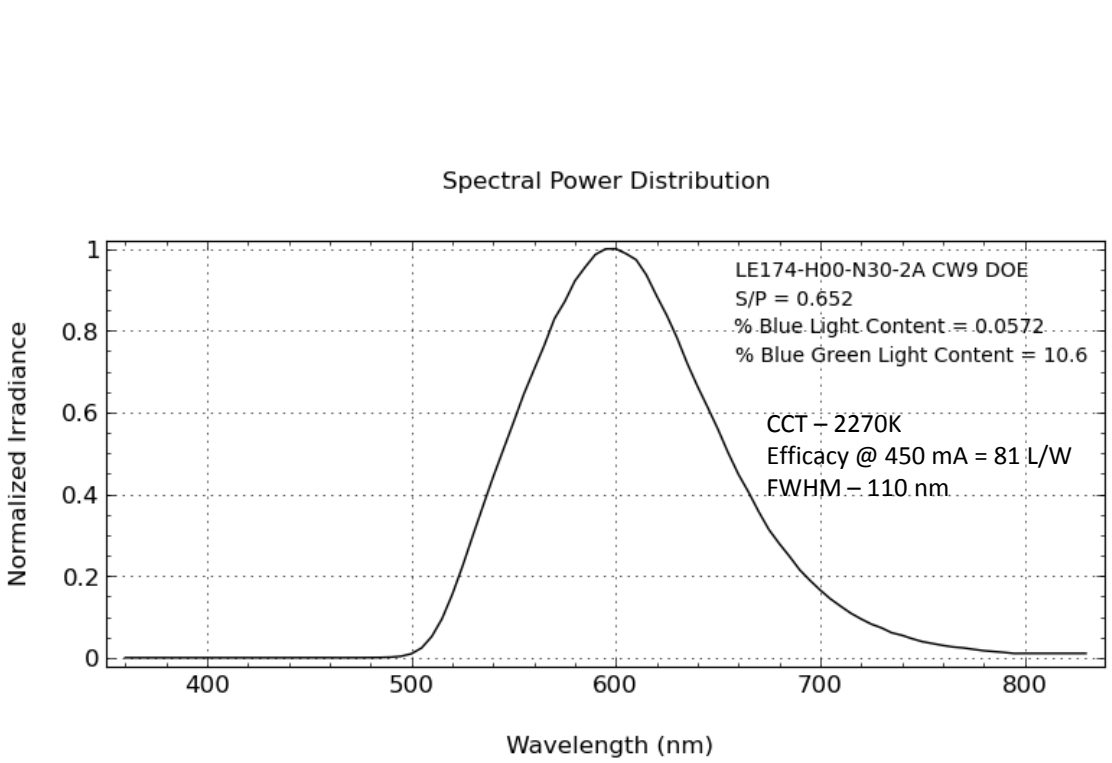

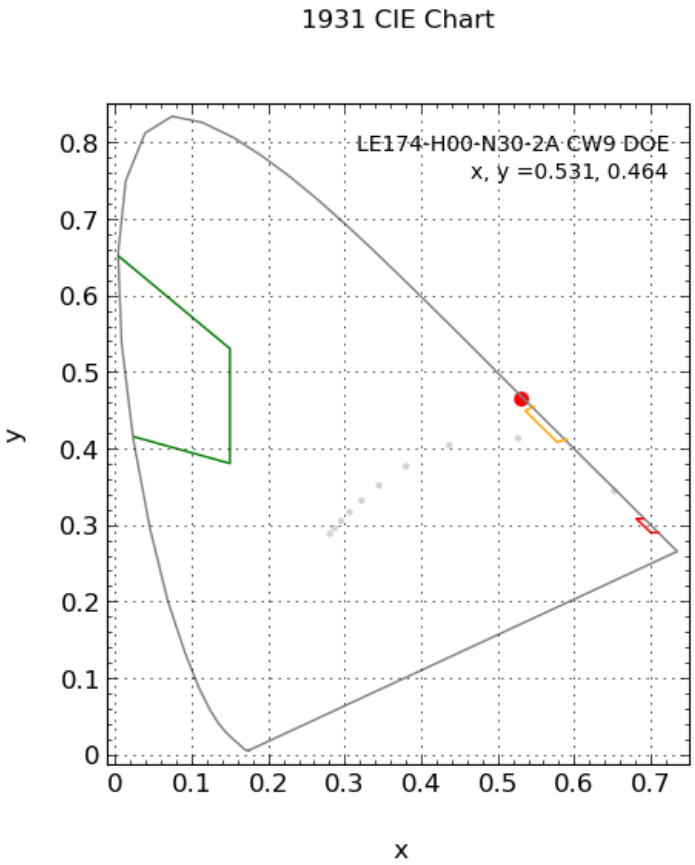

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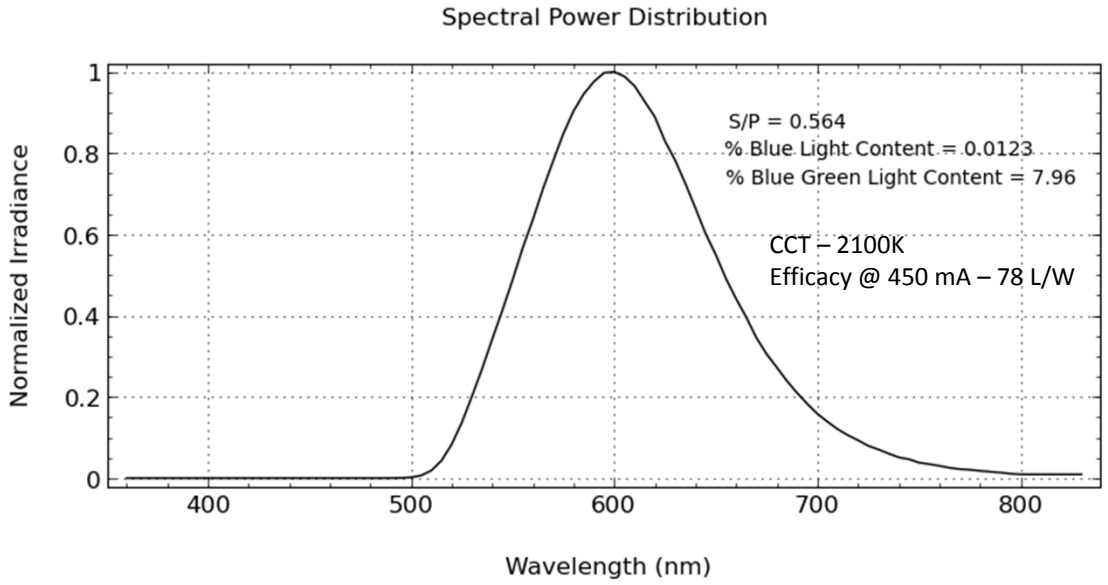
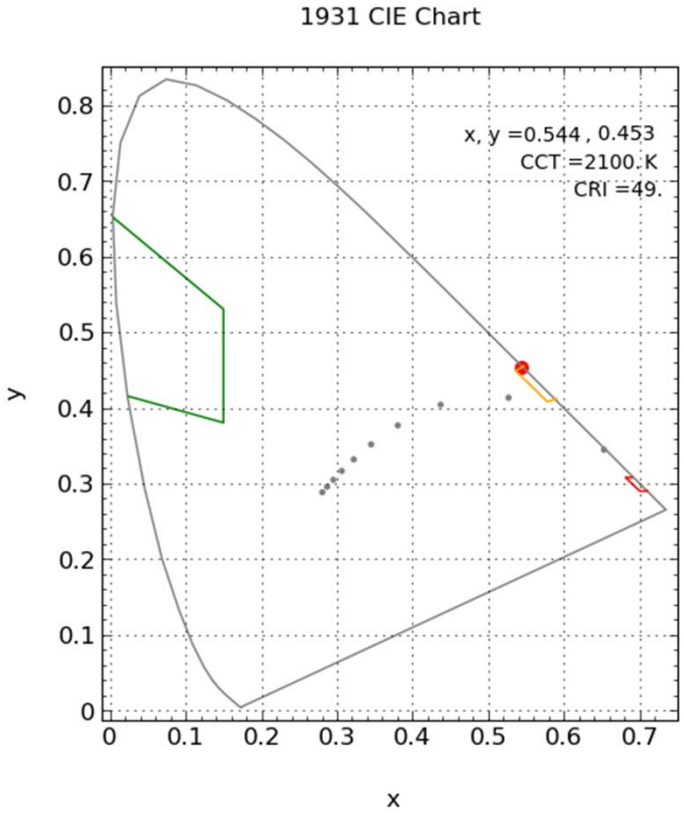
Making Every Lumen Count™

Spectral Test Report: LE174-**N30**-2V-**CW10**-DOE3





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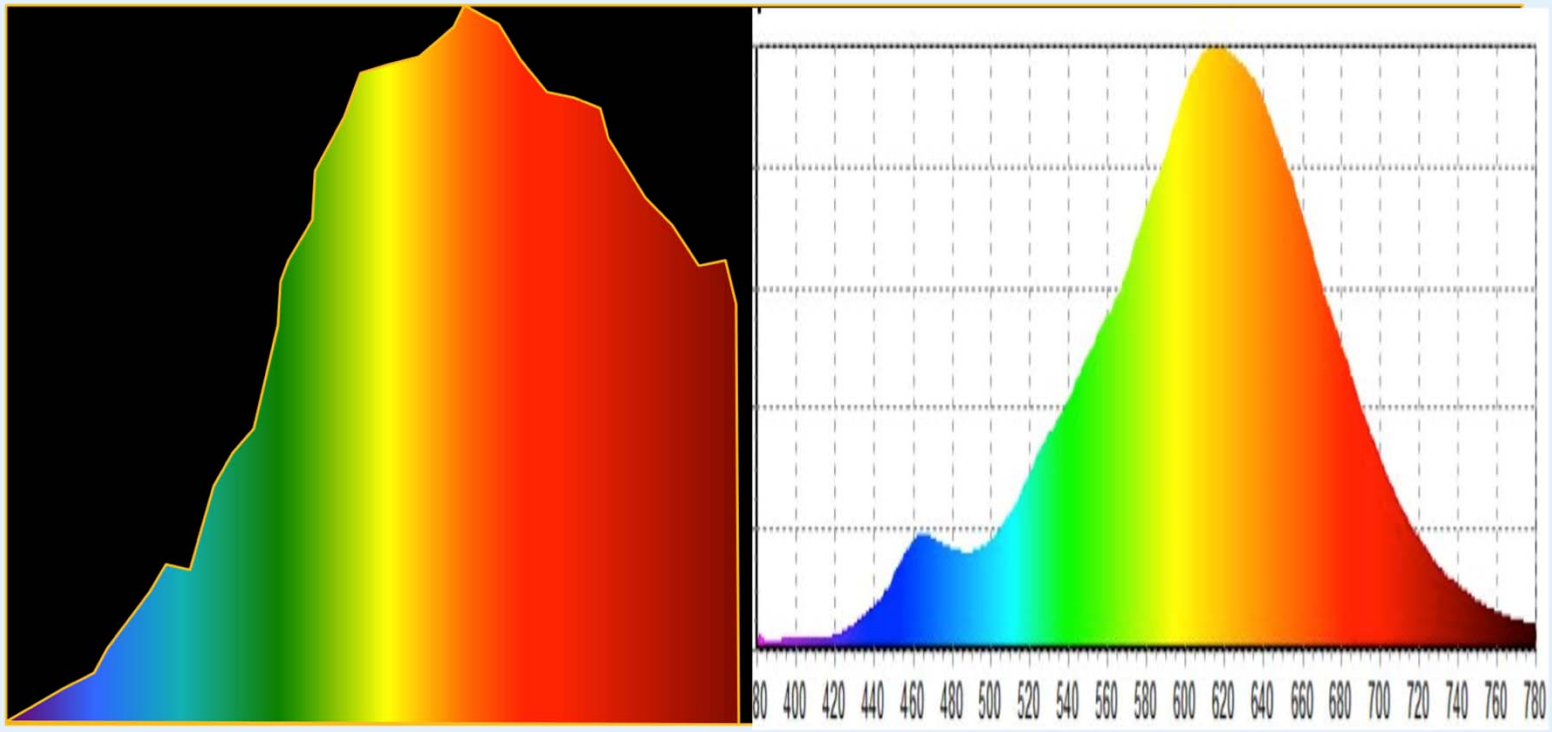


Moonlight, 4125K, λ_p=610 nm

LED, 2200K, λ_p=617 nm

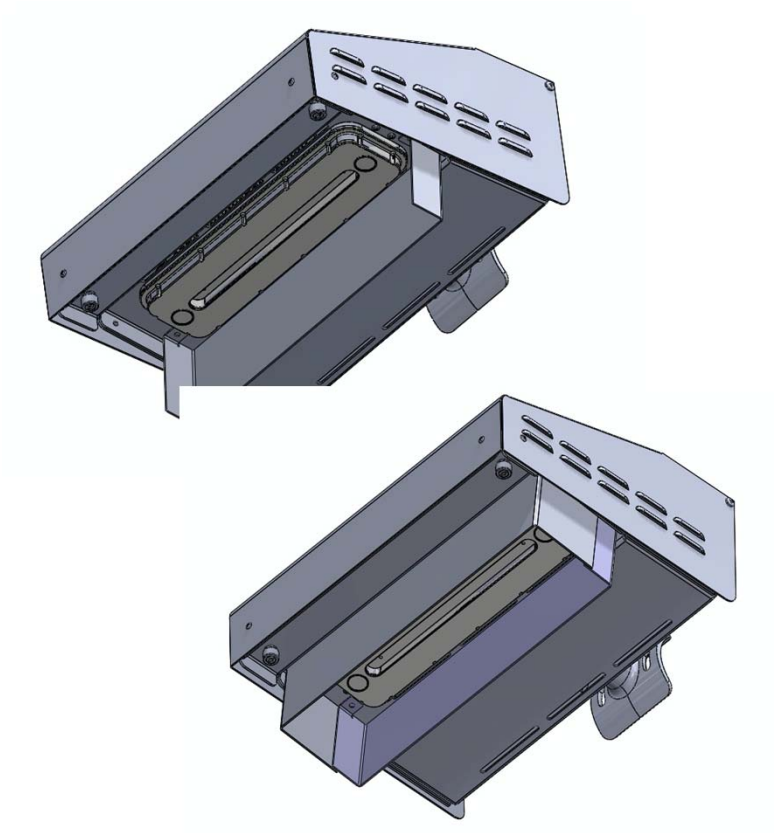
Light Pollution - Study

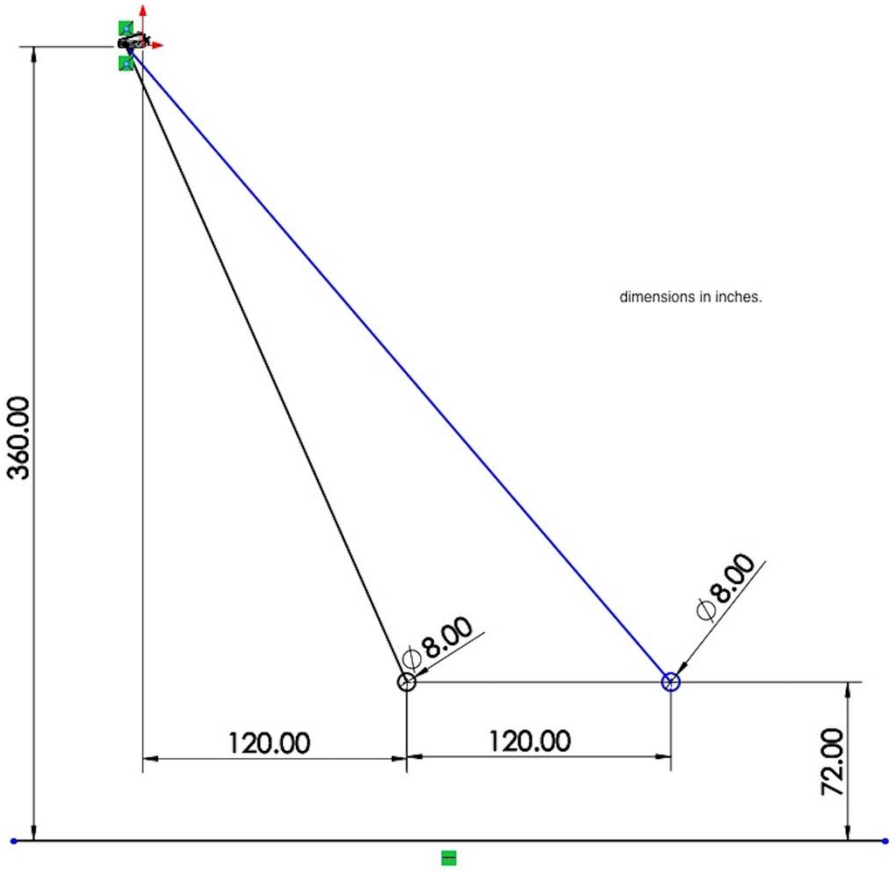
Waikoloa Village – Population – 6600
Altitude above Sea Level – 1000 ft
Street Lights – 550
Non roadway lights - 100

Light Pollution – Kona Resorts

26 W Luminaire – Residential House Shields

ETL – Listing # 5002255

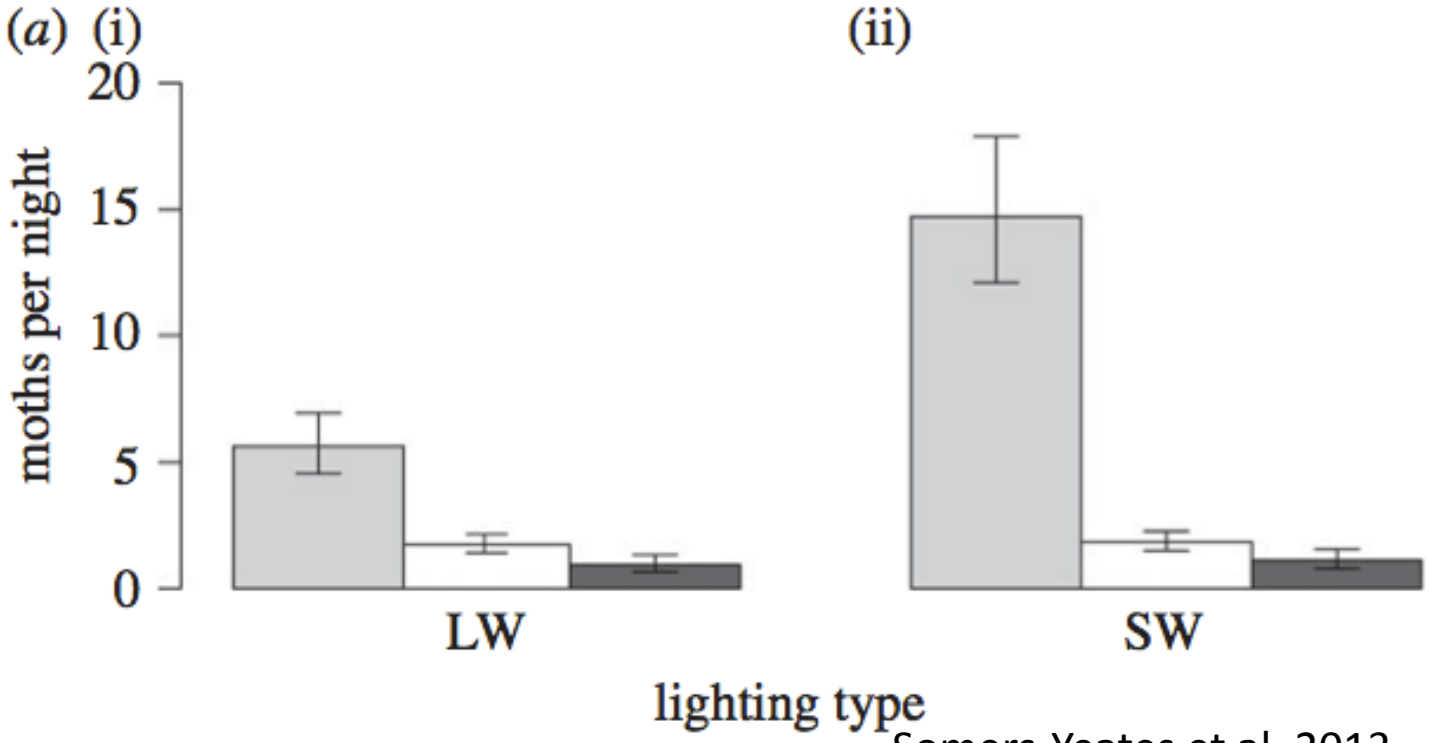




Waikoloa - Before

Controls and **spectrum** are the frontier

Short wavelengths attract more insects



Somers-Yeates et al. 2013

Roadway Lights – C of HI - Comments

Comments From Residents – County

- For first 1000 lights installed in 2012 – Energy Savings = 62%
- Citizens commented on better visibility at intersection with new lights
- Citizens like the esthetics of neighborhoods with new lights

•**Comment #2**
Date: October Comment 2 - **From:** Karen Arnold <karendw@hawaii.rr.com> 21, 2014, 10:16:12 AM HST
To: <Ronald.Thiel@hawaiicounty.gov>
Subject: ALII STREET LIGHTS

•First, thank you, thank you for changing out the street lights in Alii Heights. Only the people who live in this area and have since the beginning know what it has been like the last eight or so years, once they were turned on. Honestly, I was having to sleep with my bedroom shades down to get rid of the light shining from across the street onto my bed - and during one of the hottest summers in a very long time. We can now enjoy sitting outside at night and not have our front yard lit up as if the sun was still up. We live on a corner and from our lanai we have four lights that surround our house - really?

•That's not counting another four on the other streets that would shine on our property. It is sooooo nice now and we are very appreciative of the work our friend and neighbor Don Nelson has put into this. Looking forward to when the rest of the lights on Kapu Kapu and the street above us are changed out as well. Again, thank you for helping our community.