

FINAL LETTER REPORT

ADAPTIVE OUTDOOR LIGHTING FOR THE HEALTH CARE SECTOR



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ABOUT CLTC

The California Lighting Technology Center's mission is to stimulate the development and application of energy-efficient lighting by conducting technology development and demonstrations, outreach and educational activities, in partnership with lighting manufacturers, lighting professionals, the electric utility community and governmental agencies. CLTC was established as a collaborative effort between the California Energy Commission and UC Davis, with support by the U.S. Department of Energy and the National Electrical Manufacturers Association (NEMA).

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1 EXECUTIVE SUMMARY

Addressing the outdoor lighting of commercial facilities is an important part of state and national efforts to reduce energy consumption, lower associated operating costs and decrease greenhouse gas emissions. New technologies such as adaptive networked lighting control systems can help significantly reduce energy use in unoccupied outdoor areas while adding new amenities and safety features to previously static luminaires.

Health care facilities often have very stringent lighting requirements. The successful implementation of adaptive outdoor lighting systems in this sector will verify the positive impact of such systems, validating the technology for both this sector and other commercial sectors with less stringent lighting requirements.

Retrofit technologies selected for this 2013–2014 demonstration at NorthBay VacaValley Hospital included 57 LED luminaires, passive infrared (PIR) and microwave motion sensors, and a wireless radio frequency mesh network control system. Products were selected for their demonstrated ability to operate lights at full and dimmed levels during periods of occupancy and vacancy, respectively, and allow for remote access to verify operation and transmit maintenance alerts. Selection criteria were also set to meet or exceed the Illuminating Engineering Society's recommended practices for photometric performance and the DesignLights Consortium's criteria for inclusion on its Qualified Products List.

Individual system components had to be customized in order to integrate the luminaires, sensors, networked control modules, and mounting hardware into one system. Customization work for this demonstration was performed in the lab at the California Lighting Technology Center (CLTC), UC Davis. Large-scale customization will require that integration be performed either at the factory or by a participating energy service company (ESCO) or contractor. For its role in this demonstration, CLTC was recognized with a 2014 award for Best Use of Lighting Controls in a Single Facility from the Lighting Energy Efficiency in Parking (LEEP) Campaign.

Laboratory and field measurements were conducted to verify the electrical and photometric performance of the adaptive outdoor lighting system. Metering systems calibrated to industry standards were used to collect quantitative data on the system's operation.

The pre-retrofit energy use for the baseline lighting system was calculated assuming full light output of the incumbent luminaires selected for retrofit. The pre-retrofit energy consumption of the demonstration site totaled 43,657 kilowatt-hours (kWh) per year. After implementing the adaptive controls, the lighting system's energy use was monitored and extrapolated to an annual total of 14,639 kWh. This 66.4% reduction in lighting energy use is based on observed occupancy rates of 35–55% in various areas of the site. At NorthBay VacaValley's blended, off-peak electricity rate

of \$0.08 per kWh, the retrofit is expected to yield annual energy cost savings of \$2,321. Over the system's estimated life of 10 years, these savings will total approximately \$23,210.

Economic analysis of the installation at NorthBay VacaValley Hospital, as compared to the predominantly induction-based incumbent lighting system, was performed using the energy data collected at the site. Simple payback, return on investment (ROI) and the internal rate of return (IRR) were calculated for a cross-section of energy costs.

Calculations were conducted considering the cost of energy, the NorthBay VacaValley Hospital adaptive lighting system costs, maintenance costs, disposal costs, salvage values, and local utility incentives. Pacific Gas and Electric (PG&E) rebates were included in each cost scenario as a representative incentive facilities receive today when installing adaptive lighting systems.

The PG&E incentive provides a \$40–\$70 rebate per luminaire, with the higher rebate awarded for installations of luminaires that have a greater load reduction due to the retrofit. For the NorthBay VacaValley Hospital installation, the rebates were applied based on the difference in power consumption (watts) between the newly installed luminaires and the incumbent luminaires.

The table below illustrates how ROI, IRR and simple payback vary, based on a range of energy costs. As the market for adaptive lighting systems develops, costs for luminaires, controls and installation (labor) continue to decline, and these prices are expected to continue to come down.

| Energy Cost (\$/kWh) | \$0.08032 ¹ | \$0.10 | \$0.12 | \$0.14 | \$0.16 | \$0.18 | \$0.20 |
|------------------------|------------------------|--------|--------|--------|--------|--------|--------|
| ROI | -0.36 | -0.23 | -0.10 | 0.02 | 0.15 | 0.28 | 0.40 |
| IRR (%) | -2.00 | 0.00 | 2.00 | 4.00 | 6.00 | 8.00 | 9.00 |
| Simple Payback (Years) | 21.00 | 16.87 | 14.06 | 12.05 | 10.54 | 9.37 | 8.43 |

When conducting a lighting system upgrade, the economic analysis will be largely affected by the incumbent lighting system's baseline energy use profile. The majority of luminaires at the NorthBay VacaValley Hospital site are induction luminaires. These luminaires were installed in place of the original luminaires within the last five years. As a result, a baseline wattage of an assumed high pressure sodium (HPS) incumbent luminaire was reduced from 288 Watts to 187.2 Watts. Comparing the adaptive lighting system to an HPS baseline, the simple

¹ Based on NorthBay VacaValley's off-peak, blended rate of \$0.08032/kWh through PG&E (50% winter and 50% summer energy rates).

payback for the installation is reduced to 13.38 years, with an ROI of -0.07 and a positive IRR of 3.0%.¹

2 INTRODUCTION

Commercial outdoor lighting is a key area to address in efforts to reduce energy consumption, lower associated operating costs and decrease greenhouse gas emissions. New technologies, such as adaptive luminaires and networked lighting control systems, can help significantly reduce energy use in unoccupied outdoor areas while adding new amenities and safety features to previously static luminaires.

2.1 OPPORTUNITY

The Energy Information Association's (EIA) 2007 Commercial Buildings Energy Consumption Survey (CBECS) estimated there are 3,040 large hospitals (over 200,000 sq. ft. in size) in the U.S. and that they use a total of 57 billion kWh of electricity (57,000 GWh) annually.² Indoor and outdoor lighting loads were estimated to constitute at least 10% of that electricity use (5,700 GWh annually).³ Health care facilities' extended overnight operating hours make them optimal sites for adaptive outdoor lighting systems.

Most health care facilities also have very stringent lighting requirements. Successful deployment of adaptive outdoor lighting systems in this sector may therefore help validate the technology and lead to broader adoption in other commercial sectors.

From a policy perspective, reducing lighting electricity use at large hospitals aids in meeting the goals of the Energy Security and Independence Act (2007)⁴ and the DOE Strategic Plan (2011), which seeks to "reduce greenhouse gas emissions 17% by 2020 from a 2005 baseline and to "develop efficiency standards and test procedures to address at least 75% of the energy used in the building sector."

² "Energy Characteristics and Energy Consumed in Large Hospital Buildings in the United States in 2007." *Commercial Buildings Energy Consumption Survey*. U.S. Energy Information Administration, August 2012. Web. 20 March 2014.

³ "Energy-Efficient Hospital Lighting Strategies Pay Off Quickly." *Commercial Building Initiative*. U.S. Department of Energy Efficiency & Renewable Energy, July 2011. PDF.

⁴ The Energy Security and Independence Act (2007) was enacted to "move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government, and for other purposes" and directs the Department of Energy to support and educate the public about high-performance green buildings, including technologies to help achieve a goal of net-zero energy use.

Case studies of adaptive (bi-level) LED lighting with occupancy-based controls have been shown to reduce outdoor lighting energy use by as much as 90%.^{5,6} Adaptive lighting solutions for parking lots and garages have consistently achieved energy savings of at least 40%, and many projects have demonstrated savings in excess of 70% compared to traditional luminaires without controls.⁷ Results depend on occupancy rates and patterns, proper commissioning of the technology, and system tuning and scheduling for the site. Mesh network control systems that use radio frequency (RF) communication can somewhat increase energy savings, by allowing for more refined control of individual luminaires or groups of luminaires and by enabling direction-of-travel (DOT) and other energy-saving features.

This demonstration identifies adaptive lighting components appropriate for new construction and retrofit applications into today's market. It is intended to serve as a model for similar sites seeking to improve their outdoor lighting in ways that save energy and reduce greenhouse gas emissions.

The project team selected NorthBay VacaValley Hospital, located in Vacaville, CA, as the demonstration site. This site was selected because it is a typical hospital site largely representative of others in the health care sector. Adaptive outdoor lighting solutions were designed and implemented to meet the site-specific needs of the facility; however, the design strategies and outcomes are clearly applicable to other health care facilities with similar site features, uses and requirements.

⁵ Energy Upgrade California: Energy Technology Assistance Program. *Case Study | Contra Costa Parking Lot*. Energy Solutions, n.d. PDF file.

⁶ "EvoLucia LED Lighting Saves Energy, Increases Security at Sarasota Hospital." *PR Newswire*. Sunovia Energy Technologies, Inc., 22 December 2009. Web. 18 March 2014.

⁷ "PIER Solutions for Parking Lots & Garages." PIER State Partnership for Energy Efficient Demonstrations, n.d. Web. Feb. 2014.

3 METHODOLOGY

3.1 TECHNICAL OBJECTIVES

This demonstration project had several goals, including reducing outdoor lighting energy use 50–70% as compared to uncontrolled incumbent induction and high pressure sodium fixtures. Calculated energy savings estimates ranged between 21,023 to 29,190 kWh per year, based on projected occupancy rates.

Site assessments also indicated that this demonstration of networked adaptive outdoor LED lighting would increase light levels in under-lit areas, increase lighting uniformity, and improve lighting quality by providing full spectrum light sources. The luminaires and controls selected for the demonstration were also expected to reduce light trespass, per published industry standards and best practices.

This installation is also intended to demonstrate the other features of networked outdoor lighting control systems, including automatic system alerts that can help decrease maintenance requirements. A less primary objective of the project was to observe how the system's tracking of energy use and savings might improve energy-use awareness and lead to further energy use reductions.

3.2 DEMONSTRATION PROJECT DESCRIPTION

3.2.1 PROJECT LOCATION

Located in Vacaville, California, NorthBay VacaValley Hospital is a multi-story medical facility that opened in 1987. The demonstration site is a 50-bed, non-profit hospital providing a wide range of medical services to the residents of Vacaville and surrounding communities of northern Solano County. The facility includes a 24-hour emergency care department, surgery suites and a critical care center. The outdoor grounds cover approximately 150,000 ft² of mixed-use area, including visitor and employee parking, a traffic route for emergency room patient drop-off, a helipad, and smaller utility areas.

A satellite view map, a blueprint of the grounds, and a detailed site visit helped to identify specific outdoor lighting zones with unique use features, as well as anticipated occupant types and specific lighting needs (see Figure 1).

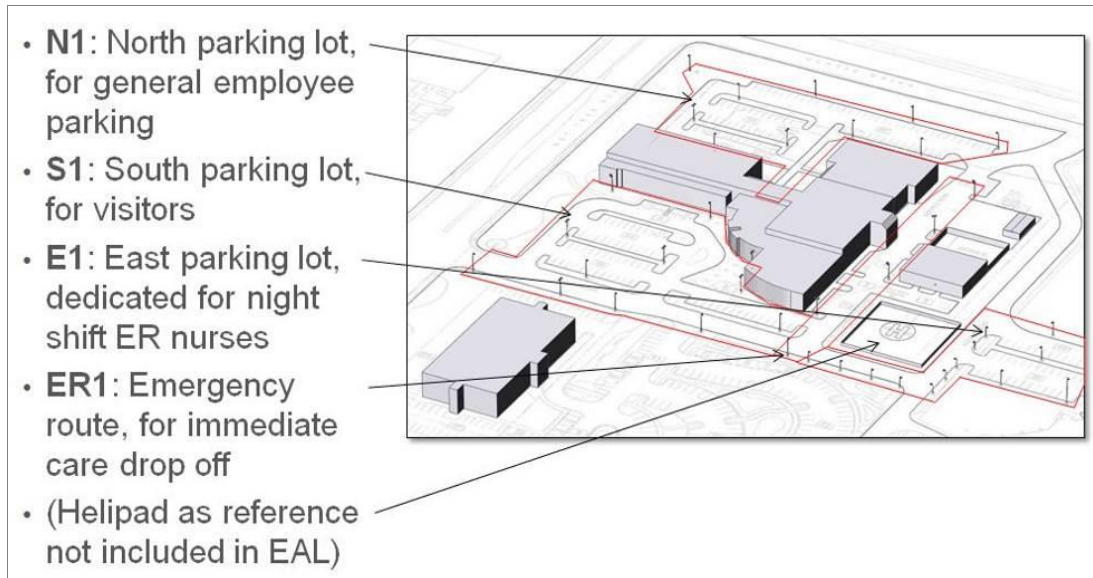


Figure 1: Combined Blueprint and CAD model of demonstration site

Interviewing the security guards helped to identify special points of concern related to site safety. Four major sections were identified (see figure 1):

1. "N1" North parking lot, for general employee parking
2. "S1" South parking lot, for visitors
3. "E1" East parking lot, dedicated for night shift ER nurses
4. "ER1" Emergency route, for immediate care drop off

The north parking lot (N1) section is used exclusively by employees. All pole-mounted, pre-retrofit luminaires in this area are induction heads. Lighting in this area was scheduled, via the RF control system, to provide high light levels during shift changes. Otherwise, the lighting in this section draws a significantly lower amount of power during the night. Any person entering this parking lot outside of normal shift change times triggers occupancy sensors, causing lighting in the whole section to go from low mode to high mode.

The visitor parking section (S1) is located in front of the main entrance. While the entrance is well lit with several bollards and wall mounted fixtures, the rest of the parking lot is under-lit due to trees covering multiple pole-mounted induction luminaire heads, especially close to the handicapped parking section. One bigger tree was recently replaced with a sapling to address this issue and allow for more nighttime lighting in this section of the parking lot. Other trees still require pruning to allow for higher light levels and better contrast ratios.

The east parking lot for night shift nurses (E1) was lit by metal halide lamps in the prior to the retrofit. These were mounted at staggered pole heights and somewhat poorly spaced. Night shift changeover also occurs here, in a similar manner as in N1, with similar expected energy savings due to a very low average occupancy rate.

The emergency route (ER1) is a special case and requires higher illuminance levels throughout, per IES RP-29-06. This is a critical area for sensor coverage and responsiveness, where the lighting system must be able to quickly switch from energy-saving mode to emergency-appropriate light levels. This area was closely monitored during installation and commissioning of the new system to ensure sensor coverage and response time met the site's requirements. All pole mounted pre-retrofit luminaires in this section were induction luminaires.

The helipad and emergency drop off lighting was not included in the site design.

3.2.2 INCUMBENT LIGHTING SYSTEM

One sample of each luminaire type installed at the demonstration site was tested for electrical and photometric parameters.



AES/NexLume "Solis"

- Induction
- 40 fixtures at demonstration site
- Test sample from Pole-ID "N-07"
- Nominal Wattage: 200 W
- Testing Preparation: Cleaned Optic



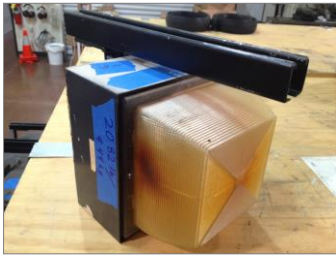
Emco, ECA-14-1-HM-70MH-277V

- High Pressure Sodium (HPS)
- 9 fixtures at demonstration site
- Test sample from Pole-ID "E-02"
- Nominal Wattage: 70 W
- Testing Preparation: New seasoned HPS lamp, Cleaned Optic



Emco, ECA-18-1-QH-250MH-277V

- Metal Halide (MH)
- 6 fixtures at demonstration site
- Test sample from Pole-ID "E-11"
- Nominal Wattage: 250 W
- Test Preparation: New seasoned MH lamp, Cleaned Optic



WP-M01

- High Pressure Sodium (HPS)
- 4 fixtures at demonstration site
- Nominal Wattage: 70 W
- Test Preparation: New seasoned HPS lamp, Cleaned Optic



Ruud GWP0625-1P

- Metal Halide (MH)
- 1 fixture at demonstration site
- Nominal Wattage: 250 W
- Test Preparation: New seasoned MH lamp, Cleaned Optic

Before laboratory testing of the incumbent fixtures, lamps were replaced with new seasoned lamps according to IES LM-54-12. All luminaires were thoroughly cleaned and tested under the voltage used at the site.

Electrical and photometric reporting includes:

- Power rating (Watt)
- Luminous flux (lumen)
- Efficacy (lumen/W)
- Spectral Power Distribution (SPD) between 350nm and 800nm
- Chromaticity Plots
- Correlated Color Temperature, CCT (Kelvin)
- Color Rendering Index, CRI
- Voltage (Volt)
- Current (Ampere)
- Power Factor
- Harmonic Distortion (UTHD% and ITHD%)

Test results for the NexLume induction luminaire are shown in Figures 2, 3, 4, and 5. The full photometric report for all luminaires is included in the appendix.

Summary

AES/NexLume "Solis", N-07

Photometric:

| Power (W) | Output (L) | CCT (K) | Duv | CRI | Efficacy |
|-----------|------------|---------|----------|------|----------|
| 187.2 | 5393 | 4646 | 0.011304 | 74.6 | 28.8 |

Electrical:

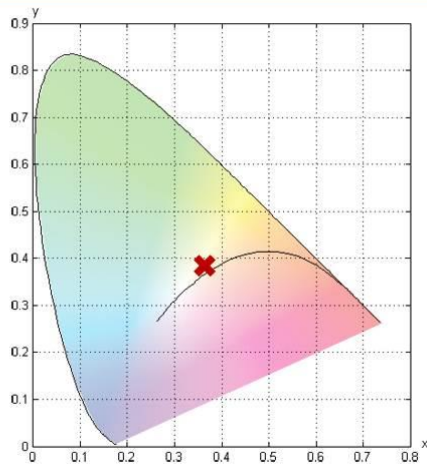
| Voltage (V) | Current (A) | Power (W) | PowerFactor | UTHD% | ITHD% |
|-------------|-------------|-----------|-------------|-------|-------|
| 276.8 | 0.748 | 187.2 | 0.9044 | 0.18 | 42.02 |

CRI:

| R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | RA |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 85.8 | 81.7 | 49.0 | 80.2 | 76.4 | 65.2 | 82.2 | 76.1 | 15.5 | 28.6 | 64.6 | 39.2 | 85.4 | 67.2 | 74.6 |

Figure 2: Electrical and Photometric Summary

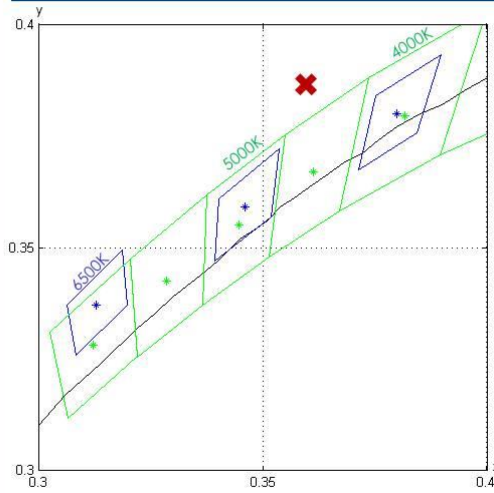
Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

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Chromaticity

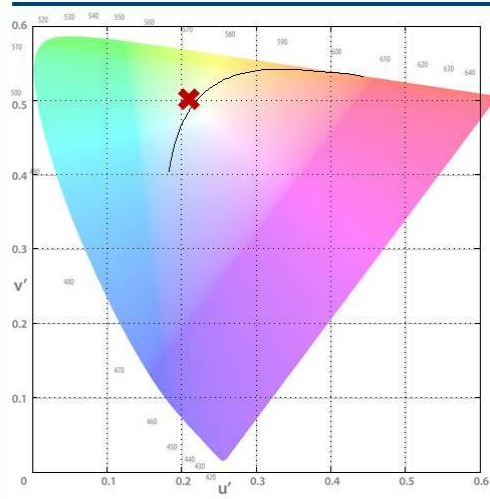


Chromaticity Diagram CIE 1931, 2 Degree

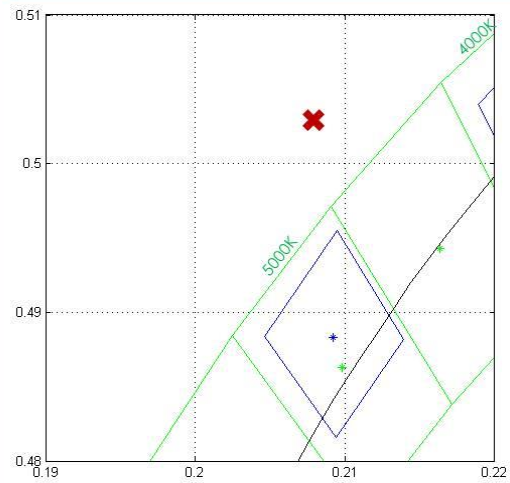
Green
Blue Q

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Figure 3: Chromaticity Diagram CIE 1931



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Figure 4: Chromaticity Diagram CIE 1976 UCS

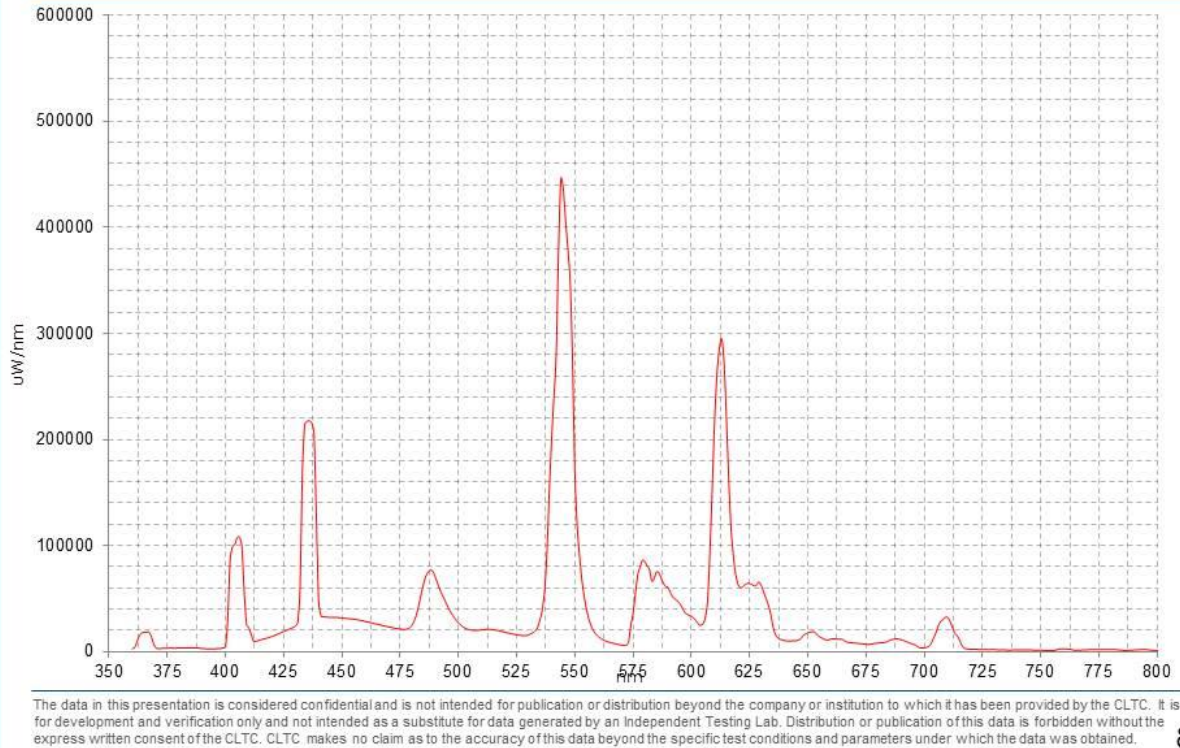


Figure 5: Spectral power distribution (SPD)

3.3 NEW TECHNOLOGY DESCRIPTION

Retrofit technologies selected for this demonstration at NorthBay VacaValley Hospital included a total of 57 LED luminaires, passive infrared (PIR) and microwave motion sensors, and a wireless radio frequency mesh network control system. Products were selected for their demonstrated ability to operate lights at full and dimmed levels during periods of occupancy and vacancy, respectively, and allow for remote access to verify operation and transmit maintenance alerts. Selection criteria were also set to meet or exceed the Illuminating Engineering Society's recommended practices for photometric performance and the DesignLights Consortium's criteria for inclusion on its Qualified Products List.

3.3.1 LUMINAIRES

There is a large range of outdoor luminaires currently available on the market with a wide variety of price points and warranty coverage. Product reliability and the extent of manufacturer warranties were considered more carefully than cost in selecting the luminaires for this demonstration. This emphasis on reliability was to

ensure products were appropriate for a health care facility, where safety is an extremely high priority.

Luminaires were selected based on photometric modeling using the software tool AGi32 with the goals of optimizing illuminance levels and contrast ratios per IES recommendations for each application at the site.

Product selection began with an examination of the Design Lights Consortium (DLC) list of approved outdoor luminaires. The Design Lights Consortium promotes quality, performance and energy efficiency in commercial sector lighting solutions through collaboration among its federal, regional, state, utility, and energy efficiency program members; luminaire manufacturers; lighting designers and other industry stakeholders throughout the U.S. and Canada. The DLC has an extremely detailed and regularly updated Qualified Product List (QPL) available at its website (www.designlights.org/QPL).

The DLC's QPL contains thousands of products that can be sorted by a variety of attributes. Products included in the QPL meet a list of specific parameters. Products selected for this demonstration project met DLC Version 1.7 product requirements.

Table 1: DLC criteria for outdoor luminaires

| DESIGNLIGHTS CONSORTIUM | | | | | | | | |
|---|--|----------------------|------------------------------|----------------------------|------------------------------------|-------------|-----------------------------------|----------------------------|
| DesignLights Consortium Product Qualification Criteria, (Last Updated 11/13/12) | | | | | | | | |
| Technical Requirements Table, v1.7 | | | | | | | | |
| | Application | Minimum Light Output | Zonal Lumen Requirements | Minimum Luminaire Efficacy | Allowable CCTs (ANSI C78.377-2008) | Minimum CRI | L ₇₀ Lumen Maintenance | Minimum Luminaire Warranty |
| 1 | Outdoor Pole/Arm-Mounted Area and Roadway Luminaires | 1,000 lm | =100%: 0-90° <10%: 80-90° | 60 lm/W | ≤5700K | 50 | 50,000 hrs | 5 years |
| 2 | Outdoor Pole/Arm-Mounted Decorative Luminaires | 1,000 lm | ≥ 65%: 0-90° | 40 lm/W | ≤5700K | 50 | 50,000 hrs | 5 years |
| 3 | Outdoor Wall-Mounted Area Luminaires | 300 lm | =100%: 0-90° <10%: 80-90° | 60 lm/W | ≤5700K | 50 | 50,000 hrs | 5 years |

The following selection criteria were among those used for the NorthBay VacaValley Hospital demonstration:

- Outdoor rated luminaire
- Minimum efficacy of 60 lm/W (equal to DLC criteria)
- CCT of 4000K or lower (as compared to DLC: < 5,700 K)
- High CRI value of at least 75 (as compared to DLC minimum: 50)
- L₇₀ of 50,000 hours (equal to DLC criteria)
- Warranty of 5 years or more (equal to DLC, which states that 7 to 10 years is preferred)

Another source of fixture criteria is the Next Generation Luminaires Design Competition (NGLDC). The DOE (Department of Energy) has partnered with the IES and IALD (International Association of Lighting Designers) to encourage, recognize and promote LED luminaires suitable for the commercial market. As of December

2012, multiple luminaires have been tested in the competition. The jury had to go through a detailed analysis of outdoor luminaires submitted for their competition in regards to visual appearance, quality of light output, maintainability, dimming capabilities and overall value. The list of awarded luminaires can be seen at the below link, and represents some of the best products in the market with adaptive controls.

(http://www.ngldc.org/pdfs/NGL12_OutdoorCatalog_Final_WEB.pdf)

Three LED luminaires were selected for this demonstration, based on the following criteria:

1. Fixture size (sufficient to accommodate sensors and RF-modules)
2. Dimming capability via 0-10V dimming driver
3. Universal input voltage for a 120–277V environment
4. CCT of 4000K to 4100K for site-wide consistency
5. Color rendering index (CRI) of at least 75
6. Dark sky-friendly with full cut off above 90° nadir
7. High efficacy (close to or above 100 lm/W)
8. Price
9. Product availability: the majority of the luminaires selected were available with a short lead time in the correct configuration for the site's needs.

For the 10-foot to 20-foot poles, the Leotek Arieta AR18 series was selected; Philips Day-Brite WTx series wall pack luminaires were selected to replace the existing wall packs, and for one ceiling luminaire, the Gardco ELG-5 series was selected.

Luminaire details are described below, with the full product cut sheet added in the appendix:



Leotek Arieta AR18-10M and -15M

- Easy installation through prepared hole pattern (round or square poles)
- Light distribution patterns Type 2, 3, 4, and 5 available
- Outstanding 10-year warranty on the luminaire
- NGLDC 2012 award of recognition



Philips Day-Brite WTM/WTL

- Integrates with RF and motion sensor
- Option to order with twist-lock receptacle
- Option to order with PIR-motion sensor



Gardco ELG-5

- Dedicated ceiling luminaire
- Option to order with PIR-motion sensor
- Requires customized adapter to integrate RF

Selected luminaires were then reviewed based on photometric modeling using the software tool AGi32 with the goal of optimizing illuminance levels and contrast ratios per IES recommendations for each application at the site.

3.3.2 CONTROLS

3.3.2.1 Sensor Details

Occupancy sensors rated for outdoor use are currently rare in the marketplace, and most that are available utilize passive infrared (PIR) motion detection. Very few employ microwave (MW) technology. WattStopper PIR sensors (models EW-205 and FS-305) provide coverage in smaller zones of the installation, where the range and coverage pattern of PIR sensors are suitable, but PIR sensor coverage can be limited where there may be larger gaps of coverage between poles.

After reviewing site sections S1, N1, E1, and ER1, a newly developed MW sensor from Lumewave with a larger and more directed field of view was installed in these sections to provide sufficient coverage of larger zones. Additional information to the microwave sensor is provided in the appendix)

The ER1 route and the N1 section have the biggest issues due to sparse pole density and no power source at the northeast entry path. This limited the number of potential sensor locations and corresponding sensor coverage pattern.

In the N1 section, custom wall packs with EW-205 PIR sensors by WattStopper were used at all building entrance and exit doors to trigger lighting in the immediate parking areas to high level when occupants are detected.

These PIR sensors also provide most of the coverage in the E1 section. A wall pack along the helipad path activates the E1 group when triggered. The visitor parking section (S1) has multiple sensors to pick up entering traffic. When an occupant is detected entering or exiting the hospital, a wall-mounted, stand-alone RF-enabled PIR sensor at the south exit doors signals all luminaires in the lot to increase light levels from low to high mode via a group command from the network software.



WattStopper FS-305



FS-305 Lense Options



WattStopper EW-205



Lumewave MWX

Figure 6: Occupancy Sensors selected for demonstration

The sensors' specified range was modeled in 3D CAD to assess site coverage before installation. Figure 8 shows the pole locations and coverage of the industry-standard PIR sensors in radial patterns. FS-305 sensors are represented as circles in this diagram, and EW-205 sensors are represented by the 180-degree fan shapes. The MW sensor locations and the sensors' direction of detection are indicated by the pie shapes in Figure 8.

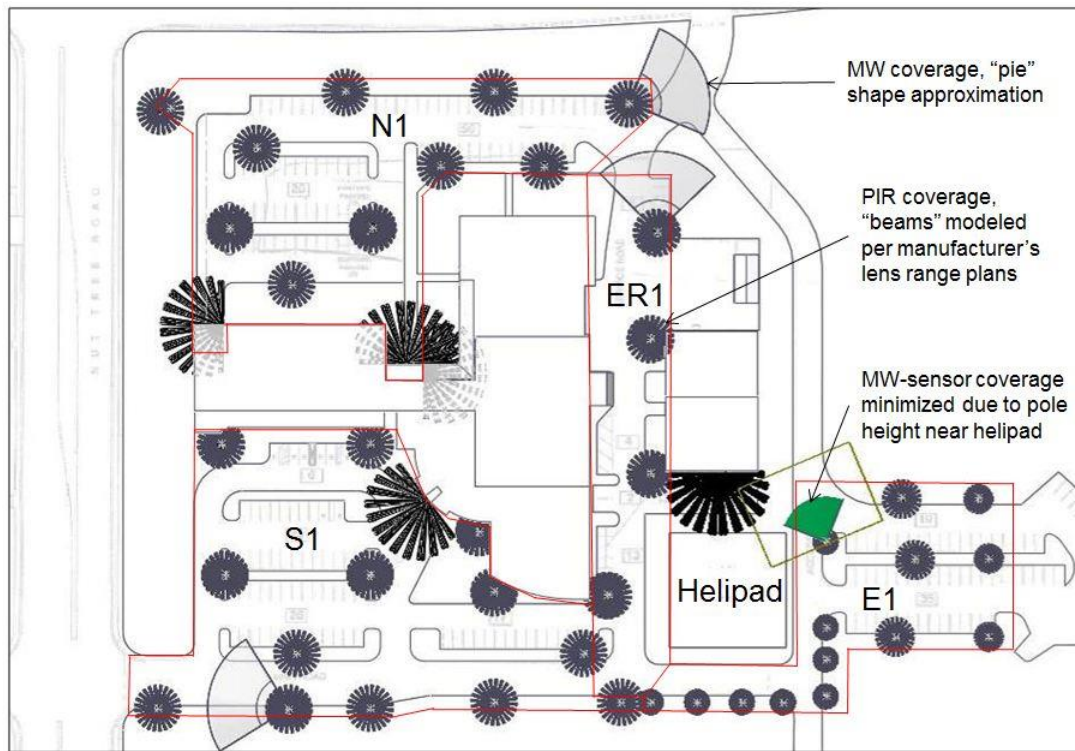


Figure 7: Modeled sensor coverage areas for NorthBay VacaValley Hospital facility

3.3.2.2 Radio Frequency Control System

CLTC engaged multiple industry and manufacturing partners to collect specific details on their RF-system offerings. Manufacturers consulted include GE Lighting, Philips Lighting, Lumewave, Relume, and Acuity ROAM. Some companies have recently announced their plans to introduce holistic adaptive controlled RF luminaire solutions, products with either RF-systems or occupancy sensors embedded in the luminaires. As exciting as it is to see the industry planning to deliver these new all-in-one systems, these new systems were not available in time for this demonstration project

Feature parameters for the RF control system included:

- Luminaire grouping, with the possibility for multiple groups reacting to one sensor
- 0–10V dimming controls
- Timed events and schedules

- Sensor input to trigger high mode and activate assigned group(s)
- Secure encoding of RF transmissions (128-bit AES encryption or similar)
- Higher up-front cost preferable to recurring costs after installation
- Precise power metering to accurately measure energy use
- Low peak energy use of nodes and gateway (below 5W when transmitting)

Low peak energy use was specified to minimize electromagnetic interference (EMI). EMI is defined as “any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics and electrical equipment.” This is a particular concern for health care facilities, where the function of important medical equipment, including pace makers, must not be interrupted.

Other important selection factors for RF systems included:

- Range of RF-systems communication to cover full area of use
- One gateway to be able to cover all points/nodes involved in this setting
- Backup astronomical clock
- Sunrise/sunset trimming
- Failure detection and maintenance alerts
- Web-based access

The Lumewave Wireless Lighting Control System was chosen for the NorthBay VacaValley Hospital installation, as it is a proven, commercially available system. In addition to meeting all of the site criteria and selection parameters listed below, the Lumewave system allows for customized sensor inputs that are instrumental for the VacaValley Hospital site's functionality. While some RF-systems have initial one-time cost with low installation requirements, others require more expensive PC-based servers or have recurring cost models due to cloud-based or extended full-service programs. Lumewave has no recurring costs for this system after installation, which meets the expressed preference of the stakeholders.

Figure 8 depicts the nodes physical appearance of the RF node. They are available in two different mounting options: a threaded connector or with a NEMA style three-pin twist-lock receptacle. Standard colors are grey and bronze, custom colors are available on request depending on quantities. Additional product information is included in the appendix.



Figure 8: Lumewave TOP900-TN and TOP900-TL control modules

A gateway, an antenna and the RF control software from Lumewave (LumeStar, Version 4.169 or newer) is necessary to utilize all available features of the Lumewave RF system. A computer with any Windows operating system that receives current, regular service updates is necessary to run the software. Apple and Linux systems are currently not supported. The LumeStar software allows authorized users to control luminaire grouping and profiles, adjust event schedules, and monitor accumulated energy use and occupancy patterns (Figure 9).

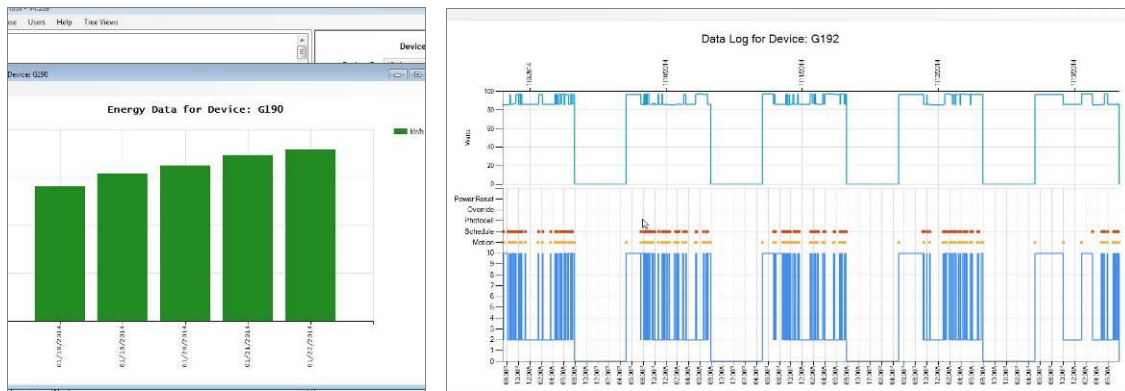


Figure 9: LumeStar 4.169 control software displays of energy use (left) and data logging (right)

3.3.3 CUSTOMIZATION & PRE-COMMISSIONING

All specified luminaires were received, reviewed, customized and pre-commissioned at the CLTC facility to ensure integration and the functionality of the adaptive lighting system.

The Leotek Arieta LED luminaire housing requires a knock-out hole for sensor installation, at the bottom of its lid. A knock-out hole for a TOP900 network control module was added on the top of the main body cast (see Figures 10 and 11).



Figure 10: Leotek Arieta sample (left) and inside view of the luminaire housing (right)



Figure 11: Hole for RF module installation (left); PIR sensor installation (right).

All modified fixtures were shipped from CLTC to the site with the sensors installed. The RF nodes were 100% pre-commissioned and tested at CLTC, and installed in the field in conjunction with the contractors.

The Philips Day-Brite wall pack arrived with factory-prepared holes for twist-lock integration of the RF modules and motion sensors (see Figure 12).



Figure 12: Mounting holes for RF module (left) and PIR sensor (middle); sensor installed (right).

The Gardco ELG ceiling fixture utilizes a dedicated casting for the inclusion of a PIR sensor. The custom adapter for the RF module was designed and machined while considering physical limitations, wiring constraints, appearance, and exposure due to outdoor use (see Figure 13).

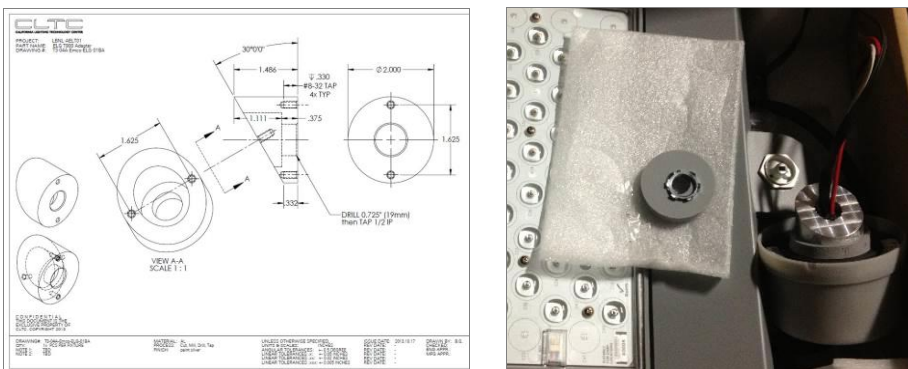


Figure 83: RF module adapter plan in CAD (left) and RF module ready for installation (right).

An instrumental component of the adaptive lighting system design at the S1 south parking lot is the stand-alone RF-enabled PIR sensor at the main entrance. This sensor detects occupants leaving the hospital and signals nearby fixtures to increase light levels from low to high mode via a group command from the software.

For this sensor, the RF node (model EMB) was used. It is a recently developed product from Lumewave, designed to provide a minimized unit with a smaller physical footprint. Power to this sensor is provided through the light boxes above the main entrance and is linked to the outdoor lighting time clock for the main building to ensure function throughout an entire night.

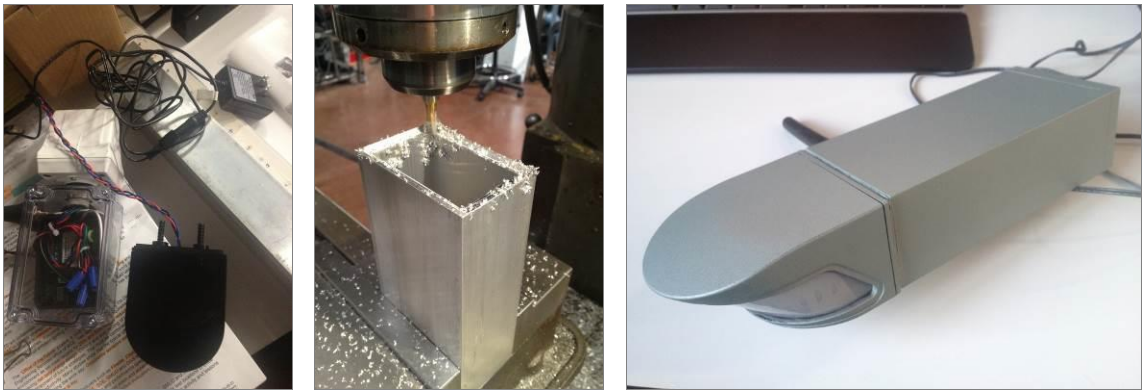


Figure 14: Stand-alone RF/PIR sensor mockup (left), adapter milling (middle), and an installation-ready sensor component (right).

3.3.4 NEW TECHNOLOGY LABORATORY EVALUATION

Once customized and commissioned, one sample of each LED luminaire was evaluated in the two-meter integrating sphere at CLTC to characterize electrical and photometric performance (see Figure 15).



Figure 15: Integrating sphere testing of (left to right) the Leotek Arieta, Day-Brite WTM and Gardco ELG.

Measurements were conducted over a dimming range, with the RF control system used to step through the dimming range. As example the Leotek Arieta 15M power and luminous output are shown in Figure 16 to Figure 23. Dimmed control settings were recorded relative to energy consumption and light output. The full photometric and electrical test reports are included in the appendix.

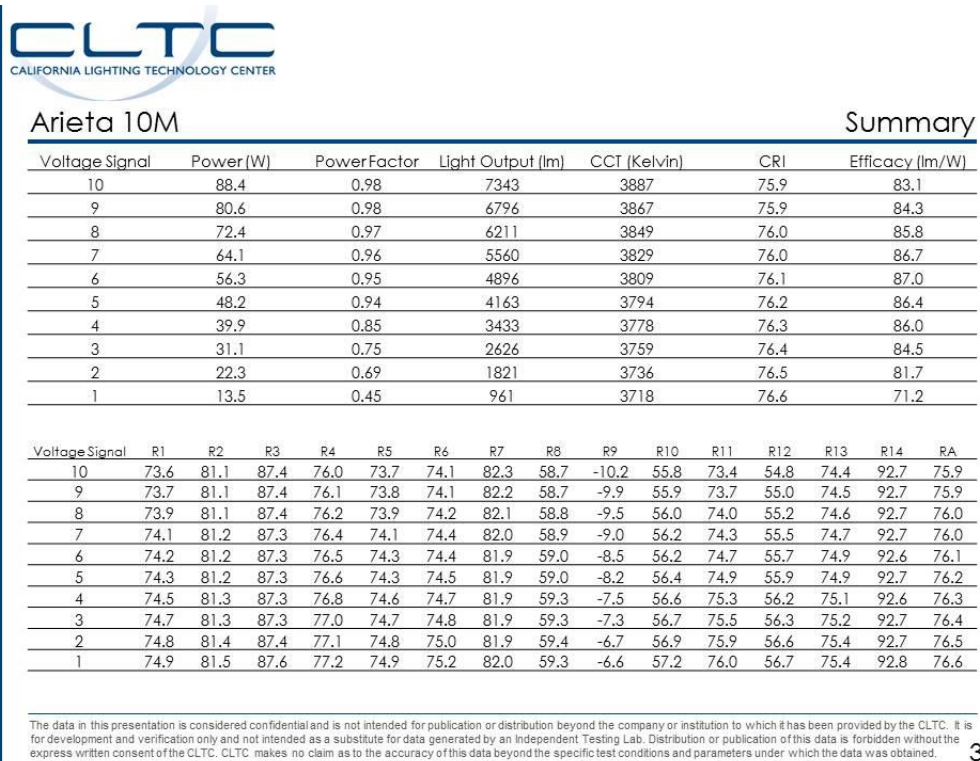


Figure 16: Electrical and photometric summary

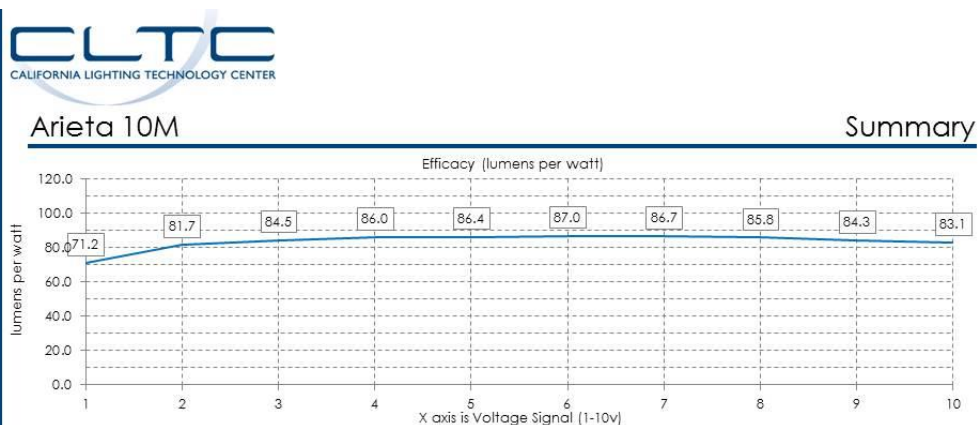


Figure 17: Efficacy over dimming range

Arieta 10M

Summary

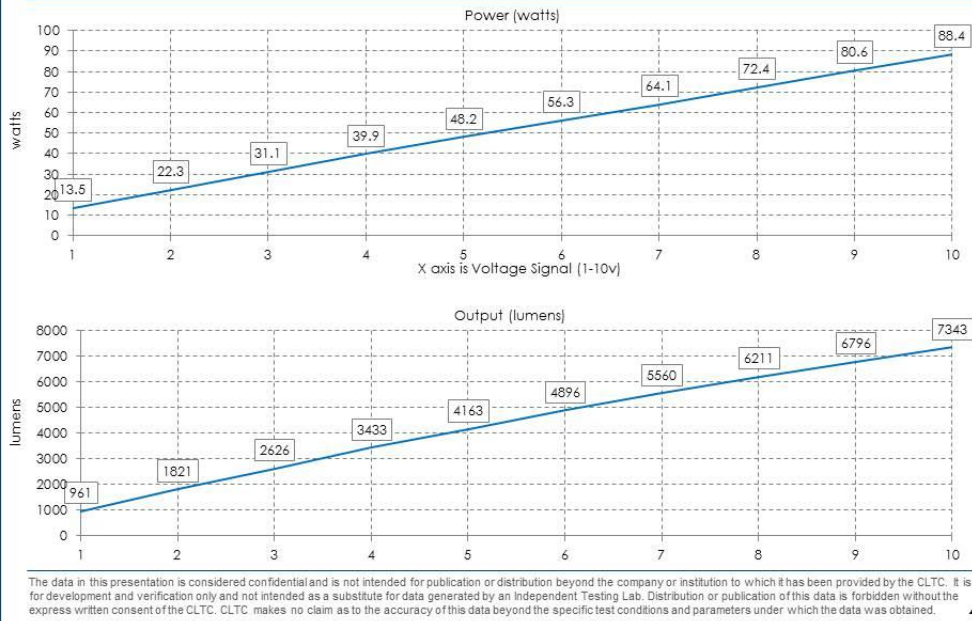


Figure 18: Power and luminous output over dimming range

Arieta 10M

Summary

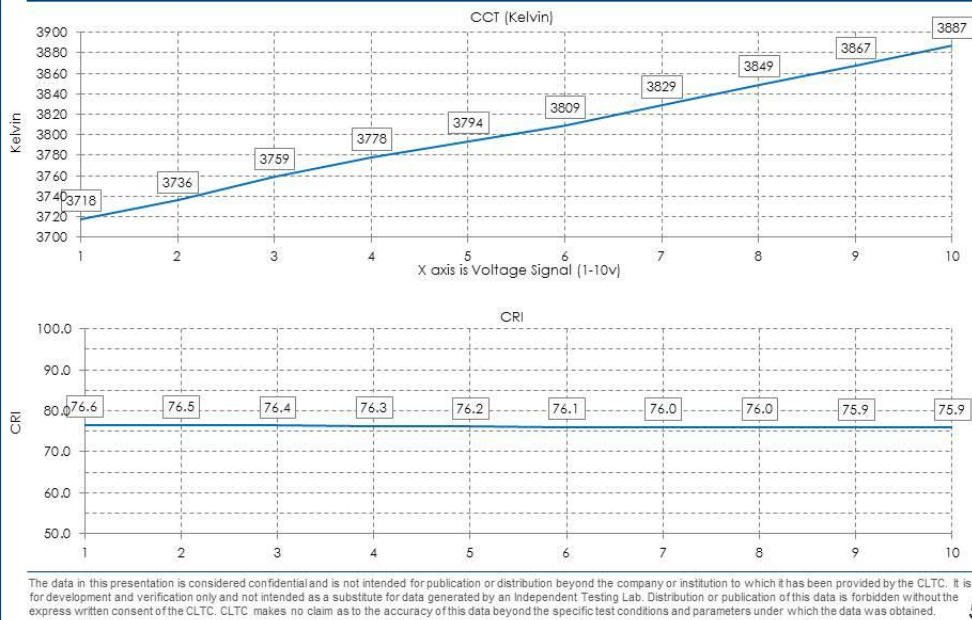
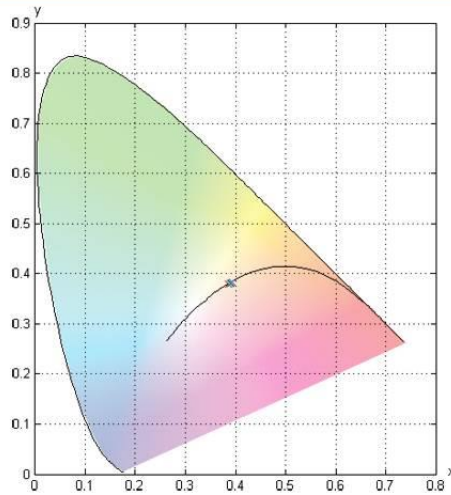


Figure 19: CCT and CRI over dimming range

Arieta 10M

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

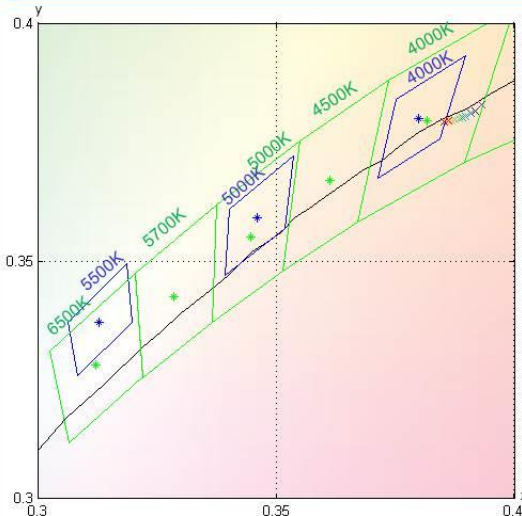
| | CIE X | CIE Y |
|---|--------|--------|
| ✖ | 0.3853 | 0.3792 |
| ✖ | 0.3861 | 0.3794 |
| ✖ | 0.3868 | 0.3794 |
| ✖ | 0.3876 | 0.3796 |
| ✖ | 0.3885 | 0.3799 |
| ✖ | 0.3892 | 0.3802 |
| ✖ | 0.3899 | 0.3804 |
| ✖ | 0.3909 | 0.3810 |
| ✖ | 0.3919 | 0.3816 |
| ✖ | 0.3931 | 0.3829 |

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Figure 20: Chromaticity Diagram CIE 1931

Arieta 10M

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

| | CIE X | CIE Y |
|---|--------|--------|
| ✖ | 0.3853 | 0.3792 |
| ✖ | 0.3861 | 0.3794 |
| ✖ | 0.3868 | 0.3794 |
| ✖ | 0.3876 | 0.3796 |
| ✖ | 0.3885 | 0.3799 |
| ✖ | 0.3892 | 0.3802 |
| ✖ | 0.3899 | 0.3804 |
| ✖ | 0.3909 | 0.3810 |
| ✖ | 0.3919 | 0.3816 |
| ✖ | 0.3931 | 0.3829 |

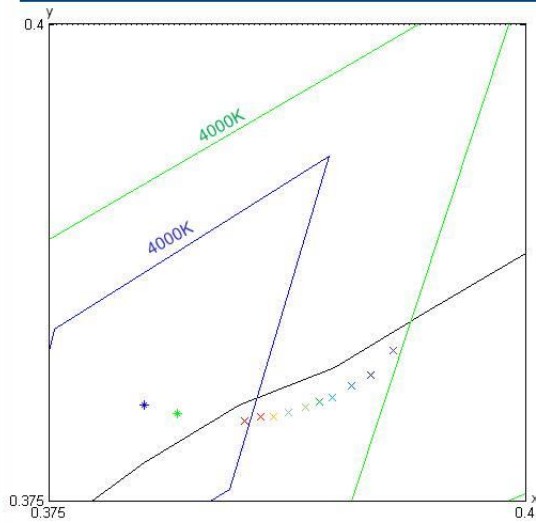
Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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Figure 21: Chromaticity Diagram CIE 1931-2 Degree

Arieta 10M

Chromaticity



| | CIE X | CIE Y |
|---|--------|--------|
| ✖ | 0.3853 | 0.3792 |
| ✖ | 0.3861 | 0.3794 |
| ✖ | 0.3868 | 0.3794 |
| ✖ | 0.3876 | 0.3796 |
| ✖ | 0.3885 | 0.3799 |
| ✖ | 0.3892 | 0.3802 |
| ✖ | 0.3899 | 0.3804 |
| ✖ | 0.3909 | 0.3810 |
| ✖ | 0.3919 | 0.3816 |
| ✖ | 0.3931 | 0.3829 |

Chromaticity Diagram CIE 1931, 2 Degree

Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

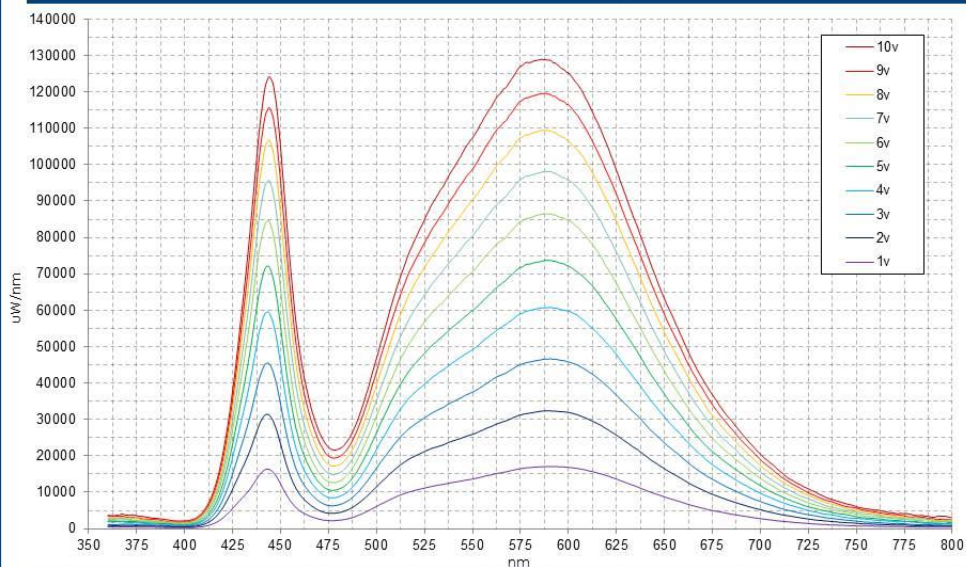
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Figure 22: Chromaticity Diagram CIE 1931-2 Degree

Arieta 10M

Spectral Power Distribution



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Figure 23: Spectral power distribution (SPD) of luminaire

3.3.5 TECHNOLOGY INSTALLATION

Installation of the adaptive lighting system was completed in August 2013 on the pole-mounted fixtures. Fixtures were installed over four days by the ESCO's contractor team. All luminaires, RF network control modules and wiring assemblies were prepared at the site by CLTC staff for the contractors. Mounting plates facilitated installation of the wall packs and ceiling luminaires. CLTC staff was on site for troubleshooting.

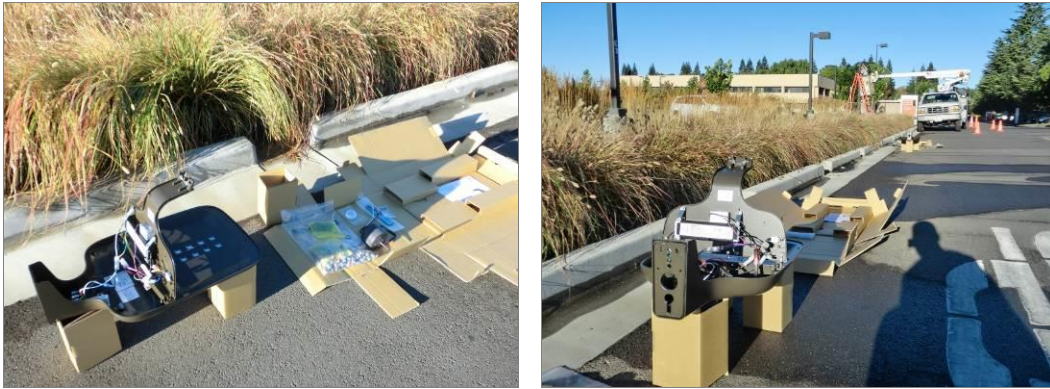


Figure 24: Luminaire modifications and wiring were prepared by CLTC staff



Figure 25: Lighting installation at the east parking area (left) and emergency route (right).

At the demonstration site, the ESCO Siemens provided a computer system to host the LumeStar software for the site. The newly installed luminaires were commissioned using the LumeStar software. The system was tested twice on the day of installation to insure functionality of the system and be able to utilize the contractors with a boom truck while still on site if needed.

Once all pole-mounted luminaires were installed and tested, the system was set to operate in static mode, at 100% light output.



Figure 26: Installation of customized wall packs, ceiling fixture and stand-alone RF-sensor

After finalizing hardware installation at the site on December 2013, the system was set to function in adaptive, or bi-level, mode. The lighting levels of the four main sections (S1, N1, E1 and ER1) were separately tuned to meet the requirements established by the hospital's security team for each area. Energy use data was logged to track the impact of the occupancy-sensitive lighting control system.

4 M & V EVALUATION PLAN

The monitoring and verification evaluation plan was developed to verify the energy savings for the demonstration of the exterior adaptive lighting system. Site visits to define the facility circuitry were conducted. Metering systems were designed to capture revenue grade monitoring of the exterior lighting circuitry.

4.1 TECHNOLOGY SPECIFICATION

Monitoring and verification (M&V) equipment was specified after an audit of the outdoor circuit configuration at the demonstration site. The voltage at the site is three-phase 277-volt alternating current (AC). M&V equipment specified and installed at the site includes current transducers (CTs), Continental Control Systems (CCS) WattNode meters, Onset pulse adapters and data loggers. The metering equipment was tested in laboratory conditions to verify functionality and was installed by the ESCO electrician in cooperation with the demonstration site's engineers. For additional metering equipment specifications, specification sheets are in the appendix.

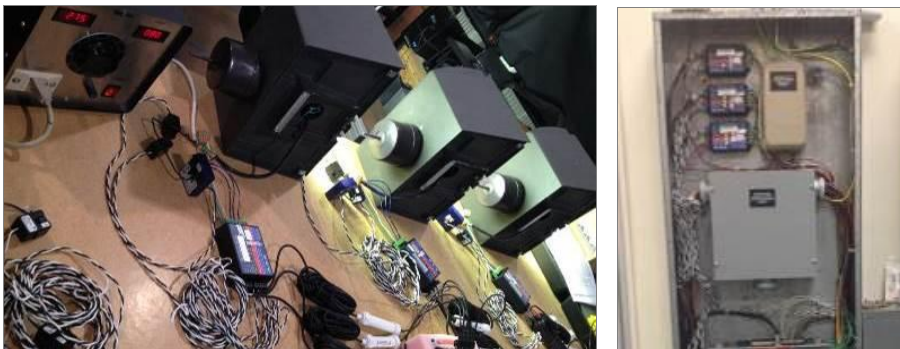


Figure 27: M&V equipment bench test and installation at the site's breaker panel

4.2 METERING PLAN

Pre-retrofit energy use at the site is based on calculated values for full output of the incumbent system. Energy data was collected for one hour to determine the energy use of the post-retrofit luminaires when operating statically at full lighting output.

To determine the post-retrofit system's savings with the adaptive lighting mode enabled, data was collected over a period of 45 days after motion sensors and the network control system were activated.

5 RESULTS

5.1 ENERGY USE RESULTS

5.1.1 ADAPTIVE LIGHTING SYSTEM ENERGY REDUCTION

The pre-retrofit energy use for the baseline lighting system was calculated assuming full light output of the incumbent luminaires selected for retrofit. The pre-retrofit energy consumption of the demonstration site totaled 43,657 kWh per year.

To calculate the LED baseline, energy data was logged, collected and analyzed operating at full light output for one hour to determine the energy use of the post-retrofit luminaires. The post-retrofit static LED lighting system totaled a calculated 28,853 kWh per year, resulting in a 33.9% energy use reduction over the installed baseline.

After implementing and activating the adaptive controls (motion sensors and the network control system), the lighting system's energy use was collected over a period of 45 days. After extrapolating the monitored energy use to allow for variations in time-of-use based on length of night over one year, the calculated energy use of the adaptive lighting system totaled 14,639 kWh annually, resulting in a 66.4% energy reduction. Comparing the adaptive strategy to the static LED baseline, the controls saved an additional 49.2%.

The majority of incumbent luminaires at the NorthBay VacaValley Hospital site were induction luminaires. These luminaires were installed within the last five years, replacing the original luminaires. As a result, the baseline power consumption of a typical high-pressure sodium (HPS) luminaire (288 watts) was reduced to that of a more efficient induction luminaire (187.2 watts). Had the networked adaptive LED system replaced an HPS system (with a calculated annual energy use of 60,188 kWh), outdoor lighting energy use would have been reduced 75.7%, versus the 66.4% energy savings realized by the NorthBay VacaValley Hospital demonstration.

5.1.2 ECONOMIC ANALYSIS

Economic analysis of the installation at NorthBay VacaValley Hospital, as compared to the predominantly induction-based incumbent lighting system, was performed using the energy data collected at the site. Simple payback, return on investment (ROI) and the internal rate of return (IRR) were calculated for a cross-section of energy costs.

Calculations were conducted considering the cost of energy, the NorthBay VacaValley Hospital adaptive lighting system costs, maintenance costs, disposal costs, salvage values, and local utility incentives. Pacific Gas and Electric (PG&E)

rebates were included in each cost scenario as a representative incentive facilities receive today when installing adaptive lighting systems.

The PG&E incentive provides a \$40–\$70 rebate per luminaire, with the higher rebate awarded for installations of luminaires that have a greater load reduction due to the retrofit. For the NorthBay VacaValley Hospital installation, the rebates were applied based on the difference in wattage between the newly installed luminaires and the incumbent luminaires.

The table below illustrates how ROI, IRR and simple payback vary for a range of energy costs.⁸ As the market for adaptive lighting systems develops, costs for luminaires, controls and installation (labor) continue to decline, and this trend is expected to continue.

Table 2: Economic Analysis of NorthBay VacaValley Hospital Demonstration Site

| Energy Cost (\$/kWh) | \$0.08032 | \$0.10 | \$0.12 | \$0.14 | \$0.16 | \$0.18 | \$0.20 |
|-----------------------------|------------------|---------------|---------------|---------------|---------------|---------------|---------------|
| ROI | -0.36 | -0.23 | -0.10 | 0.02 | 0.15 | 0.28 | 0.40 |
| IRR, % | -2.00 | 0.00 | 2.00 | 4.00 | 6.00 | 8.00 | 9.00 |
| Simple Payback, Years | 21.00 | 16.87 | 14.06 | 12.05 | 10.54 | 9.37 | 8.43 |

When conducting a lighting system upgrade, the economic analysis will be largely affected by the incumbent lighting system’s baseline energy use profile. The majority of luminaires at the NorthBay VacaValley Hospital site are induction luminaires. These luminaires were installed in place of the original high-pressure sodium (HPS) luminaires within the last five years. As a result, the baseline wattage of the assumed incumbent HPS luminaires was reduced from 288 Watts to the 187.2 Watts induction luminaire. Assuming an HPS baseline, the simple payback for the adaptive LED lighting system installation is reduced to 13.38 years, with an ROI of -0.07 and a positive IRR of 3.0%.⁸

5.2 PHOTOMETRIC FIELD EVALUATION RESULTS

A site audit was performed to gather photometric performance data for the medical center’s previously installed outdoor lighting system. The Illuminating Engineering Society (IES) provides light level recommendations and current best practices for outdoor lighting. These recommendations were used for various applications at the project site, including parking lots (see Table 3). IES documents do not provide recommended contrast ratios for some outdoor applications addressed at the retrofit site (as indicated by “N/A” in Table 3).

⁸ Based on NorthBay VacaValley’s off-peak, blended rate of \$0.08032/kWh through PG&E (50% winter and 50% summer energy rates).

Table 3: IES Illuminance Recommendations for Outdoor Applications Common to Health Care Sites

| Outdoor Application | Horizontal Illuminance (lux) | Vertical Illuminance (lux) | Contrast ratio (Max to Min) | Contrast Ratio (Average to Min) |
|---------------------------------|----------------------------------|----------------------------------|-----------------------------|---------------------------------|
| Parking Lots | 5 ⁹ -30 ¹⁰ | 2.5 ¹ -8 ² | 15:1 ¹ | 4:1 ² |
| Parking Garages | 10 ¹ -60 ² | 5-8 ² | 10:1 ¹ | 4:1 ² |
| Parking Garage Gathering Points | 50 ¹ | 5-8 ² | N/A | 4:1 ² |
| Parking Garage Entrances | 500 ¹ | 5-8 ² | 10:1 ¹ | N/A |
| Parking Garage Ramps | 10-20 ¹ | 5-10 ² | 10:1 ¹ | N/A |
| Ambulance Drive-up | 500 ¹¹ | 100 ³ | N/A | N/A |
| Outdoor Walkways | 30 ³ | 30 ³ | N/A | N/A |
| Outdoor Entrances | 100 ³ | 100 ³ | N/A | N/A |

⁹ IES RP-20-98, *Lighting for Parking Facilities*, pg. 3, 11

¹⁰ IES G-1-03, *Guideline on Security Lighting for People, Property, and Public Spaces*, pg. 8-9

¹¹ IES RP-29-06, *Lighting for Hospitals and Health care facilities*

5.2.1 PRE-RETROFIT ILLUMINANCE CONDITIONS

For illuminance mapping, 11 sections were selected to represent typical lighting zones at the facility. The site map in Figure 28 depicts illuminance plots for these 11 sections of the demonstration site.

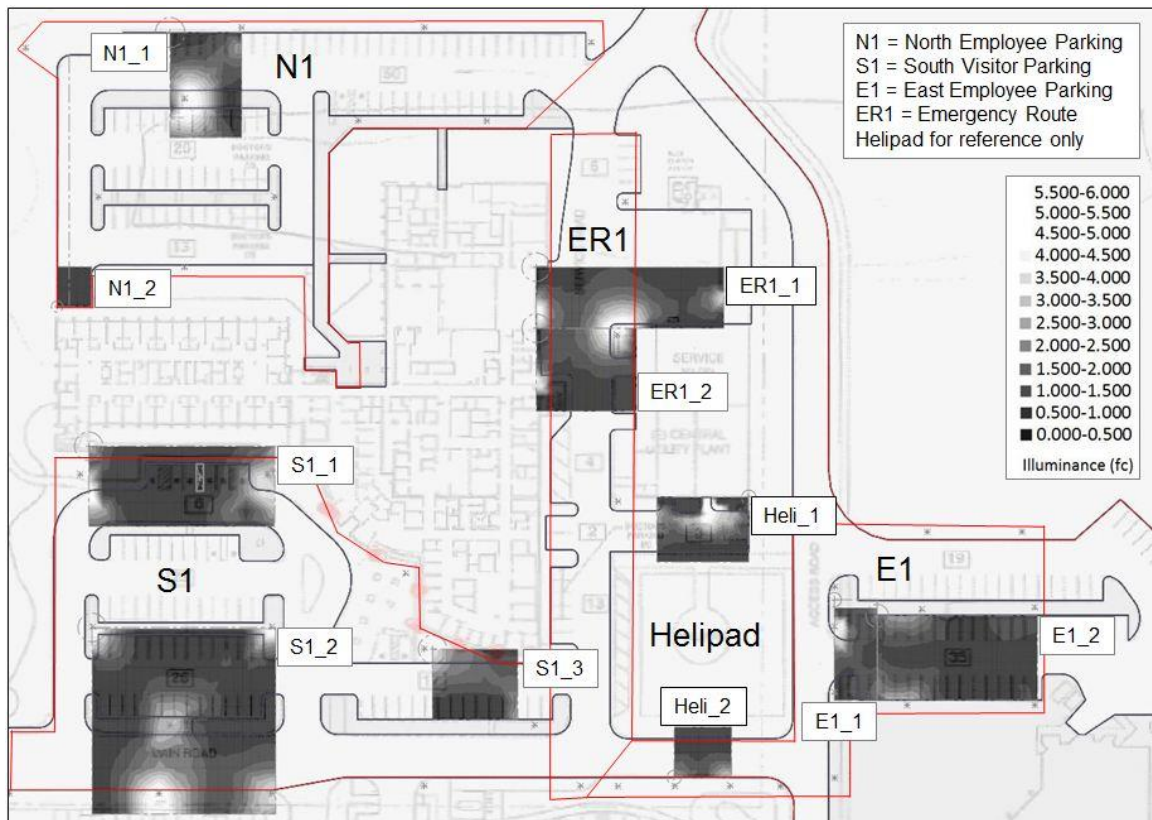


Figure 28: Pre-retrofit illuminance plots of 11 outdoor areas at the NorthBay VacaValley Hospital facility.

Illuminance measurements were collected in accordance with IES LM50-99 recommended reporting procedure.¹² Konica Minolta T-10A illuminance meters were used to take measurements at grade level, in varying grid resolutions defined by the mounting height in the specific area, per IES RP-20.



Figure 29: Illuminance meter, Konica Minolta T-10A

Table 4 and Figure 30 show the pre-retrofit illuminance measurements for the S1_2 zone at the demonstration site. Measurements for all other grids are provided in the appendix.

Table 4: Illuminance Measurements for Grid S1_2

| | A | B | C | D | E | F | G | H | I | J | K | L |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 6.170 | 2.660 | 1.037 | 0.046 | 0.068 | 0.055 | 0.051 | 0.060 | 0.346 | Car | 3.020 | 9.480 |
| 2 | 3.840 | 2.175 | 0.902 | 0.085 | 0.119 | 0.130 | 0.164 | 0.111 | 0.488 | Car | 2.645 | 2.115 |
| 3 | 0.499 | 1.050 | 0.600 | 0.137 | 0.230 | 0.204 | 0.243 | 0.196 | 0.561 | 0.373 | 0.752 | 0.299 |
| 4 | 0.277 | 0.260 | 0.245 | 0.253 | 0.470 | 0.432 | 0.442 | 0.378 | 0.436 | 0.376 | 0.094 | 0.114 |
| 5 | 0.113 | 0.142 | 0.218 | 0.431 | 0.888 | 0.921 | 0.863 | 0.608 | 0.318 | 0.146 | 0.133 | 0.107 |
| 6 | 0.108 | 0.122 | 0.265 | 0.558 | 2.248 | 2.345 | 1.909 | 0.910 | 0.325 | 0.205 | 0.124 | 0.116 |
| 7 | 0.114 | 0.135 | 0.205 | 0.548 | 2.521 | 3.060 | 0.550 | 0.303 | 0.269 | 0.063 | 0.180 | 0.192 |
| 8 | 0.164 | 0.175 | 0.275 | 0.572 | 2.840 | 2.395 | 1.015 | 0.416 | 0.211 | 0.312 | 0.390 | 0.363 |
| 9 | 0.198 | 0.235 | 0.607 | 1.229 | 1.843 | 1.620 | 1.531 | 0.490 | 0.412 | 0.495 | 0.607 | 0.668 |
| 10 | 0.272 | 0.385 | 0.908 | 1.582 | 2.137 | 1.754 | 1.475 | 0.839 | 0.714 | 0.955 | 1.196 | 1.300 |
| 11 | 0.317 | 0.434 | 1.379 | 2.970 | 4.140 | 2.720 | 1.802 | 0.796 | 0.695 | 1.389 | 2.713 | 3.290 |
| 12 | 0.208 | 0.380 | 1.497 | 4.000 | 6.420 | 3.500 | 1.863 | 0.638 | 0.640 | 1.391 | 3.010 | 3.900 |
| 13 | 0.127 | 0.350 | 1.428 | 4.000 | 5.800 | 3.550 | 1.866 | 0.585 | 0.691 | 1.913 | 2.890 | 2.135 |

¹² IESNA LM50-99, Page 3, section “5.0 Test Report”

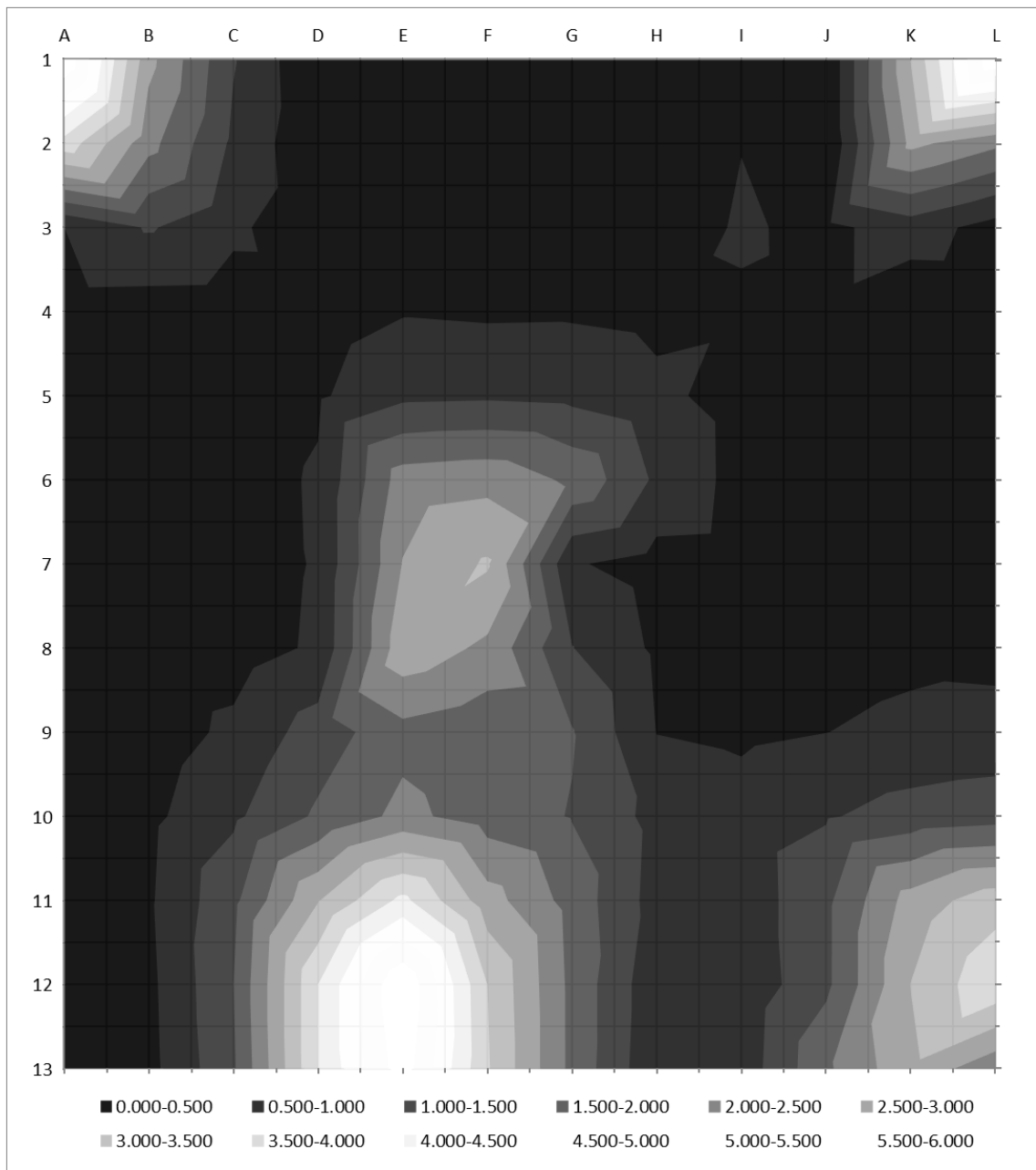


Figure 30: Illuminance Measurements for Grid S1_2

For pre-retrofit conditions for the entire demonstration site, horizontal illuminance measured at grade ranged from 0.03 foot-candles (fc) to a maximum of 9.26 fc.

5.2.2 POST-RETROFIT ILLUMINANCE CONDITIONS

Post-retrofit illuminance measurements were taken in the same 11 zones selected for pre-retrofit assessment and analyzed to verify system performance. Figure 31 shows pre-retrofit illuminance measurements (left), post-retrofit illuminance measurements in low mode (middle), and post-retrofit illuminance measurements

in high mode (right) for the S1_2 example zone. Measurements and 2D-plot comparison for all grids are provided in the appendix.

As Figure 31 illustrates, even in low mode, the post-retrofit lighting provides more even light distribution, with shadows between light points significantly reduced.

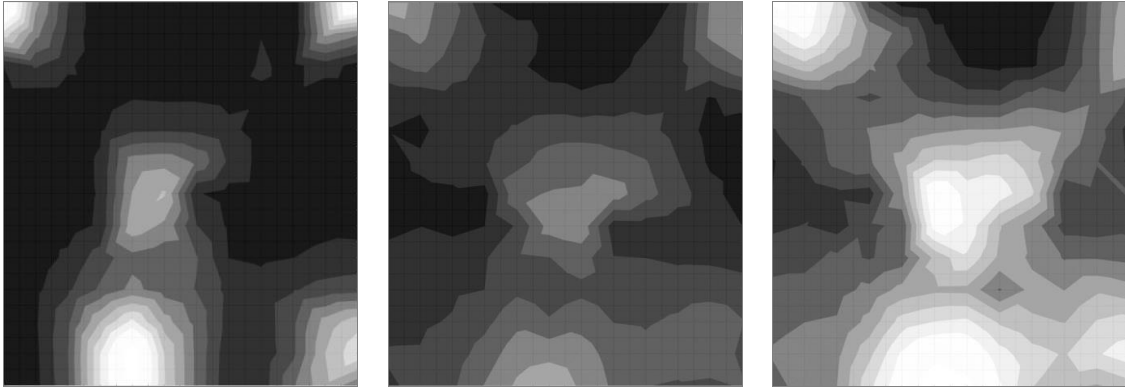


Figure 31: Illuminance measurements for Grid S1_2, pre-retrofit vs. post-retrofit, in low and high lighting power modes.

5.2.3 LIGHTING DESIGN COMPARISON

IES recommended illuminance levels (Table 3) were used to design the post-retrofit system, to compare in-situ illuminance measurements before and after the retrofit, and to verify field performance of the system.

Table 5 contains the comparison of each illuminance grid between the pre- and post-retrofit contrast ratio values as compared to the target values summarized in Table 3. The complete set of field measurement values are provided in the appendix.

Table 5: Contrast Ratios for the VacaValley Hospital Demonstration Site

| VVNBH Illuminance map comparison | PRE-Retrofit | POST low | POST high | PRE-Retrofit | POST low | POST high |
|--|--------------|--------------|--------------|--------------|--------------|--------------|
| | Max-Min | Max-Min | Max-Min | Avg-Min | Avg-Min | Avg-Min |
| | (ratio, x:1) | (ratio, x:1) | (ratio, x:1) | (ratio, x:1) | (ratio, x:1) | (ratio, x:1) |
| IES recommended | 15 | 15 | 15 | 4 | 4 | 4 |
| N1_1 | 95.5 | 11.5 | 12.7 | 24.5 | 4.9 | 5.6 |
| N1_2 | 8.9 | 31.5 | 40.1 | 2.5 | 7.1 | 8.4 |
| ER1_1 | 176.8 | 43.1 | 43.3 | 29.8 | 11.7 | 12.0 |
| ER1_2 | 67.7 | 66.6 | 41.0 | 12.0 | 16.2 | 12.8 |
| S1_1 | 198.5 | 82.0 | 91.3 | 26.4 | 22.0 | 24.1 |
| S1_2 | 206.1 | 49.1 | 66.6 | 24.7 | 19.3 | 24.8 |
| S1_3 | 52.9 | 4.0 | 6.7 | 13.5 | 2.0 | 3.1 |
| Heli_1 | 100.0 | 115.2 | 209.8 | 24.0 | 23.9 | 46.5 |
| Heli_2 | 35.8 | 39.9 | 49.1 | 7.8 | 13.4 | 13.3 |
| E1_1 | 40.3 | 16.0 | 15.2 | 7.4 | 3.6 | 3.4 |
| E1_2 | 39.7 | 87.4 | 116.7 | 39.7 | 32.6 | 42.7 |

Table 5 shows that several zones fulfill or surpass IES recommended contrast ratios as compared to the incumbent luminaires. N1_2 and Heli1_1 illuminance measurements show the new luminaires result in higher contrast ratios than the incumbent system. For N1_2, the incumbent lighting system provided low light levels throughout the test grid leading to contrast ratios that surpass IES recommended design practice.

5.3 SURVEY RESULTS

5.3.1 INSTALLATION TEAM SURVEY

The contractor participated in an installation team survey after the retrofit was completed. Anecdotally, the installation team had positive feedback with respect to ease of installation of the new pole-mounted luminaires in comparison to other products they had installed in the past; however, the contractor recommended that future project teams be aware that mounting hardware may not be appropriate for every application. For example, the mounting screws were too short to be used with flat-to-round pole adapters. For this site, longer stainless steel bolts were necessary.

5.3.2 END-USER SURVEY

An end-user survey was deployed to gather feedback on the outdoor lighting system changes. The survey questions were developed to capture various metrics, such as end-user type (doctors, nurses, security staff, etc.), time of day when typically at the site, the end-user's perception of the importance of lighting in both their home and outdoors, and specific questions regarding the recent upgrade of the outdoor lighting at the health care facility.

The survey was deployed digitally via the Google online survey tool and circulated through an email link to NorthBay Hospital staff members. The survey was collected over a time period of five weeks, spanning March 25, 2014 to May 1, 2014.

The survey had a total of 42 responses. Figure 33 breaks down the responses by end-user type. The largest population of staff members reached by the survey was general staff (16), followed by nurses (12) and security staff (10). Three visitors also participated in the survey.

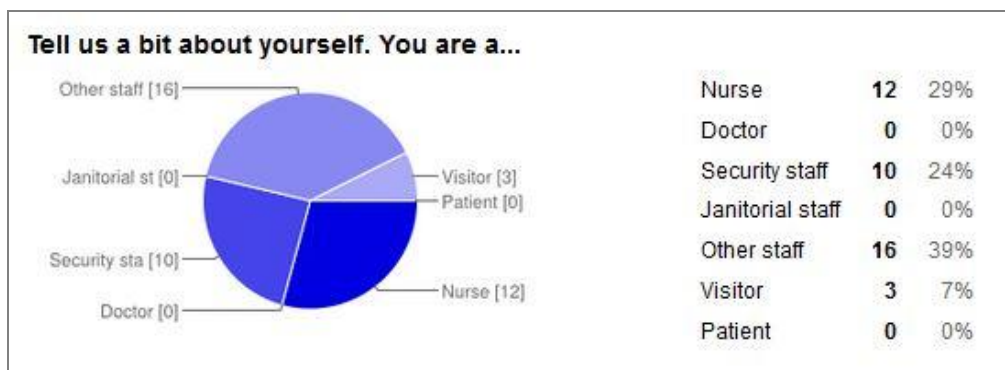


Figure 32: Survey population details

Of those surveyed, 47% reported being at the health care facility during the nighttime hours of 6 p.m. to 8 a.m.

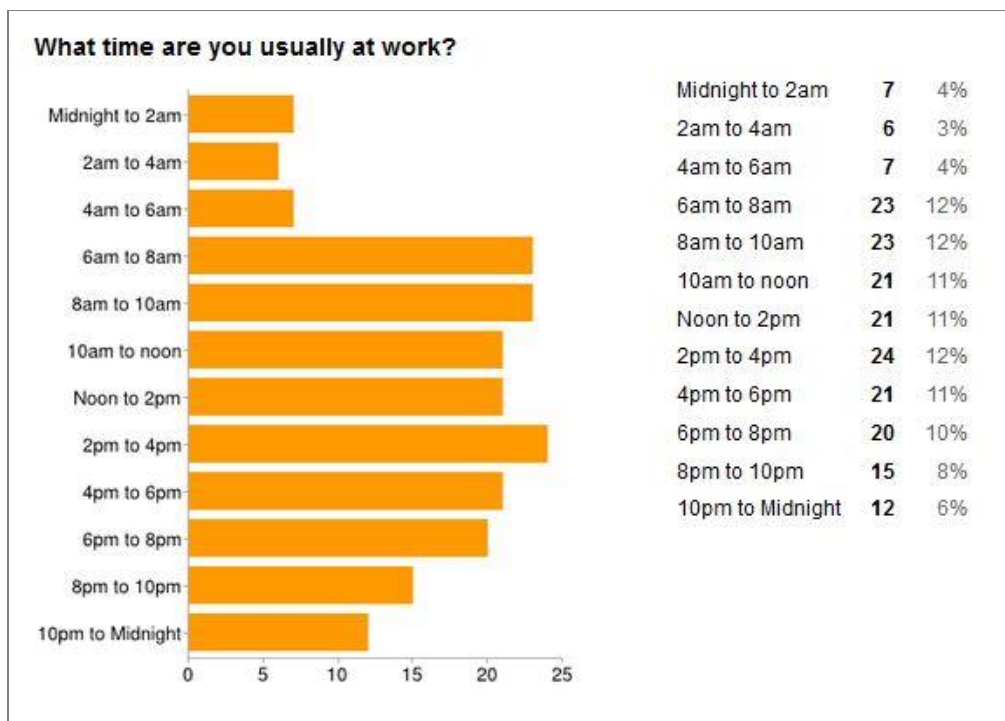


Figure 33: Time typically spent at work of surveyed population

The following questions are displayed in a diverging stacked bar chart. Red is used to display negative or denying results. Green indicates positive or confirming results. Gray indicates abstention votes. Absolute count numbers have been converted to percentages, based on the total of 42 survey responses received.

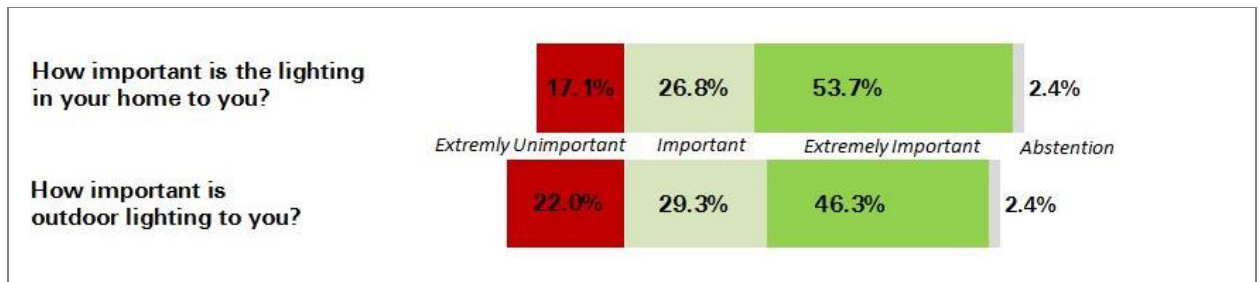


Figure 34: The importance of lighting to the surveyed population

Specific questions about the lighting system upgrade were aimed at assessing end-users' perceptions of the system, including contrast, flickering, and color characteristics.

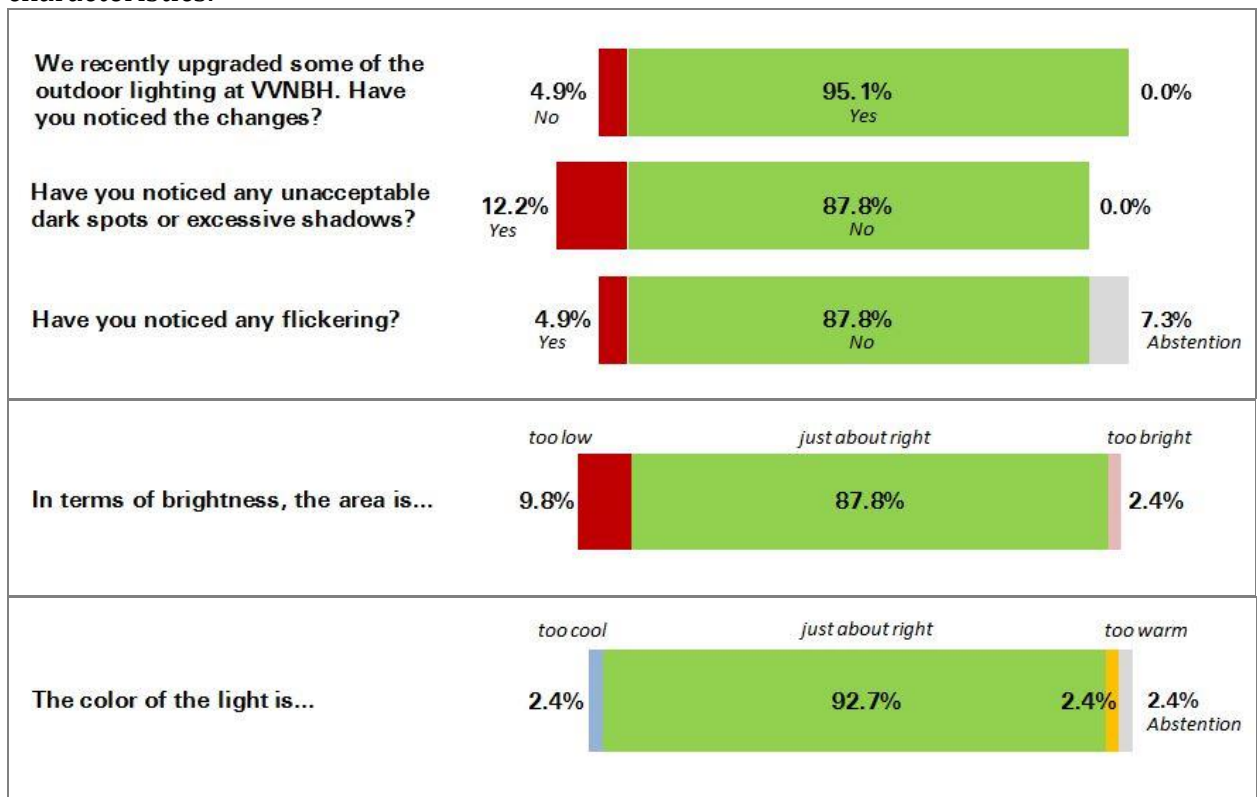


Figure 35: End-user perceptions of the post-retrofit lighting

As the responses in Figure 36 indicate, feedback regarding brightness, color characteristics, flicker, and evenness of light distribution was overwhelmingly positive. One end-user of the new lighting system stated, "Walking my dog at night is so much clearer. Lighting has much better contrast. Feel much better when my kids are out at night [and able to be] seen by others."

Feedback from hospital security staff indicates that the VacaValley Hospital installation provided an improved environment: "[CLTC staff] asked my opinion on many things regarding how bright the lights should be and in what areas I, as

security, would feel they should be at their brightest point ... I think it was great work and that it did wonders for the facility.”

In response to the adaptive lighting system installed in the parking lot, one end-user stated: “I would [also] appreciate improved outdoor lighting in the patio adjacent to the cafe at VacaValley Hospital.”

Another end-user offered this specific feedback: “[I] like the switch to LED's [sic], but not the on and off on and off.”

Nearly 88% of survey respondents did not notice any unacceptable dark spots or excessive shadows with the new lighting, but one person surveyed noted: “Dark spots/shadows in employee entrance parking lot, northwest corner.”

6 SUMMARY FINDINGS AND CONCLUSIONS

6.1 OVERALL TECHNOLOGY ASSESSMENT

System performance and reliability must be considered in addition to costs if an adaptive outdoor lighting system is to succeed in saving energy and yielding financial benefits. Savings and ROI calculations must be based on the specific parameters associated with each site.

6.2 BEST PRACTICES

System specifications must address customers' needs, including light level requirements, site details such as traffic and occupancy patterns, controls requirements, and any other site-specific requirements.

Specific luminaire characteristics, such as the dimming curve, need to be identified at the beginning of the design process to ensure system functionality is not limited by the technology's capabilities.

Adaptive lighting system design (beyond traditional lighting design practice) is necessary to ensure the system can adapt to local conditions and respond to the needs of facility managers and other stakeholders, including security and activity schedules. Successful system design allows for the implementation of new luminaires and adjustments in sensor coverage.

Feedback from hospital security staff indicates that the VacaValley Hospital installation provided an improved environment: "[CLTC staff] asked my opinion on many things regarding how bright the lights should be and in what areas I, as security, would feel they should be at their brightest point. So I pointed out areas where it would appear to be darkest and at times I think they should come on to their brightest points... I think it was great work and that it did wonders for the facility."

6.3 BARRIERS AND GATEWAYS TO ADOPTION

Today, many luminaires must be customized to enable adaptive outdoor lighting strategies. This is not yet a straightforward process. ESCOs and/or lighting system component manufacturers need to work together to develop a broadly applicable integration process.

The education of installation teams is crucial to the success of adaptive lighting systems, as these systems require critical installation steps that are not included in traditional lighting systems. Training and certification programs like the California Advanced Lighting Controls Training Program (CALCTP) and National Advanced

Lighting Controls Training Program (NALCTP) are designed to provide this education and training and to help stakeholders identify contractors and electricians who are qualified to work with advanced lighting control technologies.

6.4 MARKET POTENTIAL

Adaptive lighting offers increased energy savings and improved amenity compared to traditional systems. The photometric performance measurements and end-user survey results gathered in the course of this demonstration strongly indicate stakeholders will see value in adding the technology to their portfolio of lighting solutions.

Including networked controls for an outdoor lighting system adds to the total cost of the system and may extend the simple payback period; however, lower energy consumption and reduced maintenance costs increase long-term energy savings and may therefore result in greater cost savings over the life of the lighting system. Projected maintenance costs are also lower, as the electrical components of dimmable LED luminaires are expected to last longer than static non-solid-state lighting counterparts.

While the occupancy sensors can be considered a one-time investment, there are various financial models of RF control systems on the market. Some systems have an initial one-time cost with very low installation requirements. Other systems require more expensive PC-based servers or have recurring cost models, due to cloud-based or extended full-service programs. Pricing for these systems is expected to decline and become easier to compare as market adoption becomes more widespread and broader-scale competition reveals consumer preferences.

Energy savings and return on investment for this demonstration project are dependent on numerous characteristics of both the pre-retrofit and post-retrofit outdoor lighting systems. The most important components of any lighting retrofit energy savings calculation are:

- Baseline energy use of the existing (pre-retrofit) luminaires
- Pre-retrofit and proposed replacement quantity of luminaires involved (considering possible decrease of total luminaires needed due to new technologies deployed)
- Current energy price and/or projected energy price increases over the time period for return on investment (ROI)
- Lighting system hours of operation for both pre-retrofit and proposed lighting systems (dusk to dawn, 24/7, or other settings), usually calculated per year
- Accumulated pre-retrofit system maintenance costs related to relamping and the maintenance of electrical components, compared to post-retrofit system maintenance costs

In addition to these traditional calculation factors, the cost-effectiveness of network adaptive lighting systems also depends upon:

- Adjustable dimming setting for vacant areas
- Timing of motion sensor triggers and timeouts or scheduled events
- Occupancy rates and patterns

6.5 RECOMMENDATIONS FOR BROADER IMPLEMENTATION THROUGH EXPANDED TOOLS AND RESOURCES

Facilities or groups, such as ESCOs, wishing to market or broadly implement the adaptive outdoor lighting system strategy must develop new tools and resources to facilitate its adoption.

Standard implementation and economic models are insufficient to accurately account for overall savings benefits of an adaptive lighting system. The development of a standardized tool for this comparison is required.

More educational programs with curriculum and hands-on training, like that offered through NALCTP, will be critical to the successful design, installation and operation of outdoor adaptive lighting systems.

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8 APPENDIX

8.1 LUMINAIRE, SENSOR AND RF SYSTEM SPECIFICATIONS

8.1.1 SPECIFICATIONS FOR POST-RETROFIT LUMINAIRE - LEOTEK ARIETA 15M AND 10M:



The Leader in Electro-Optics Technology

a subsidiary company of LITEON[®]

Job Name:

Type:

Complete Catalog Number:

Arieta™ LED Area Luminaire

Ordering Example

| | | | | | | |
|-----------------------|--|--|--|--|---|--|
| AR18 | 15M | MV | NW | Select | DB | Select |
| AR18 – LED Area Light | Number/Type of LEDs 6M 10M 15M 18M 20M 24M 30M | Voltage MV - 120 -277V HV - 347 -480V | Nominal Color Temperature¹ NW – 4000K | Light Distribution 2 - Type 2 3 - Type 3 4 - Type 4 5- Type 5 | Finish² BK-Black DB – Dark Bronze | Accessories/Options BSK - Bird Spider Kit RPA - Round Pole Adaptor HSS ³ - House Side Shield PCR - NEMA Photocontrol Receptacle 350 - Factory set 350mA Drive Current 530 - Factory set 530mA Drive Current 700 - Factory set 700mA Drive Current |

Notes:
 1. NW standard. Consult factory for other LED color temperatures.
 2. Black and Dark Bronze standard. Consult factory for other finishes.
 3. Flush mounted shield easily field installed. Cuts light off 1/2 mounting height behind luminaire.

Luminaire Specifications

Housing: Die cast aluminum housing with universal mounting design allows for attachment to pole without redrilling in retrofit applications. Meets ANSI C136.31-2001 Normal Application Vibration Standards. All hardware is stainless steel. Thermal management system maintains LED junction temperature assuring long LED life and efficiency. Electrical components are accessed without tools and are mounted on removable power door. Power door features quick electrical disconnects to terminal block and LED board.

Light Emitting Diodes: Hi-flux/Hi-power white LEDs produce a minimum of 95% of initial intensity at 100,000 hours of life. LEDs are tested in accordance with IES LM-80 testing procedures. They have a mean correlated color temperature of 4000K (standard). LEDs are 100% mercury and lead free.

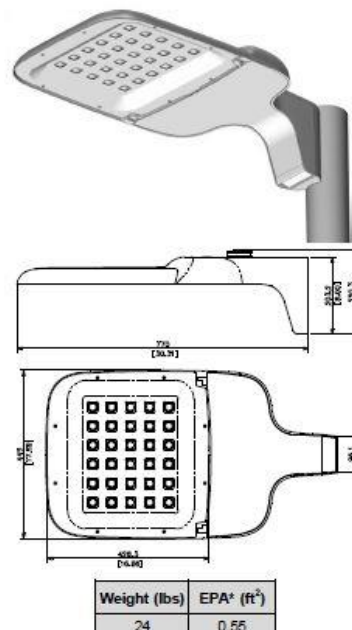
Optical Systems: Micro-lens systems produce IES Type 2, Type 3, Type 4, or Type 5 distributions. Optical system provides sharp cutoff of high angle brightness and produces 0% total lumens above 90°.

Electrical: Power supply features a minimum power factor of .90 and <20% Total Harmonic Distortion (THD). EMC meets or exceeds FCC CFR Part 15. Transient voltage complies with ANSI C62.41 Cat. A. Power supply drive current is field adjustable. Integral surge protector is tested per ANSI/IEEE C62.45 procedures based on ANSI/IEEE C62.41.2 definitions for standard and optional waveforms for Location Category C-High.

Finish: Housing receives a fade and abrasion resistant, epoxy polyester powder coat finish.

Listings/Ratings/Warranties/Patents: Luminaires are UL listed for use in wet locations in the United States and Canada. Optical systems maintain an IP66 rating. Ten-year limited warranty is standard on all components. Patents pending.

Photometry: All luminaires are photometrically tested by certified independent testing laboratories in accordance with IES LM-79 testing procedures.



*Effective Projected Area
(consult factory for multiple units)

LED GREEN Technology





The Leader in Electro-Optics Technology

a subsidiary company of LITEON

HID Replacement Chart

| Luminaire | Drive Current | Nominal Lumens ^a | System Watts | System Efficacy ^b | Typical HID Replacement ^b |
|-----------|---------------|-----------------------------|--------------|------------------------------|--|
| AR18-6M | 350mA | 2794 | 27 | 105 | (1) A Hi, (1) B Med/Lo |
| AR18-6M | 530mA | 3872 | 39 | 100 | (1) B Hi, (1) C Hi, (1) D Med, (1) E Hi, (1) F Lo |
| AR18-6M | 700mA | 4807 | 51 | 94 | (1) D Hi, (1) F Med, (1) G Lo |
| AR18-10M | 350mA | 4656 | 44.3 | 105 | (1) D Hi, (1) F Med, (1) G Lo |
| AR18-10M | 530mA | 6453 | 64.8 | 100 | (1) G Hi, (1) H Med, (1) I Hi |
| AR18-10M | 700mA | 8012 | 85.3 | 94 | (1) H Hi, (1) K Hi, (2) D Med, |
| AR18-15M | 350mA | 6984 | 66.4 | 105 | (1) H Med, (1) K Med, (1) L Lo |
| AR18-15M | 530mA | 9679 | 97.2 | 100 | (1) M Med, (1) O Med, (1) S Lo |
| AR18-15M | 700mA | 12018 | 128.0 | 94 | (1) S Med, (2) J Lo, (2) I Hi |
| AR18-18M | 350mA | 8024 | 73.9 | 109 | (1) H Hi, (1) K Hi, (2) D Med, |
| AR18-18M | 530mA | 11067 | 111.9 | 99 | (1) Q Hi, (1) N Med, (2) K Lo, (2) G Med |
| AR18-18M | 700mA | 13834 | 147.8 | 94 | (1) W Lo, (2) L Lo, (2) K Med, (2) Q Lo |
| AR18-20M | 350mA | 8914 | 82.1 | 109 | (1) Q Med, (1) N Lo, (2) F Med, (2) G Lo |
| AR18-20M | 530mA | 12296 | 124.3 | 99 | (1) U Lo, (1) P Med, (1) S Med, (2) J Lo, (2) I Hi |
| AR18-20M | 700mA | 15369 | 164.2 | 94 | (1) U Med, (1) V Lo, (1) P Hi, (2) M Lo, (2) O Lo, (2) J Med |
| AR18-24M | 350mA | 10698 | 98.5 | 109 | (1) N Med, (1) Q Hi, (1) R Lo, (2) I Med, (2) H Lo, (2) K Lo |
| AR18-24M | 530mA | 14756 | 149.2 | 99 | (1) P Hi, (1) S Hi, (2) J Med, (2) Q Lo, (2) M Lo, (2) O Lo |
| AR18-24M | 700mA | 18445 | 197.0 | 94 | (1) U Hi, (2) J Hi, (2) Q Med |
| AR18-30M | 350mA | 13372 | 123.1 | 109 | (1) W Lo, (1) R Med, (2) G Hi, (2) H Med, (2) K Med, (2) L Lo |
| AR18-30M | 530mA | 18445 | 186.4 | 99 | (1) U Hi, (1) X Lo, (1) V Med, (2) Q Med, (2) J Hi, (2) M Med, (2) O Med |
| AR18-30M | 700mA | 23056 | 246.3 | 94 | (1) X Med, (1) V Hi, (2) M Hi, (2) O Hi, (2) Q Hi, (2) S Med |

Selecting the right Arieta™ product to replace existing HID area luminaire:

- From the list below identify the letter code associated with the wattage, lamp source and maintenance cycle of the existing installation.
- Determine if the application should require a "Low" (Lo), "Medium" (Med), or "High" (Hi) level of illuminance replacement. Low level products are typically selected for applications where somewhat reduced illuminance values may be acceptable and greater energy savings are desired. Medium level products are generally found to provide visibility that is comparable or better than the HID unit that is being replaced. High level products are normally specified when required to meet or exceed average illuminance values or when highly conservative light loss factors are applied.
- In the chart above, locate the appropriate letter code, number of luminaires per pole and illuminance level (lo, med, hi) in the far right column and the corresponding Arieta™ product/drive current in the two left columns.
- Based on the lighting design and application, select the appropriate lighting distribution (Type 2, 3, 4 or 5).

Notes: a) System lumens shown are based on Type 5 distribution. Actual lumens may vary +/- 10% with distribution type and normal testing tolerances.

b) This chart only represents luminaires that are typically selected for retrofitting HID area lights. Leotek recommends that users consult with their local Leotek Representative for selection of the best luminaire based on the precise design criteria and application characteristics.

A) 100W Metal Halide - Spot Relamp Applications

B) 100W Metal Halide - Group Relamp Applications

C) 100W HPS - Spot Relamp Applications

D) 100W HPS - Group Relamp Applications

E) 150W/175W MH Spot Relamp Applications

F) 150W/175W MH Group Relamp Applications

G) 150W HPS - Spot Relamp Applications

H) 150W HPS - Group Relamp Applications

I) 250W Pulse Start MH - Spot Relamp Applications

J) 250W Pulse Start MH - Group Relamp Applications

K) 250W Pulse Start MH/Horizontal Lamp - Spot Relamp Applications

L) 250W Pulse Start MH/Horizontal Lamp - Group Relamp Applications

M) 250W Pulse Start MH/Vertical Lamp - Spot Relamp Applications

N) 250W Pulse Start MH/Vertical Lamp - Group Relamp Applications

O) 250W HPS - Spot Relamp Applications

P) 250W HPS - Group Relamp Applications

Q) 400W Pulse Start MH - Spot Relamp Applications

R) 400W Pulse Start MH - Group Relamp Applications

S) 400W Pulse Start MH/Horizontal Lamp - Spot Relamp Applications

T) 400W Pulse Start MH/Horizontal Lamp - Group Relamp Applications

U) 400W Pulse Start MH/Vertical Lamp - Spot Relamp Applications

V) 400W Pulse Start MH/Vertical Lamp - Group Relamp Applications

W) 400W HPS - Spot Relamp Applications

X) 400W HPS - Group Relamp Applications

8.1.2 SPECIFICATIONS FOR POST-RETROFIT LUMINAIRE - DAYBRITE WTM:

NITE BRITES

JOB NAME

TYPE

WTM/WRM/WBM- LED MEDIUM FULL CUTOFF WALL PACK 40 and 60 watt LED



The LED Medium Full Cutoff Wall Pack offers a sleek design and cutoff performance with a wide range of uses. It delivers the lighting needed for the exteriors of retail buildings, businesses, walkways, underpasses or entrance doors.



ORDERING MATRIX

SAMPLE CATALOG NUMBER: WTM60WLU-FWT-BK

| WTM | 40W | L | U | - | - | - | - | RF/Lumewave Top900 |
|------------------------------------|--|-------------------------------|--|---|---|---|---|---|
| FAMILY WTM WRM WBM | WATTAGE 40W - 40W Neutral White (4100K) 60W - 60W Neutral White (4100K) | LAMP SOURCE L - LED | VOLTAGE 34 - 347 volt U - Universal 120-277 volts 50Hz or 60Hz | OPTICS SC2 - Wide Distribution MC3 - Medium Distribution FWT - Forward Throw | PAINT COLORS BLANK - Dark Bronze Textured WT - White Textured BK - Black Textured AL - Silver Aluminum Textured NP - Gray Aluminum Textured GY - Industrial Gray Textured (Consult factory for other colors) | LENS BLANK - Clear Tempered Glass Lens FGS - Flat Solite Diffusing Tempered Glass Lens | OPTIONS add as suffix LP - Lamp with fixture WDF - Wired Double Fuse ^a WSF - Wired Single Fuse ^a PCR - Photocell Receptacle ^b PE - Photo Control | Footnotes: ^a Order Twist Lock Photo Control separately ^a Use with 208 and 240 volt. ^b Use with 120, 277 and 347 volt. General Notes: All options are factory installed. All accessories are field installed. |

ACCESSORIES (order separately)
PC-LT - Photo Control Twist Lock multi-mount

ACCESSORIES (order separately)

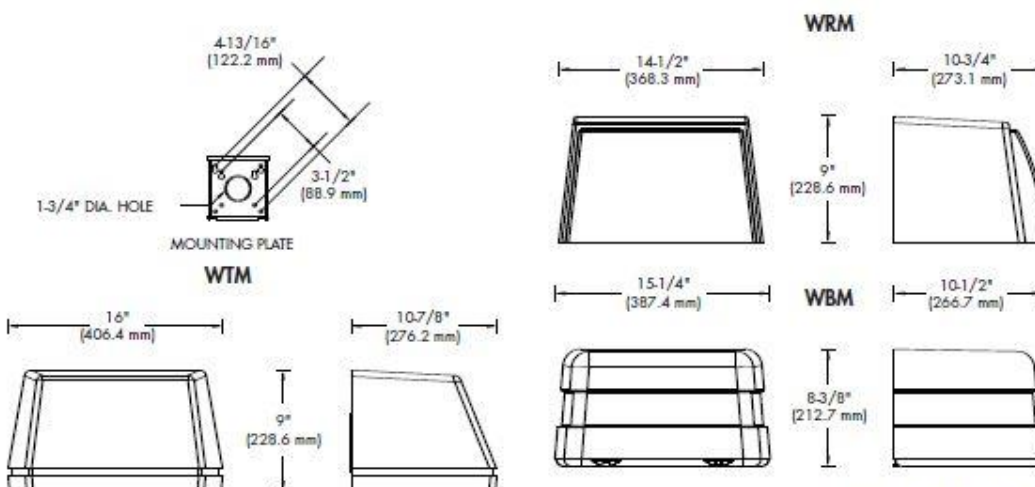
PC-MT - Photo Control Twist Lock, multi-volt (must
use PCR option)
PCR-SC - PCR Shorting Cap
(For additional descriptions of Wall Light accessories
refer to sheet number OA-50030.)

Footnotes:
^aOrder Twist Lock Photo Control separately.
^bUse with 208 and 240 volt.
^cUse with 120, 277 and 347 volt.

General Notes:
All options are factory installed.
All accessories are field installed.
Data subject to change without notice.

Predicted L70 Lifetime:
25°C Ambient - >60,000 hours
40°C Ambient - >60,000 hours
(based upon LED manufacturer's supplied LM-80
data and in-situ laboratory testing)

DIMENSIONS



WEIGHT = 19 lbs. (max.)

PHILIPS
Day-Brite

WTM/WRM/WBM-LED MEDIUM FULL CUTOFF WALL PACK

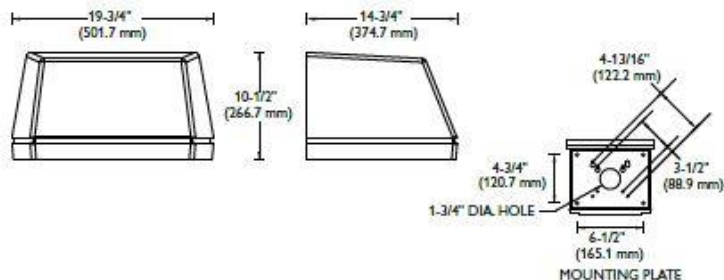
WL-43171

8.1.3 SPECIFICATIONS FOR POST-RETROFIT LUMINAIRE - DAYBRITE WTL:

Features

- Heavy duty die cast aluminum housing.
- Die-cast aluminum heat sink designed for excellent thermal transfer to extend component life.
- Silicone gasketing provides protection against moisture.
- Quick mount wall plate mounts directly to 3-1/2" octagon or 4" square outlet box for easy installation.
- Polyester powder finish for impact, corrosion and UV resistance.
- Tempered glass lens.
- Furnished with surge protector.
- Components are RoHS compliant.
- LED light engine and driver are field replaceable.
- Certified to meet UL 1598 standards for wet location, and 40°C ambient.

Dimensions



Outdoor

WTL

LED Large Full Cutoff Wall Light



The LED WTL Large Full Cutoff Wall Light offers a sleek design and cutoff performance with a wide range of uses. It delivers the lighting needed for the exteriors of retail buildings, businesses, walkways, underpasses or entrance doors.

Accessories (Order Separately)

PC-MT – Photo Control Twist Lock, Multi-volt
(Must have PCR option)
PCR-SC – PCR Shorting Cap
(For additional descriptions of Wall Light accessories refer to page 947-948.)

Green Product Choice: WTL90WLU-FWT-BK

| WTL | 90W | L | - | - | - | - | - |
|----------------------|---|---|--|---|--|--|---|
| Family WTL | Voltage 90W – 90W LED Neutral White (4100K) | Voltage 34 – 347 U – Universal 120-277 volts 50 Hz or 60Hz | | Paint Colors BLANK – Dark Bronze Textured WT – White Textured BK – Black Textured AL – Silver Aluminum NP – Gray Aluminum Textured GY – Industrial Gray Textured (Consult factory for other colors) | | Lens BLANK – Clear Tempered Glass Lens FGS – Flat Solis Diffusing Tempered Glass Lens | |
| | | Lamp Source L – LED | Optics SC2 – Wide Distribution MC3 – Medium Distribution FWT – Forward Throw | | Options MD180 – Integral Motion Detector (120-277V) WSF – Wired Single Fuse ¹ WDF – Wired Double Fuse ² PCR – Photo Control Receptacle ³ | | |

General Notes

All options are factory installed.
All accessories are field installed.

Footnotes:

¹Order twist lock photo control separately.
²Use with 208 and 240 volt.
³Use with 120, 277 and 347 volt.

Predicted L₇₀ Lifetime

25°C Ambient - >60,000 hours
40°C Ambient - >60,000 hours
(based upon LED manufacturer's supplied LM-80 data and in-situ laboratory testing)

For more information concerning the WTL LED Large Full Cutoff Wall Light, consult specification sheet number WL-43161 at www.daybrite.com. Consult the website for warranty information. Data subject to change without notice.

8.1.4 SPECIFICATIONS FOR POST-RETROFIT LUMINAIRE - GARDCO ELG:

| |
|--------|
| Job: |
| Type: |
| Notes: |



Emco

ELG

Page 1 of 4

LED Parking Garage Luminaire - Generation 2

Available with Motion Response and Integrated with Wireless Lighting Control System

Philips Gardco's Emco product family features the ELG parking garage luminaire, providing an excellent quality of light in a parking garage application. The high performance integrated lens LED optical systems provide excellent performance, minimizing glare and light trespass. Philips Gardco LED integrated lens technology combines with superior thermal control to provide maximized light output and maximum energy savings. A concentrated downlight optic is available for use at garage entrances or at higher mounting heights within a parking garage. The ELG utilizes the identical Quick Mount Plate system that has been proven in years of service with the Philips Gardco GP1 garage luminaire family. Generation 2 luminaires are available with dimming, as well as motion response technology to further enhance potential energy savings. The ELG is also available with a motion sensor and wireless control module, for integration with the LimeLight™ Wireless Lighting Control System. The result is complete parking garage lighting control system.



| PREFIX | OPTICAL SYSTEM | LED WATTAGE | LED SELECTION | VOLTAGE | FINISH | OPTIONS |
|---------|----------------|-------------|---------------|---------|--------|---------|
| ELG-DIM | 5 | 70LA | NW | UNIV | NP | |

Enter the order code into the appropriate box above. Note: Philips Gardco reserves the right to refuse a configuration. Not all combinations and configurations are valid. Refer to notes below for exclusions and limitations. For questions or concerns, please consult the factory.

PREFIX

ELG Emco LED Garage Luminaire
ELG-DIM^{1,4} ELG with 0-10V Dimming
ELG-MR² ELG with Motion Response
ELG-RC^{3,4} ELG with Wireless Control Module and Motion Sensor.
 For use only as part of a complete control system including ELG-RC luminaires and the LimeLight™ Wireless Lighting Control System.

1. Luminaire includes 0-10V input wires for dimming control by a dimming system supplied by others.
2. Luminaire includes a motion sensor which reduces power input and light output by 80% when the area is unoccupied. See page 4 for more information on the motion sensor provided.
3. ELG-RC luminaires are available only as part of a complete wireless lighting control system. The system includes the luminaire with wireless control module and motion sensor, and all components and services provided with the LimeLight™ Wireless Lighting Control System. The entire system must be configured and factory quoted by Philips Gardco. ELG-RC luminaires are not available separately. ELG-RC luminaires are not available with emergency battery packs.
4. Available in UNIV (120V through 277V) only.

OPTICAL SYSTEM

5 Type 5 Utilizing Integrated Lens
CD Concentrated Downlight Utilizing Integrated Concentrated Downlight Lens

LED WATTAGE with LUMEN DATA

| Order Code | Description | LED Current (mA) | Average System Watts ⁵ | LED Selection | Type 5 Optic | | CD Optic |
|--------------|--|------------------|-----------------------------------|---------------|-----------------------------|-----------------------------|-----------------------------|
| | | | | | Standard Optic | With Diffusing Lens (DL) | Concentrated Downlight Lens |
| | | | | | Initial Lumens ⁶ | Initial Lumens ⁶ | Initial Lumens ⁶ |
| 70LA | 70 watt, (1) LED integral lens array. | 400 | 70 | CW | 6,329 (s) | 5,821 (s) | 5,938 (s) |
| | | | | NW | 6,028 | 5,706 | 5,821 |
| | | | | WW | 4,099 (s) | 3,880 (s) | 3,958 (s) |
| 110LA | 110 watt, (1) LED integral lens array. | 600 | 110 | CW | 8,504 (s) | 7,450 (s) | 7,600 (s) |
| | | | | NW | 8,100 | 7,304 (s) | 7,451 (s) |
| | | | | WW | 5,508 (s) | 5,006 (s) | 5,067 (s) |

5. System input wattage may vary based on input voltage, by up to +/- 10%, and based on manufacturer forward voltage, by up to +/- 8%.

6. Lumen values based on photometric tests performed in compliance with IESNA LM-79.

(s) indicates values are scaled value based on tests of similar, but not identical, luminaire configurations.

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E200-001/0912

PHILIPS





Emco

ELG

Page 2 of 4

LED Parking Garage Luminaire - Generation 2

| LED SELECTION | | VOLTAGE | | FINISH | |
|---------------|----------------|---------|--|--------|------------------------|
| CW | 6,000°K, 75CRI | UNIV | 120V through 277V, 50hz to 60hz input. | NP | Natural Aluminum Paint |
| NW | 4,000°K, 75CRI | 347 | 347V input. | | |
| WW | 3,000°K, 75CRI | 480 | 480V input. Available in 110LA only. | | |

OPTIONS

| | |
|---------------------|--|
| F ^{7,13} | Fusing |
| DL ⁸ | Diffusing Integrated Lens |
| PCB ^{7,13} | Button Photocontrol |
| BD ^{9,11} | Bird Deterrent Spike Kit |
| BX ^{10,11} | Bird Excluding Shroud |
| PB ¹² | J-Box for Pendant Mounting |
| SPR ¹³ | Surge Protection - 120V through 277V - meeting ANSI C62.41.2 |
| SPRH ¹³ | Surge Protection - 347V through 480V - meeting ANSI C62.41.2 |

7. 120V - 277V only. Specify actual input voltage.

8. DL integrated lens replaces Type 5 clear integrated lens. Not available with CD optic. The diffuse lens reduces performance significantly.

9. Kit of 25 injection molded plastic bird deterrent spikes.

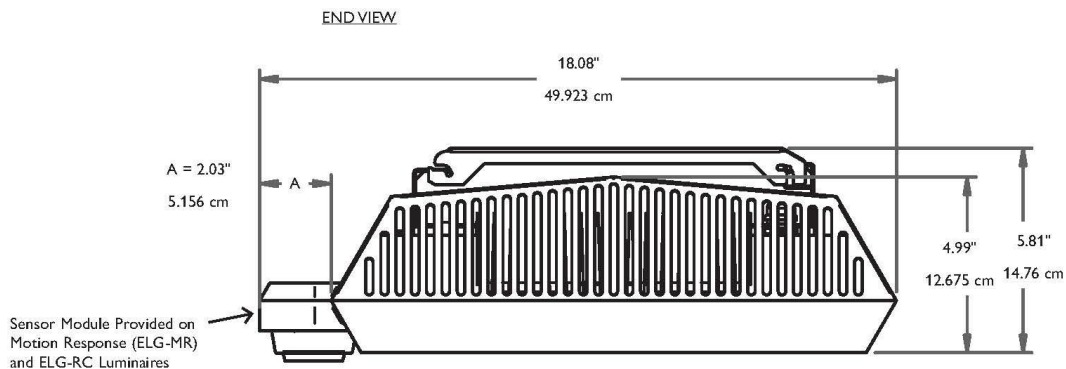
10. Shroud is for Pendant mount only. 12" (30.48cm) minimum pendant length required. Pendant by others.

11. BD and BX options cannot be utilized on the same luminaire. BD and BX options are installed in the field only.

12. For rigid and swivel pendant mount. Pendants by others.

13. Not available on the ELG-RC. The wireless remote control module and the wireless lighting control system make these options unnecessary.

DIMENSIONS (continued on page 3)



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PHILIPS





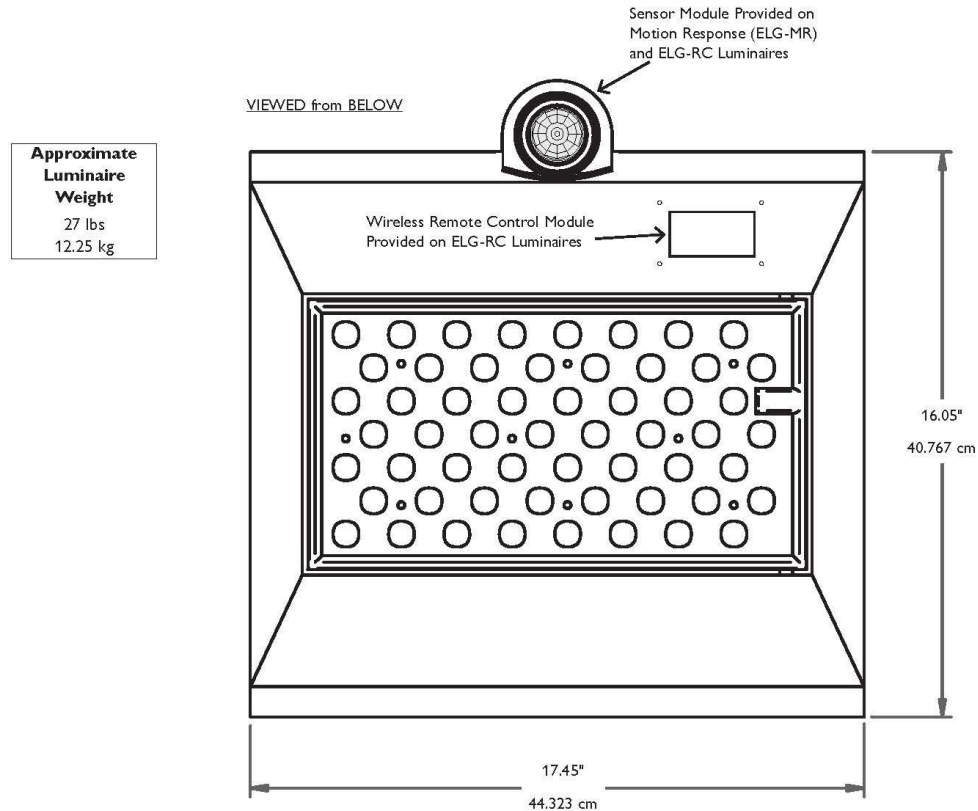
Emco

ELG

Page 3 of 4

LED Parking Garage Luminaire - Generation 2

DIMENSIONS (continued from page 2)



SPECIFICATIONS (continued on page 4)

GENERAL: Each ELG luminaire is a ceiling surface or ceiling pendant mounted garage or canopy luminaire with integrated lens optics featuring LEDs mounted in a fixed array. Internal components are totally enclosed in a rain-tight, dust-tight and corrosion resistant housing. Luminaires are suitable for wet locations.

HOUSING: The ELG housing consists of a rugged die cast aluminum housing body with an integral LED thermal management system.

IP RATING: The ELG is IP65 rated.

QUICK MOUNT PLATE AND MOUNTING: A die formed 14 ga. galvanized steel plate is supplied for mounting to a recessed, surface, or rigid pendant hung 4" (10.16 cm) j-box (standard j-box and rigid pendant by others). An integral hanger tab on the plate supports the luminaire during wiring. Mounting design permits simple retrofit at existing parking garages that utilize the Gardco GP1, and were installed with the same Quick Mount Plate System. All pendants, including rigid pendants and swivel pendants (utilized with the balanced j-box JB option), are supplied by others.

Caution: Philips Gardco is not responsible for failure of mounting components supplied by others. Proper care should be exercised in mounting component selection to insure adequate luminaire support, given luminaire weight, vibration potential and thermal conditions present in the application. If luminaires are supported solely by screws into a composite j-box, additional support directly to structure is recommended. Failure to properly support the luminaire may cause damage or injury, for which Philips Gardco is not responsible.

OPTICAL SYSTEMS: The Type 5 optic is an integrated lens LED array providing an IES Type V distribution. A Type 5 optic with the optional diffused integrated lens is available to limit perceived luminaire brightness, while reducing overall luminaire lumen output. The concentrated downlight optic provides a circular pattern of concentrated light directly below the luminaire, for use at garage entrances or at higher mounting heights as may be required within a parking garage. All LED integrated lens arrays are replaceable.

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Page 4 of 4

LED Parking Garage Luminaire - Generation 2

SPECIFICATIONS (continued from page 3)

LED PERFORMANCE:

| PREDICTED LUMEN DEPRECIATION DATA ¹⁴ | | |
|---|------------------------|-------------------------------------|
| Ambient Temperature °C | LED Wattage/ Driver mA | L ₇₀ Hours ¹⁵ |
| 25 °C | 70LA / 400 | 100,000 |
| | 110LA / 600 | 75,000 |
| 40 °C | 70LA / 400 | 65,000 |
| | 110LA / 600 | 60,000 |
| L70 Data per IES TM-21-11 ¹⁶ | | 60,000 |
| ¹⁴ Predicted performance derived from LED manufacturer's data and engineering design estimates, based on IESNA LM-80 methodology. Actual experience may vary due to field application conditions. ¹⁵ L ₇₀ is the predicted time when LED performance depreciates to 70% of initial lumen output. ¹⁶ Based on 10,000 hour tests data provided by the LED manufacturer, and the limits imposed by IES TM-21-11. Applies to all wattages and driver mA values shown in the table, as well as 25°C and 40°C ambient temperature conditions. Note: For Motion Response luminaires, and luminaires which are dimmed for a significant portion of operating time, L ₇₀ values are presumed likely to exceed the values shown in the table above. No specific test data to verify this presumption is available at this time. | | |

ELECTRICAL: Luminaires are equipped with an LED driver system that accepts 120V through 277V, 50hz to 60hz, (UNIV), or a driver that accepts 347V or 480V input. Component-to-component wiring within the luminaire will carry no more than 80% of rated current and is listed by UL for use at 600 VAC at 302°F/150°C or higher. Plug disconnects are listed by UL for use at 600 VAC, 15A or higher. Power factor is not less than 90%. Luminaires consume 0.0 watts in the off state.

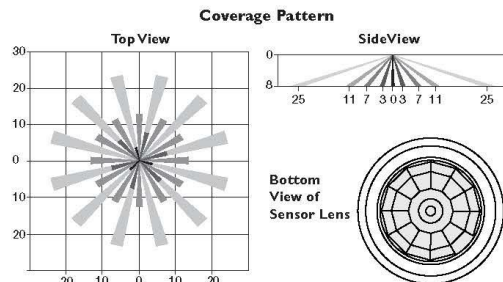
LED THERMAL MANAGEMENT: The ELG housing design provides aluminum integral thermal radiation fins in the upper housing, combined with lateral air ways, to provide the excellent thermal management so critical to long LED system life. Metallic screens are integrated to the top of the housing to prevent the buildup of dust, dirt and contaminants, while permitting required air flow for cooling.

MOTION SENSORS: ELG-MR and ELG-RC luminaires include a passive infrared (PIR) motion sensor (WattStopper® FS-305 equipped with an FS-L2W lens) capable of detecting motion within 24 feet of the sensor, 360° around the luminaire, when placed at an 8 foot mounting height. The PIR sensor is mounted as indicated in drawings on pages 2 and 3. Motion sensor off state power is 0.0 watts.

In Motion Response (MR) luminaires, when no motion is detected for 5 minutes, the Motion Response system reduces the wattage by 80%, to 20% of the normal constant wattage, reducing the light level accordingly. When motion is detected by the PIR, the luminaire returns to full wattage and full light output.

Performance of the motion sensor in ELG-RC luminaires is determined by the settings programmed into the LimeLight™ Wireless Lighting Control System.

The approximate motion sensor coverage pattern is as shown above.



ELG-RC LUMINAIRES: Luminaires are provided only as part of a complete parking garage control system. The system includes the luminaire with wireless remote control module and motion sensor; and all components and services that comprise the LimeLight™ Wireless Lighting Control System. The entire system must be configured and factory quoted by Philips Gardco. ELG-RC luminaires are not available separately.

FINISH: Each luminaire receives a fade and abrasion resistant, electrostatically applied, thermally cured, triglycidal isocyanurate (TGIC) textured polyester powdercoat finish. Standard color is Natural Aluminum Paint.

LABELS: All luminaires bear either UL or CUL (where applicable) Wet Location labels.

WARRANTY: Luminaires feature a 1 year limited warranty. LED luminaires with LED arrays feature a 5 year limited warranty covering the LED arrays. LED drivers are covered by a 5 year limited warranty. PIR sensors carry a 5 year limited warranty from the sensor manufacturer. The LimeLight™ Wireless Lighting Control System carries a 5 year limited warranty from the manufacturer. See Warranty Information on sitelighting.com for complete details and exclusions.

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8.1.5 SPECIFICATIONS FOR SENSOR - WATTSTOPPER FS-305-LU:

WattStopper®

SPECIFICATIONS

| | |
|--------------------------|--|
| Voltage | 12 - 24 VDC |
| Wiring | +12V, control, common |
| Current Consumption | maximum 6.5mA @ 24VDC |
| Coverage | |
| FS-L2W Lens @ 8' height | .48' diameter |
| FS-L3W Lens @ 20' height | .40' diameter |
| FS-L4W Lens @ 40' height | .60' diameter |
| Operating Temperature | -40°F [-40°C] to 131°F [55°C] |
| Dimensions | |
| Throat | 1.14" diameter (28.8mm) |
| Collar | 1.28" diameter (32.6mm) |
| Lens Pipe Length | 0.38" (9.6mm) |
| Body | 1.38" x 2.35" x 0.88" (35mm x 59.5mm x 22.7mm) |

OPEN DEVICE for installation in the Listed Enclosure per Installation Instructions.

DESCRIPTION AND OPERATION

The FS-305-LU motion sensor connects to Lumewave's TOP900TL module. This slim, low-profile sensor is designed for installation inside the bottom of a light fixture body. The PIR lens connects to the FS-305-LU through a 1 1/8" diameter hole in the bottom of the fixture.

The sensors use passive infrared (PIR) sensing technology that reacts to changes in infrared energy (moving body heat) within the coverage area. Consideration must be given to sensor placement. Avoid placing the sensor where shelving or other obstructions may block the sensor's line of sight.

The FS-305-LU operates at 12 - 24 VDC and it provides an open collector output. It is designed for installation in a light fixture.

Outdoor Use at the Sensor Collar part only when (Sensor Collar part exposed and) installed at the specific location per Installation Instructions with a Listed Outdoor Enclosure.

Operation during Power-Up

During the sensor warm-up period, which can last up to a minute after initial power-up (or after a lengthy power outage), the load will remain ON until the selected time delay expires.

COVERAGE PATTERN

Density and range of the coverage pattern is determined by the type of lens and mounting height. See the FS-LxW Lens Module Coverage Guide for a description of the available coverage patterns.

WARRANTY INFORMATION

WattStopper warrants its products to be free of defects in materials and workmanship for a period of five (5) years. There are no obligations or liabilities on the part of WattStopper for consequential damages arising out of, or in connection with, the use or performance of this product or other indirect damages with respect to loss of property, revenue or profit, or cost of removal, installation or reinstallation.

WattStopper®

2800 De La Cruz Blvd.
Santa Clara, CA 95050

Phone: 800.879.8585
www.wattstopper.com

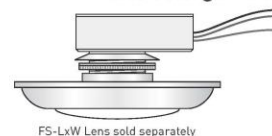
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Please Recycle

FS-305-LU

Motion Sensor for Indoor/Outdoor Use

Low Voltage • Fixture Mount



INSTALLATION AND WIRING

CAUTION
TURN THE POWER OFF AT THE CIRCUIT BREAKER BEFORE INSTALLING THE SENSOR.

1. Install the LUMEWAVE TOP900TL as described in the instructions provided with the unit.
2. Determine an appropriate mounting location inside the light fixture for the FS-305-LU. Allow a minimum distance of 1.3" (33mm) from the center of the sensor collar to the edge of the fixture.
3. Use a 1 1/8" (29mm) bit to drill a hole through the sheet metal in the bottom of the fixture.
4. From the inside of the fixture, insert the FS-305-LU lens pipe through the hole in the bottom of the fixture. Install the sensor face down, parallel to the mounting surface. Hand tighten the Lens securely against the outside of the fixture. If necessary, use the Tightening Ring, with or without the metal washer (provided), as a spacer on either side of the fixture wall.
5. Connect the FS-305-LU to the LUMEWAVE TOP900TL as shown.
6. Restore power from the circuit breaker.

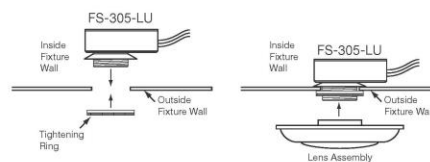
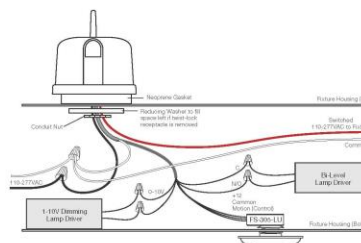


Fig 1: FS-305-LU mounting in light fixture

Note: The Outside Fixture Wall thickness should be between 0.032" and 0.10" (0.82mm and 2.54mm) for optimal sensor mounting and security.

WIRING A SINGLE SENSOR



Installation Instructions

A Group brand

8.1.6 SPECIFICATIONS FOR SENSOR - WATTSTOPPER EW-205-12-LU:

Models

EW-205-12-LU

Specifications and Features

Operating Voltage: 9 to 15 VDC

Current Consumption: maximum 10 mA @15 VDC

Requires Lumewave controller, or equivalent

PIR coverage: 270°

Compact design for fixture mounted applications

Designed for indoor and outdoor use

Operating temperature: -40° to 130°F (-40° to 54°C)

UL and cUL listed; UL 773A raintight and UL 1571 for wet locations

Five year warranty

Materials

Polycarbonate, Flame retardant UV resistant

Low Voltage Outdoor Motion Sensor



Product Overview

The EW-205-12-LU works with Lumewave's TOP900-TL, TOP900-TN, and OEM900 controllers to turn outdoor lighting fixtures On and Off based on motion. The sensor is designed for use in wet outdoor locations (UL 773A and UL1571).

The EW-205-12-LU uses a multi-cell, multi-tier Fresnel lens with a 270 degree field of view for PIR detection. Coverage density and the range of the coverage pattern is determined by mounting

height. The coverage pattern shown is tested in a controlled setting with the unit mounted at 8 ft. to 10 ft. The actual outside coverage pattern may vary substantially at the specific installation site and is dependent on several factors including weather, external light sources, mounting height and sensor tilt.

Mount the sensor where it will have a clear line of sight of the area to be sensed.

Figure 1. Dimensions:
Sensor and adaptor.

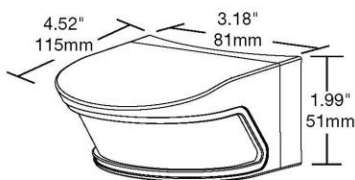


Figure 2. PIR Coverage:
Overhead view.

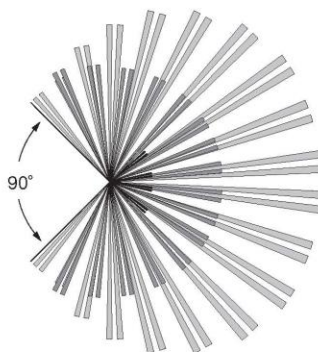
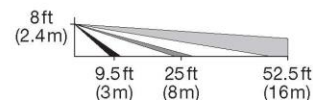


Figure 3. PIR Coverage:
Side view.



Installing the EW-205-12-LU

1. Install the LUMEWAVE TOP900-TL, TOP900-TN, or OEM900 device as described in the instructions provided with the unit.
2. Attach the sensor to the adaptor. Attach the adaptor to the fixture. [Note: the adaptor supplied with this device attaches to a Lumec SFPH4 collar ensuring a watertight seal. The screw holes

- on the adaptor line up with the holes drilled into the collar.]
3. Connect the EW-205-12-LU to the LUMEWAVE TOP900-TL, TOP900-TN, or OEM900.
4. Restore power from the circuit breaker.

Figure 4. Mounting EW-205-12-LU to pole fixture.

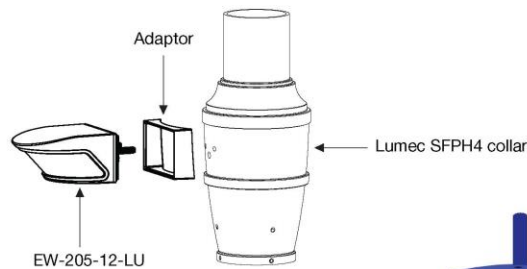
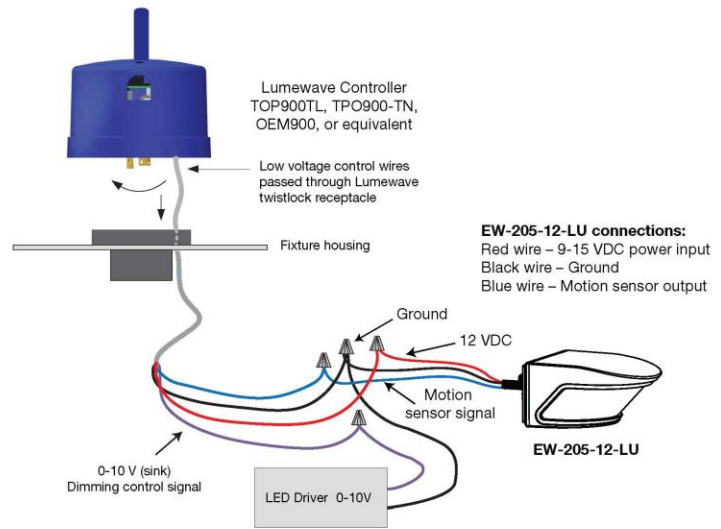


Figure 5. EW-205-12-EU wiring.



Sequence of Operation

Power-Up Operation: After initial power-up (or after a lengthy power outage), there is a sensor warm-up period, which typically lasts 30 seconds before the load turns ON.

Normal Operation: When the EW-205-12-LU detects motion it sends a signal to the controller to drive lighting to high mode. If it does not detect motion for the period of the time delay the signal drops and lighting returns to low mode. When the PIR sensor is triggered by motion, the output is pulled to ground for a minimum of 1 second. Longer periods can be observed depending on magnitude and duration of the detection signal. This sensor is intended to interface with a secondary load control device and subsequent control strategies such as daylighting hold-off, time delay, and test-mode are functions of the load control device (Lumewave or equivalent).

Ordering Information

| Catalog # | Color | Description | Input Voltage |
|--------------|-------|---|---------------|
| EW-205-12-LU | Black | Low voltage outdoor fixture mounted motion sensor | 12 VDC |

8.1.7 SPECIFICATIONS FOR SENSOR - LUMEWAVE MWX-LVE-090U-B:

Lumewave – MWX-LVE-90U-B Bluetooth Enabled Outdoor Microwave Lighting Controller



Introducing the world's first Bluetooth enabled, long-range microwave based sensor specifically designed for controlling street and area lights. Sensor can distinguish between pedestrians and vehicles offering unique control opportunities. It can detect vehicles approaching at > 400' and Pedestrians at 100'.

"MWX Setup" application may be downloaded and run on iPhone which will use the latest Bluetooth BLE 4.0 to communicate with each sensor to set and modify its control settings. This will work much better than IR in the bright outdoor light and on fixtures high on poles.

Apple Device Compatibilities

- iPhone 4S or 5 will run full application.
- iPhone 4 will run demo only

FREE iPhone/iPad application to setup sensors



Key Attributes:

- Operating Voltage: 12 – 24Vdc
- Set sensor Sensitivity High, Med, Low
- Select output filter Vehicle, Pedestrian, Both (Default)
- Mounting Threaded Nipple - vertical or right angle mounting available
- Certifications FCC/ IC Approved
- Environmental IP65

Detection Range at 20' or 30' mounting height, range dependent on size and speed of target

- Pedestrian: 100'
- Small Vehicle: 165'
- Full size SUV: 200+
- Truck or Bus 400+

Radar Sensor Attributes

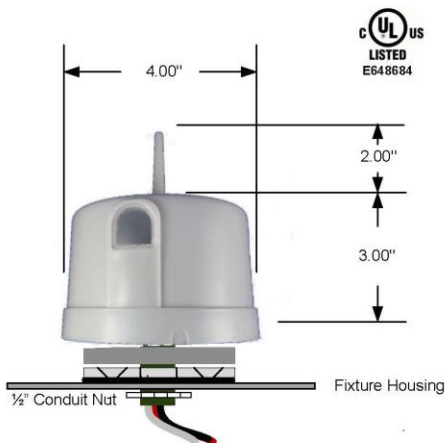
- Radar frequency: X Band, 10.250Ghz
- Power Output/Direction +17DBM
- Current at 12Vdc 50ma/1-sensor direction
- Detection Detects pedestrian and traffic movement together or individually
- Detection processing FFT (Fast Fourier Transform) analysis

Wiring

- Red 12 – 24Vdc
- Black DC Ground
- Blue Motion Signal
- Green Flashlight (Fixture Finder)

8.1.8 SPECIFICATIONS FOR RF – LUMEWAVE NODE & SYSTEM:

**** All interfaces are contained within the TOP900 module itself
No additional modules need be installed within fixture
for 0-10V or bi-level control**



Wireless Control

- Schedule on/off based on TOD or Astro-time
- Control by: Site / Network / Group / Device
- Modify and send new control schedules
- Enable/disable peer-peer control (mainly for pathway control with motion sensors)


Control Wiring

- Dimming: 0-10V
- Bi-Level control contacts
- +12V & GND for motion sensor
- Input for Motion Signal
- Input for Call Button

GPS Located, Wireless Network Lighting Control Module

- Installs through 1/2" knock-out
- Operating Voltage: 100 – 277Vac 50/60Hz
- 320J MOV Protection
- Average power consumption: <1W
- Operating Temperature: -40C to +70C (Exceeds ANSI 136.10)
- Lamp fixture control On/Off: 1000W/1000VA, 100 - 277Vac 50/60Hz
- Failsafe - ON
- Revenue Grade Power Metering @ better than 2% accuracy. Measure & Records:
 - Active (Real) Power
 - RMS Volts
 - RMS Current
 - Apparent Power
 - Power Factor
 - Data-Logger: Logs all output transitions including dimming output levels
- Measure Light Level & Module Temperature
- Programmable control schedule based on TOD and/or astronomical time
- Programmable weekday and weekend control schedules
- Maintenance thresholds settings for current and voltage
- Photocell control only for daytime overrides when dark or if unit loses its clock time
- Override any control Commands
- Tilt Sensor: Knock-down indication (Option)
- Photocell dark/light synchronization function
- Detect fixture failures
- Wireless Node:
 - Wireless Standard: IEEE 802.15.4
 - Operating Frequency: 902 – 928MHz
 - RF power +24dbm
 - FCC Modular Certified
 - Network Type: Star- Mesh Repeater
 - Networks: Wired/Wireless LAN, WAN, WWAN
 - 3Km (2 mile) range LOS
 - Built-in message forwarding and repeater function in all nodes

FCC & IC Approved
IP66 Certified
UL cUL E348684

| | |
|---|--------------------------|
|  Lumewave, Inc. Wireless Lighting Controls | Part No: 100107 TOP900TN |
| Description: Wireless Photocell Replacement Control Module | |
| Drawn By: MKK | Date: 10-6-12 Rev: H |

8.2 PHOTOMETRIC AND ELECTRICAL TEST REPORTS

8.2.1 PHOTOMETRIC REPORT FOR PRE-RETROFIT LUMINAIRES



VVNBH – Pre-retrofit luminaires

AES/NexLume "Solis", Emco ECA-14,
Emco ECA-18, RUUD GWP0625-1P,
"WP-M01"

Prepared for:
Bernhard Goesmann, Development Engineer
California Lighting Technology Center

Prepared by:
Tim Yu, Development Engineer
California Lighting Technology Center

Revised: May 2nd, 2014

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RESEARCH **INNOVATION** **PARTNERSHIP**
633 Pena Dr. Davis, CA 95618 | cltc.ucdavis.edu | PH: 530-747-3838 F: 530-747-3809



Notes – Integrating Sphere

- Power provided by a California Instruments 2253ix PSU.
- Power measurement taken with a Yokogawa PZ4000 PA.
THD measurements taken with PZ4000's harmonics mode.
- Photometric measurements made with a SMS-500 Spectrometer in a 2 meter integrating sphere with Labsphere software.
- Auxiliary correction applied for fixture self absorptions.

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1

8.2.1.1 Photometric report for Pre-retrofit Luminaire, NexLume "Solis", N-07, 200W, 277V



Summary

AES/NexLume "Solis", N-07

Photometric:

| Power(W) | Output(L) | CCT(K) | Duv | CRI | Efficacy |
|----------|-----------|--------|----------|------|----------|
| 187.2 | 5393 | 4646 | 0.011304 | 74.6 | 28.8 |

Electrical:

| Voltage(V) | Current(A) | Power(W) | PowerFactor | UTHD% | ITHD% |
|------------|------------|----------|-------------|-------|-------|
| 276.8 | 0.748 | 187.2 | 0.9044 | 0.18 | 42.02 |

CRI:

| R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | RA |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 85.8 | 81.7 | 49.0 | 80.2 | 76.4 | 65.2 | 82.2 | 76.1 | 15.5 | 28.6 | 64.6 | 39.2 | 85.4 | 67.2 | 74.6 |

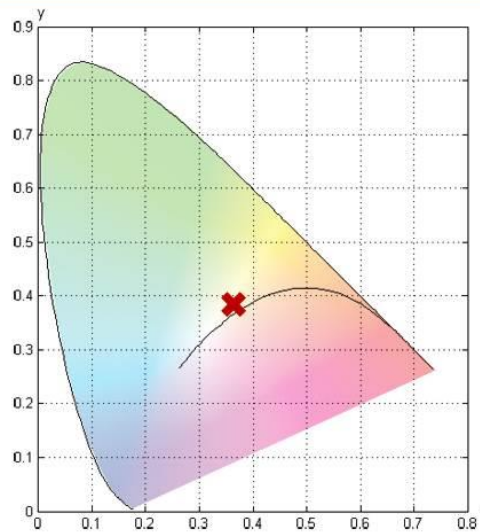
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3



Chromaticity

AES/NexLume "Solis", N-07



| CIE X | CIE Y |
|--------|--------|
| 0.3598 | 0.3868 |

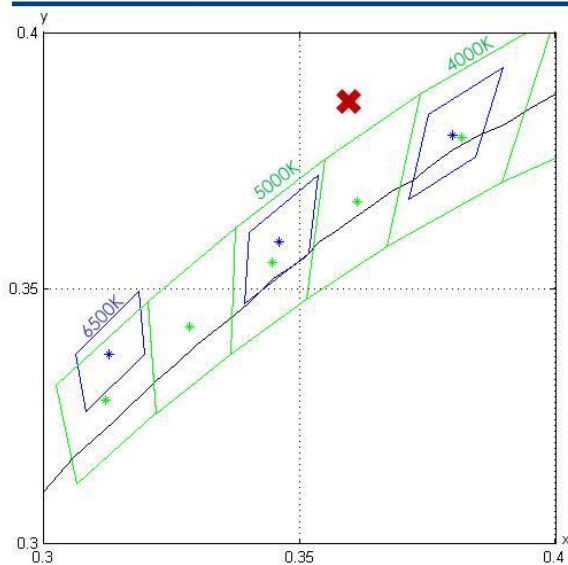
Chromaticity Diagram CIE 1931, 2 Degree

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4

Chromaticity

AES/NexLume "Solis", N-07



| | CIE X | CIE Y |
|---|--------|--------|
| ✖ | 0.3598 | 0.3868 |

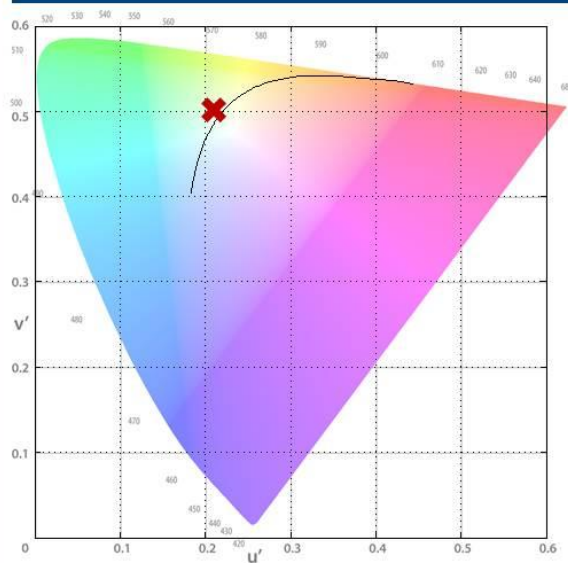
Chromaticity Diagram CIE 1931, 2 Degree

Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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5

AES/NexLume "Solis", N-07



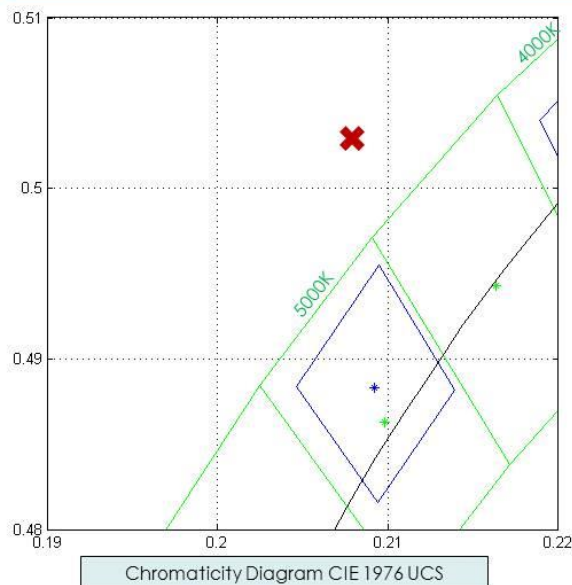
| | CIE u' | CIE v' |
|---|--------|--------|
| ✖ | 0.2079 | 0.5029 |

Chromaticity Diagram CIE 1976 UCS

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6

AES/NexLume "Solis", N-07



| | CIE u' | CIE v' |
|---|--------|--------|
| ✖ | 0.2079 | 0.5029 |

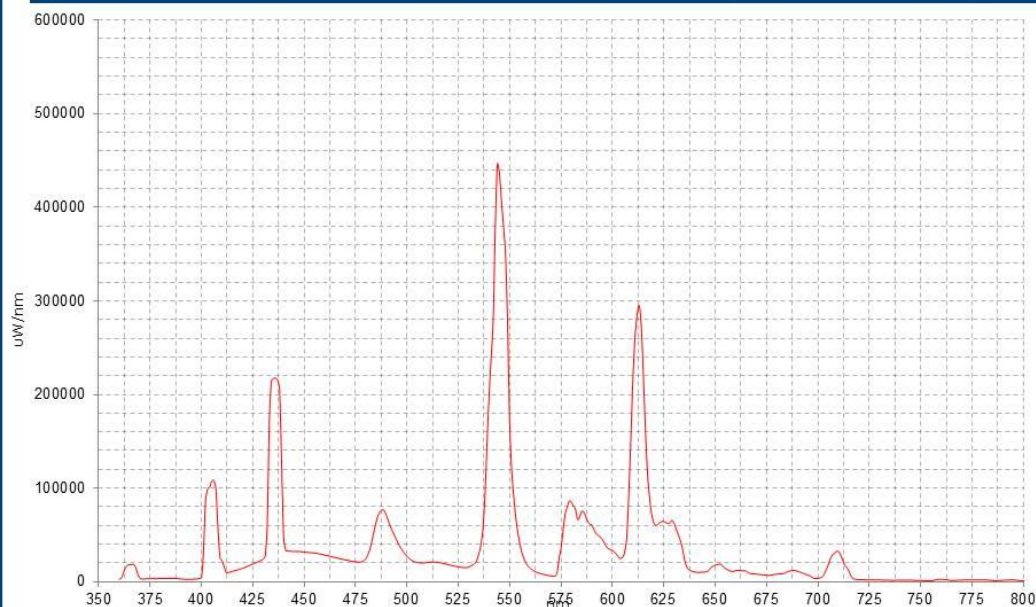
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Spectral Power Distribution

AES/NexLume "Solis", N-07



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8.2.1.2 Photometric report for Pre-retrofit Luminaires, Emco, E-02, ECA-14-1-HM-70MH-277V



Summary

EMCO, E-02

Photometric:

| Power(W) | Output(L) | CCT(K) | Duv | CRI | Efficacy |
|----------|-----------|--------|----------|-----|----------|
| 65.4 | 1225 | 1864 | 0.001164 | 1.2 | 18.7 |

Electrical:

| Voltage(V) | Current(A) | Power(W) | PowerFactor | UTHD% | ITHD% |
|------------|------------|----------|-------------|-------|-------|
| 276.9 | 0.413 | 65.4 | 0.5720 | 0.08 | 22.09 |

CRI:

| R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | RA |
|-------|------|------|-------|-------|------|------|-------|--------|------|-------|------|-----|------|-----|
| -10.7 | 60.3 | 33.6 | -36.3 | -11.6 | 51.3 | 13.1 | -89.9 | -289.6 | 41.7 | -60.6 | 23.6 | 2.7 | 56.4 | 1.2 |

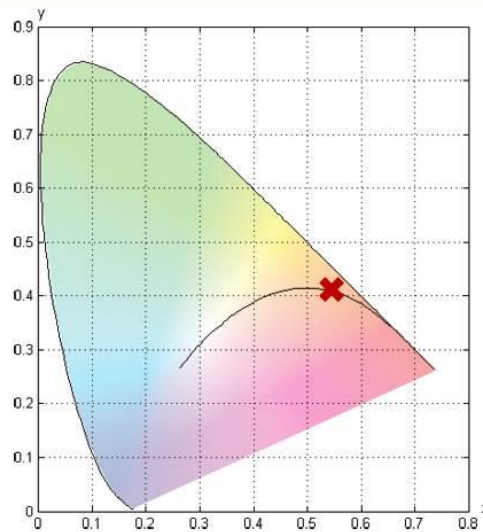
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10



Chromaticity

EMCO, E-02



| CIE X | CIE Y |
|--------|--------|
| 0.5445 | 0.4137 |

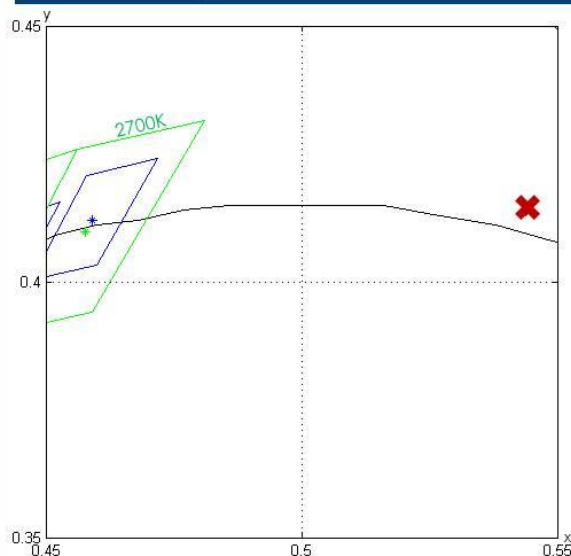
Chromaticity Diagram CIE 1931, 2 Degree

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11

Chromaticity

EMCO, E-02



Chromaticity Diagram CIE 1931, 2 Degree

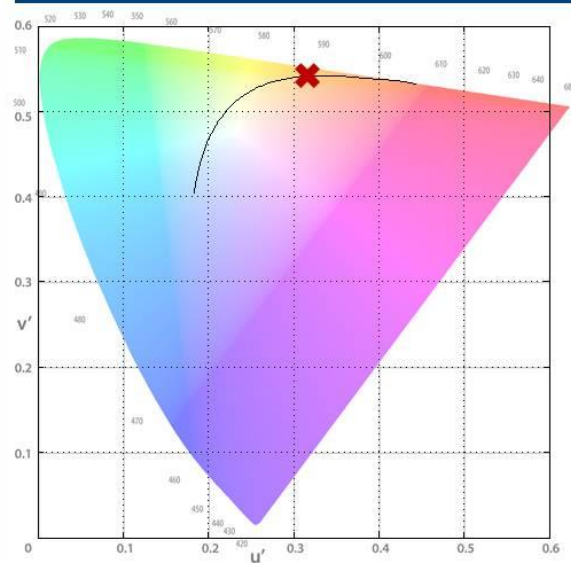
Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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| CIE X | CIE Y |
|----------|--------|
| ✖ 0.5445 | 0.4137 |

EMCO, E-02

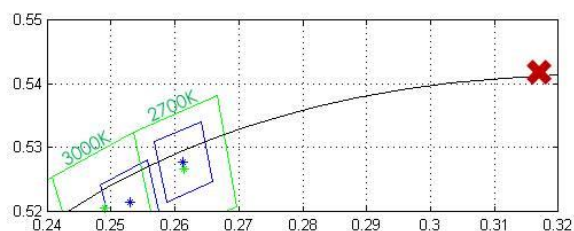


Chromaticity Diagram CIE 1976 UCS

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| CIE u' | CIE v' |
|----------|--------|
| ✖ 0.3168 | 0.5416 |



| | CIE u' | CIE v' |
|---|----------|----------|
| * | 0.3168 | 0.5416 |

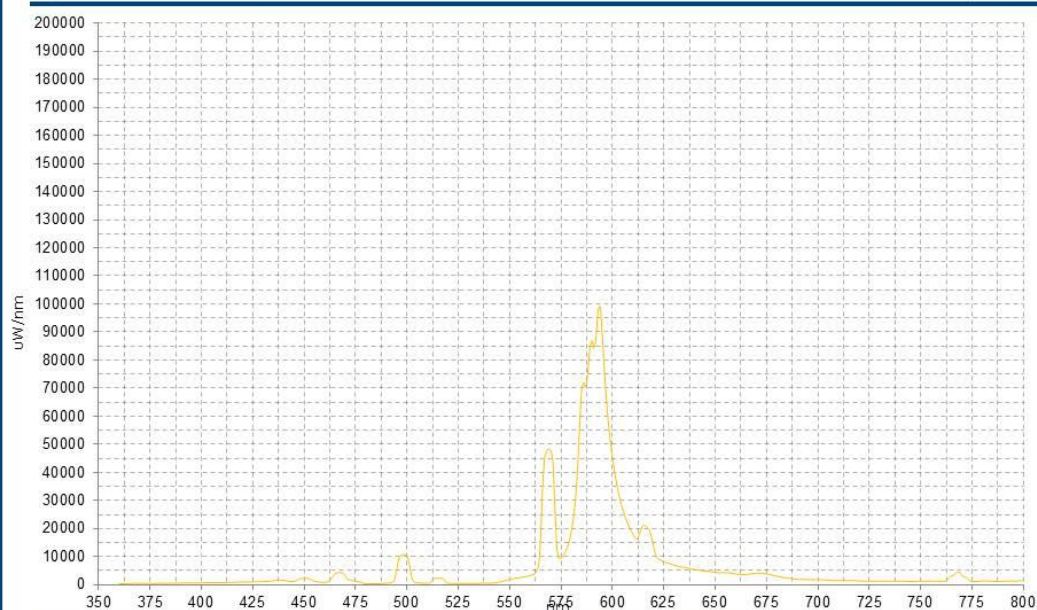
Chromaticity Diagram CIE 1976 UCS

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Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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Spectral Power Distribution



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8.2.1.3 Photometric report for Pre-retrofit Luminaires, Emco, E-11, ECA-18-1-QH-250MH-277V



Summary

EMCO, E-11

Photometric:

| Power(W) | Output(L) | CCT(K) | Duv | CRI | Efficacy |
|----------|-----------|--------|----------|------|----------|
| 171.0 | 4736 | 4850 | 0.018115 | 35.1 | 27.7 |

Electrical:

| Voltage(V) | Current(A) | Power(W) | PowerFactor | UTHD% | ITHD% |
|------------|------------|----------|-------------|-------|-------|
| 276.8 | 0.678 | 171.0 | 0.9112 | 0.06 | 41.17 |

CRI:

| R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | RA |
|------|------|------|------|------|------|------|------|--------|------|-----|------|------|------|------|
| 11.4 | 52.1 | 79.4 | 22.2 | 23.5 | 34.9 | 58.8 | -1.4 | -227.6 | -5.6 | 5.7 | 12.0 | 21.8 | 87.0 | 35.1 |

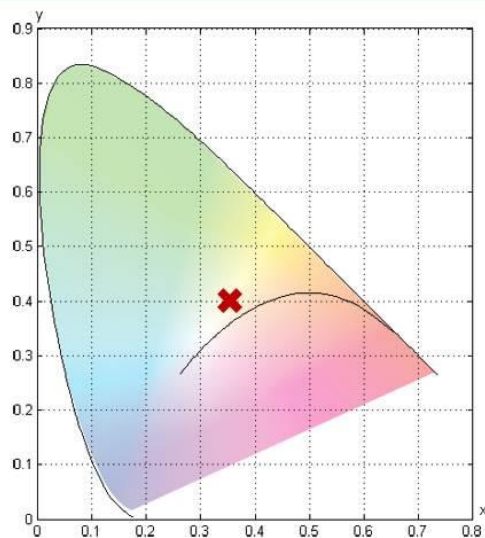
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Chromaticity

EMCO, E-11



| CIE X | CIE Y |
|--------|--------|
| 0.3543 | 0.3978 |

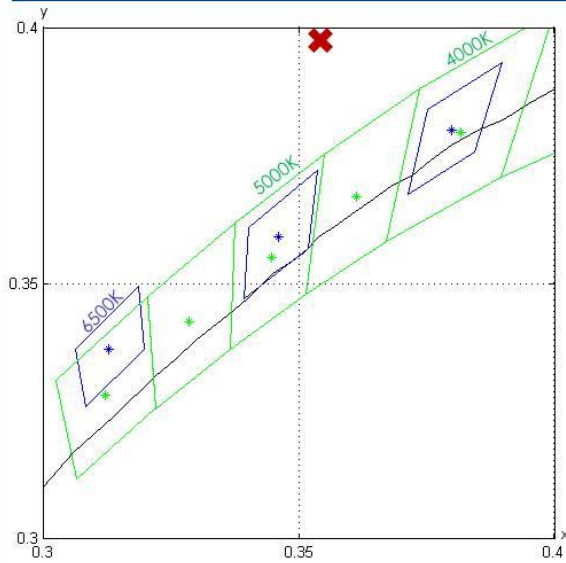
Chromaticity Diagram CIE 1931, 2 Degree

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Chromaticity

EMCO, E-11



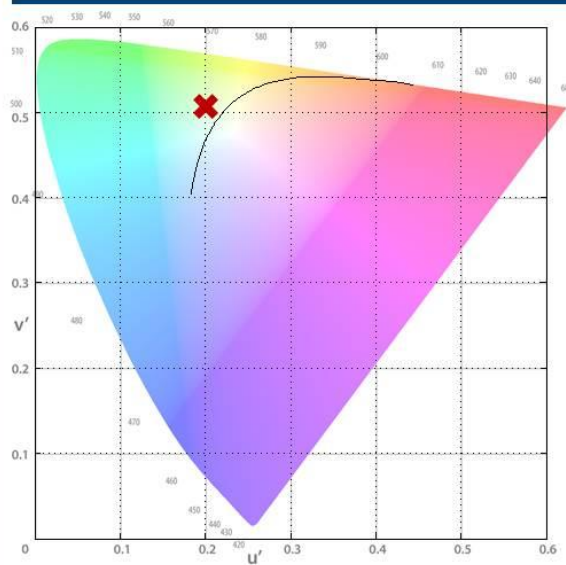
Chromaticity Diagram CIE 1931, 2 Degree

Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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EMCO, E-11

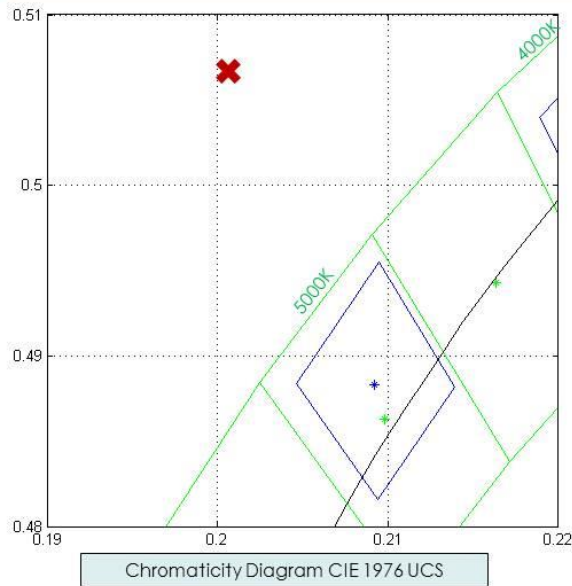


Chromaticity Diagram CIE 1976 UCS

| | CIE u' | CIE v' |
|----------|----------|----------|
| X | 0.2006 | 0.5067 |

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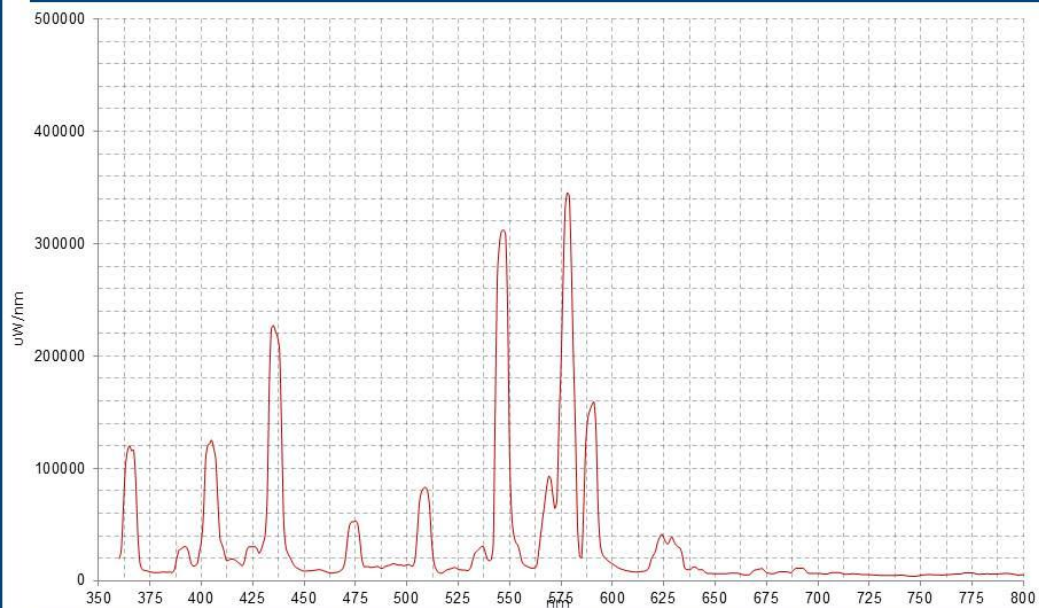


| CIE u' | CIE v' |
|--------|--------|
| 0.2006 | 0.5067 |

Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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8.2.1.4 Photometric report for Pre-retrofit Luminaire, Ruud, GWP0625-1P



Summary

RUUD, GWP0625-1P

Photometric:

| Power(W) | Output(L) | CCT(K) | Duv | CRI | Efficacy |
|----------|-----------|--------|----------|------|----------|
| 294.2 | 14467 | 4341 | 0.010688 | 60.2 | 49.2 |

Electrical:

| Voltage(V) | Current(A) | Power(W) | PowerFactor | UTHD% | ITHD% |
|------------|------------|----------|-------------|-------|-------|
| 119.4 | 2.475 | 294.2 | 0.9953 | 0.12 | 9.36 |

CRI:

| R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | RA |
|------|------|------|------|------|------|------|------|--------|------|------|------|------|------|------|
| 48.2 | 76.4 | 90.7 | 53.1 | 55.6 | 71.4 | 68.2 | 17.8 | -131.3 | 50.4 | 48.5 | 61.7 | 56.3 | 92.8 | 60.2 |

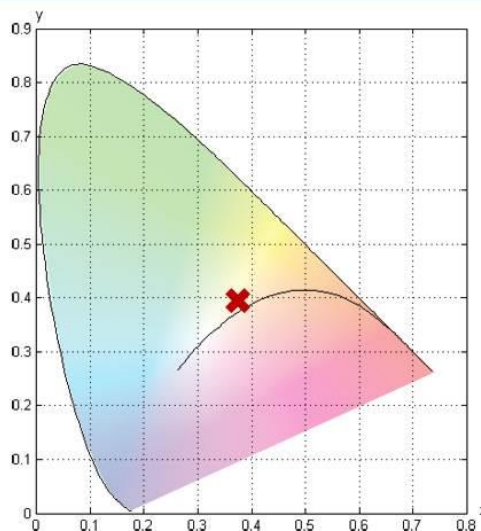
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Chromaticity

RUUD, GWP0625-1P



| CIE X | CIE Y |
|--------|--------|
| 0.3720 | 0.3945 |

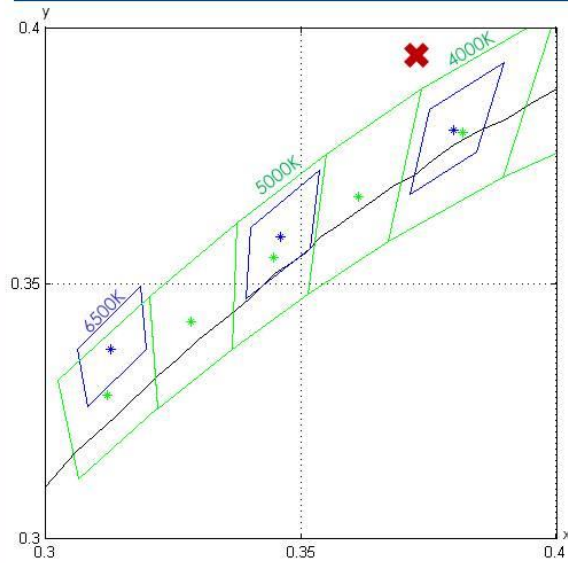
Chromaticity Diagram CIE 1931, 2 Degree

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Chromaticity

RUUD, GWP0625-1P



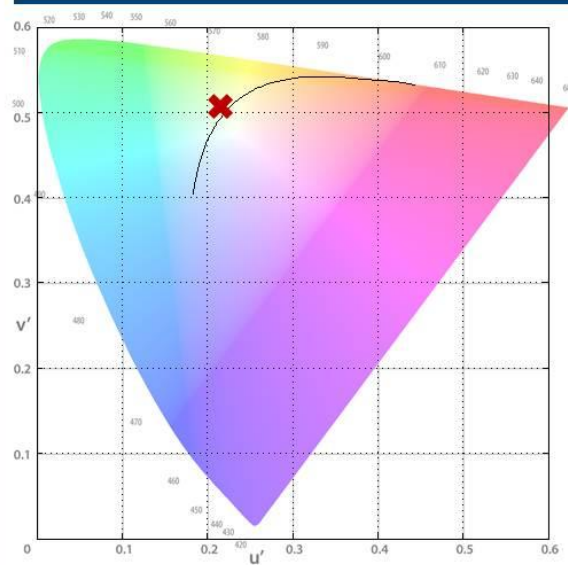
Chromaticity Diagram CIE 1931, 2 Degree

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Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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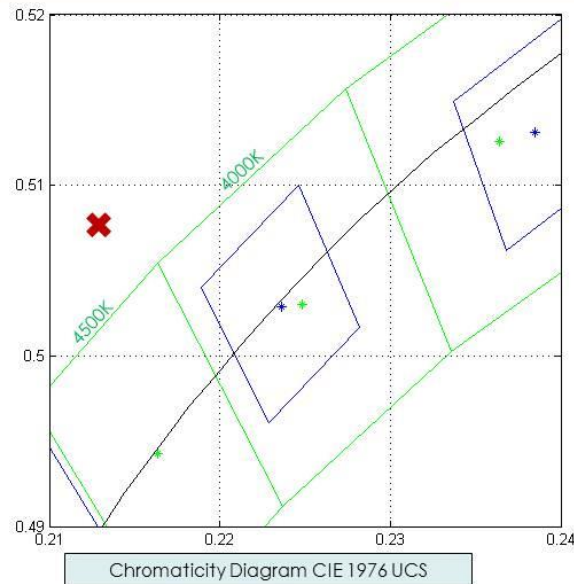
RUUD, GWP0625-1P



Chromaticity Diagram CIE 1976 UCS

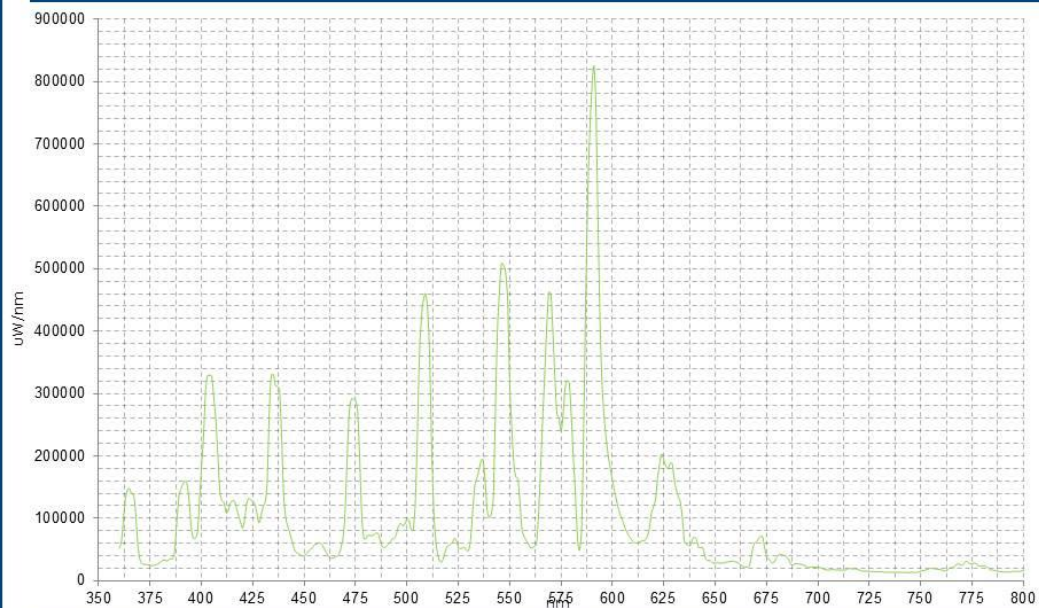
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8.2.1.5 Photometric report for Pre-retrofit Luminaire, Wall Pack “WP-M01”



Summary

WP-M01

Photometric:

| Power(W) | Output(L) | CCT(K) | Duv | CRI | Efficacy |
|----------|-----------|--------|----------|------|----------|
| 91.3 | 2688 | 1767 | 0.002459 | 13.6 | 29.4 |

Electrical:

| Voltage (V) | Current (A) | Power(W) | PowerFactor | UTHD% | ITHD% |
|-------------|-------------|----------|-------------|-------|-------|
| 119.8 | 0.782 | 91.3 | 0.9753 | 0.09 | 19.12 |

CRI:

| R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | RA |
|-----|------|------|-------|-----|------|------|-------|--------|------|-------|------|------|------|------|
| 4.3 | 63.3 | 45.2 | -20.5 | 0.2 | 54.0 | 26.3 | -63.7 | -222.9 | 44.2 | -46.3 | 24.4 | 12.9 | 64.6 | 13.6 |

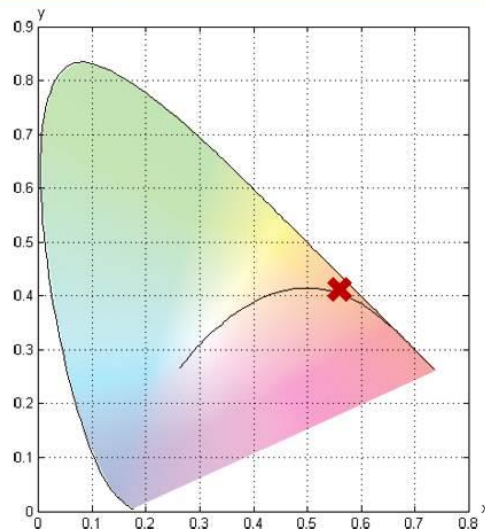
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31



Chromaticity

WP-M01



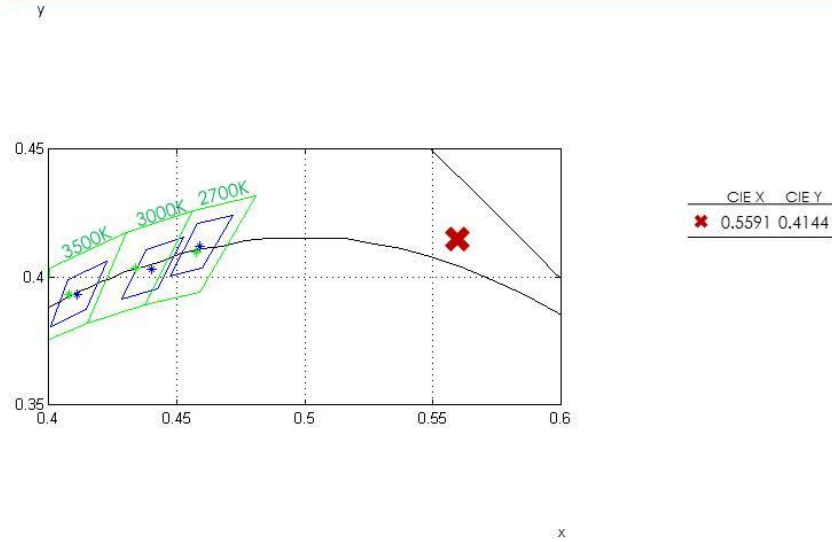
Chromaticity Diagram CIE 1931, 2 Degree

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32

Chromaticity

WP-M01



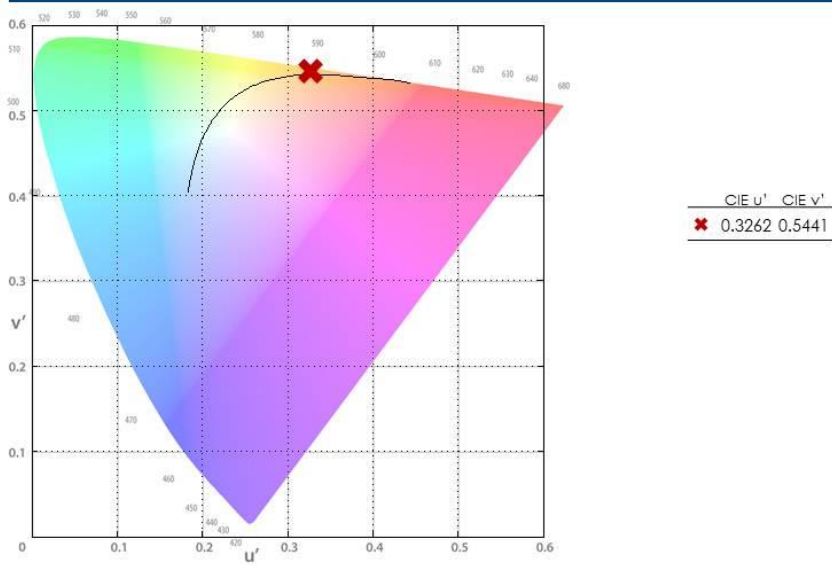
Chromaticity Diagram CIE 1931, 2 Degree

Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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33

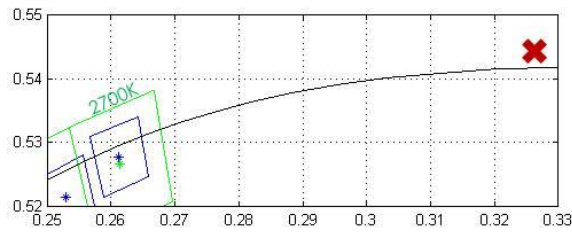
WP-M01



Chromaticity Diagram CIE 1976 UCS

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34



| CIE u' | CIE v' |
|--------|--------|
| 0.3262 | 0.5441 |

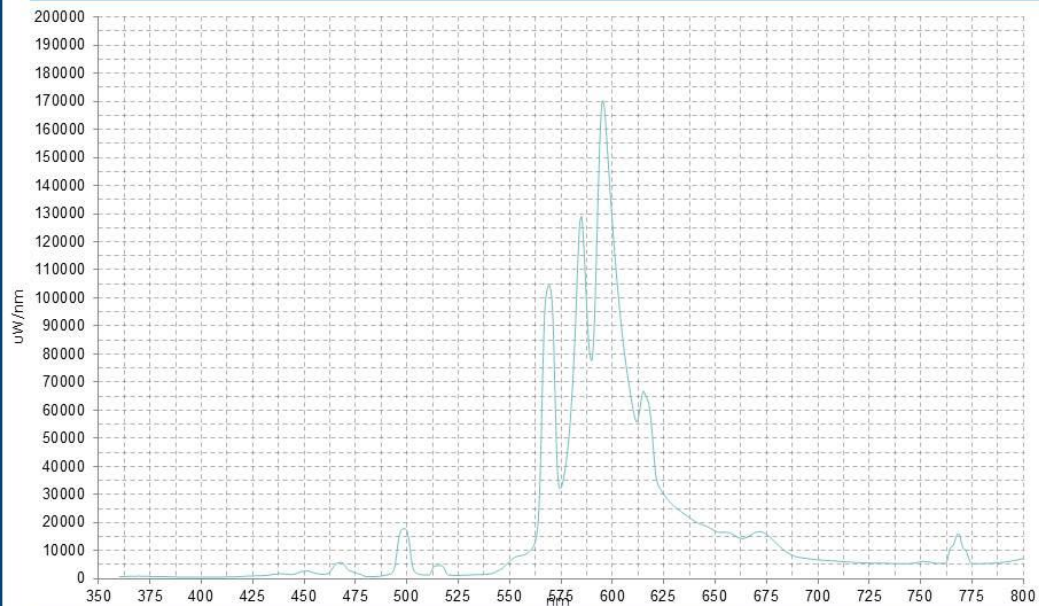
Chromaticity Diagram CIE 1976 UCS

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Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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Spectral Power Distribution



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8.2.2 PHOTOMETRIC REPORT FOR POST-RETROFIT LUMINAIRES

8.2.2.1 Photometric report for Post-retrofit Luminaires, Leotek Arieta 10M:



VVNBH – Post-retrofit luminaires Leotek Arieta 10M, Arieta15M

Prepared for:
Bernhard Goesmann, Development Engineer
California Lighting Technology Center

Prepared by:
Tim Yu, Development Engineer
California Lighting Technology Center

Revised: August 22nd, 2013

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Notes – Integrating Sphere

- Power provided by a California Instruments 2253ix PSU.
- Power measurement taken with a Yokogawa PZ4000 PA.
THD measurements taken with PZ4000's harmonics mode.
- Photometric measurements made with a SMS-500 Spectrometer in a 2 meter integrating sphere with Labsphere software.
- Auxiliary correction applied for fixture self absorptions.

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Arieta 10M

Summary

| Voltage Signal | Power (W) | Power Factor | Light Output (lm) | CCT (Kelvin) | CRI | Efficacy (lm/W) |
|----------------|-----------|--------------|-------------------|--------------|------|-----------------|
| 10 | 88.4 | 0.98 | 7343 | 3887 | 75.9 | 83.1 |
| 9 | 80.6 | 0.98 | 6796 | 3867 | 75.9 | 84.3 |
| 8 | 72.4 | 0.97 | 6211 | 3849 | 76.0 | 85.8 |
| 7 | 64.1 | 0.96 | 5560 | 3829 | 76.0 | 86.7 |
| 6 | 56.3 | 0.95 | 4896 | 3809 | 76.1 | 87.0 |
| 5 | 48.2 | 0.94 | 4163 | 3794 | 76.2 | 86.4 |
| 4 | 39.9 | 0.85 | 3433 | 3778 | 76.3 | 86.0 |
| 3 | 31.1 | 0.75 | 2626 | 3759 | 76.4 | 84.5 |
| 2 | 22.3 | 0.69 | 1821 | 3736 | 76.5 | 81.7 |
| 1 | 13.5 | 0.45 | 961 | 3718 | 76.6 | 71.2 |

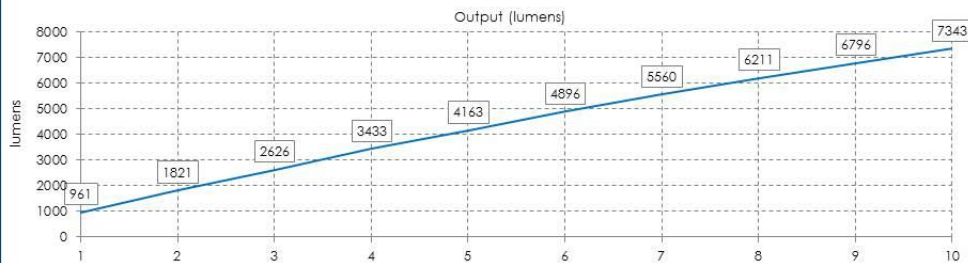
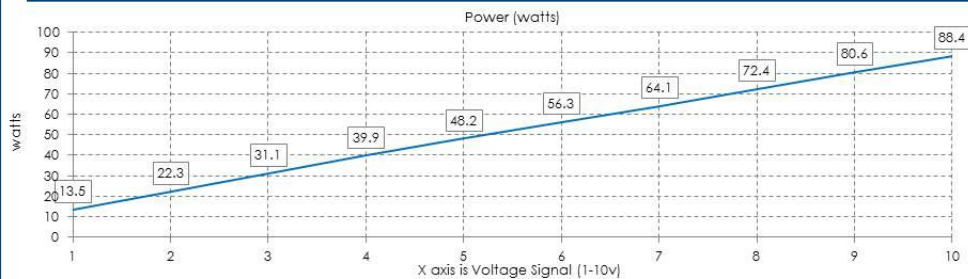
| Voltage Signal | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | RA |
|----------------|------|------|------|------|------|------|------|------|-------|------|------|------|------|------|------|
| 10 | 73.6 | 81.1 | 87.4 | 76.0 | 73.7 | 74.1 | 82.3 | 58.7 | -10.2 | 55.8 | 73.4 | 54.8 | 74.4 | 92.7 | 75.9 |
| 9 | 73.7 | 81.1 | 87.4 | 76.1 | 73.8 | 74.1 | 82.2 | 58.7 | -9.9 | 55.9 | 73.7 | 55.0 | 74.5 | 92.7 | 75.9 |
| 8 | 73.9 | 81.1 | 87.4 | 76.2 | 73.9 | 74.2 | 82.1 | 58.8 | -9.5 | 56.0 | 74.0 | 55.2 | 74.6 | 92.7 | 76.0 |
| 7 | 74.1 | 81.2 | 87.3 | 76.4 | 74.1 | 74.4 | 82.0 | 58.9 | -9.0 | 56.2 | 74.3 | 55.5 | 74.7 | 92.7 | 76.0 |
| 6 | 74.2 | 81.2 | 87.3 | 76.5 | 74.3 | 74.4 | 81.9 | 59.0 | -8.5 | 56.2 | 74.7 | 55.7 | 74.9 | 92.6 | 76.1 |
| 5 | 74.3 | 81.2 | 87.3 | 76.6 | 74.3 | 74.5 | 81.9 | 59.0 | -8.2 | 56.4 | 74.9 | 55.9 | 74.9 | 92.7 | 76.2 |
| 4 | 74.5 | 81.3 | 87.3 | 76.8 | 74.6 | 74.7 | 81.9 | 59.3 | -7.5 | 56.6 | 75.3 | 56.2 | 75.1 | 92.6 | 76.3 |
| 3 | 74.7 | 81.3 | 87.3 | 77.0 | 74.7 | 74.8 | 81.9 | 59.3 | -7.3 | 56.7 | 75.5 | 56.3 | 75.2 | 92.7 | 76.4 |
| 2 | 74.8 | 81.4 | 87.4 | 77.1 | 74.8 | 75.0 | 81.9 | 59.4 | -6.7 | 56.9 | 75.9 | 56.6 | 75.4 | 92.7 | 76.5 |
| 1 | 74.9 | 81.5 | 87.6 | 77.2 | 74.9 | 75.2 | 82.0 | 59.3 | -6.6 | 57.2 | 76.0 | 56.7 | 75.4 | 92.8 | 76.6 |

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3

Arieta 10M

Summary

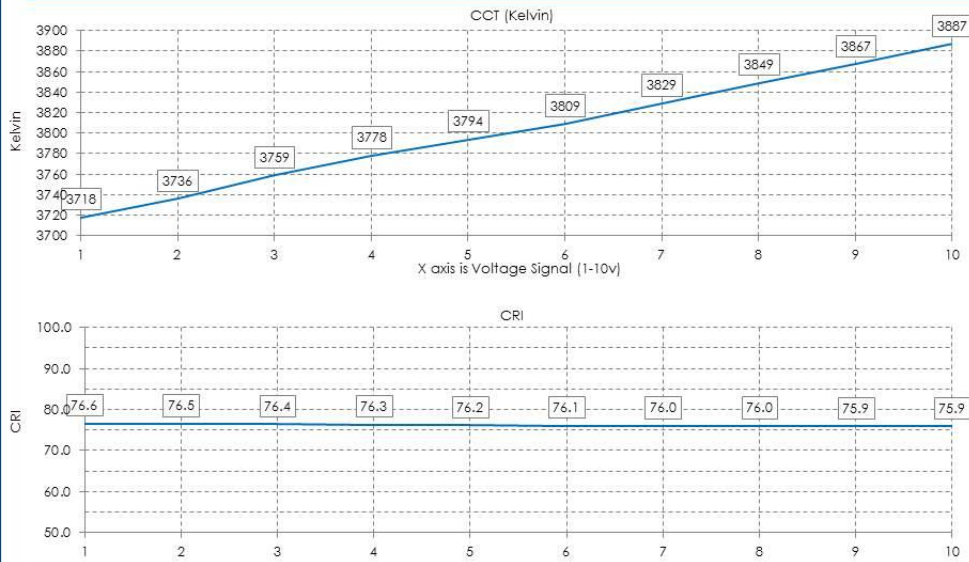


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4

Arieta 10M

Summary

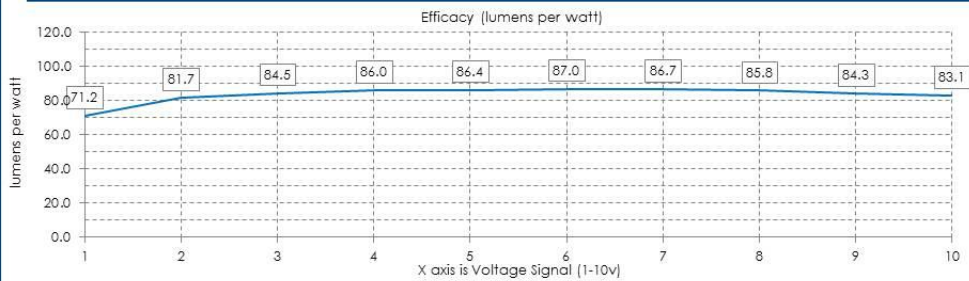


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5

Arieta 10M

Summary

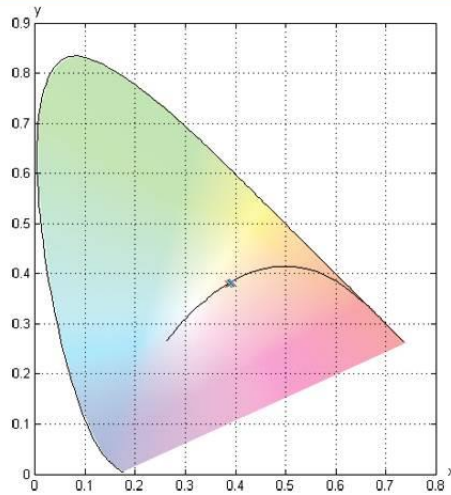


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6

Arieta 10M

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

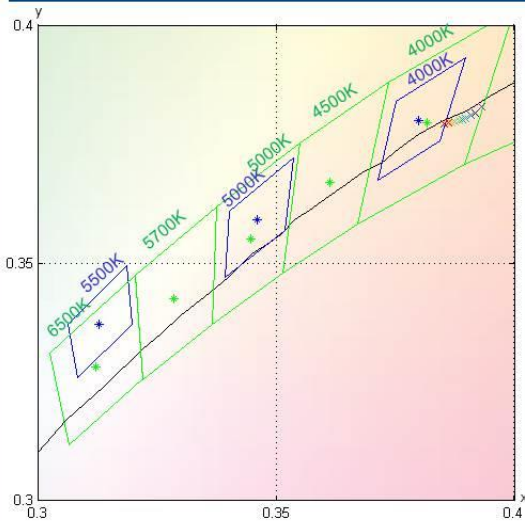
| | CIE X | CIE Y |
|---|--------|--------|
| ✖ | 0.3853 | 0.3792 |
| ✖ | 0.3861 | 0.3794 |
| ✖ | 0.3868 | 0.3794 |
| ✖ | 0.3876 | 0.3796 |
| ✖ | 0.3885 | 0.3799 |
| ✖ | 0.3892 | 0.3802 |
| ✖ | 0.3899 | 0.3804 |
| ✖ | 0.3909 | 0.3810 |
| ✖ | 0.3919 | 0.3816 |
| ✖ | 0.3931 | 0.3829 |

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7

Arieta 10M

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

| | CIE X | CIE Y |
|---|--------|--------|
| ✖ | 0.3853 | 0.3792 |
| ✖ | 0.3861 | 0.3794 |
| ✖ | 0.3868 | 0.3794 |
| ✖ | 0.3876 | 0.3796 |
| ✖ | 0.3885 | 0.3799 |
| ✖ | 0.3892 | 0.3802 |
| ✖ | 0.3899 | 0.3804 |
| ✖ | 0.3909 | 0.3810 |
| ✖ | 0.3919 | 0.3816 |
| ✖ | 0.3931 | 0.3829 |

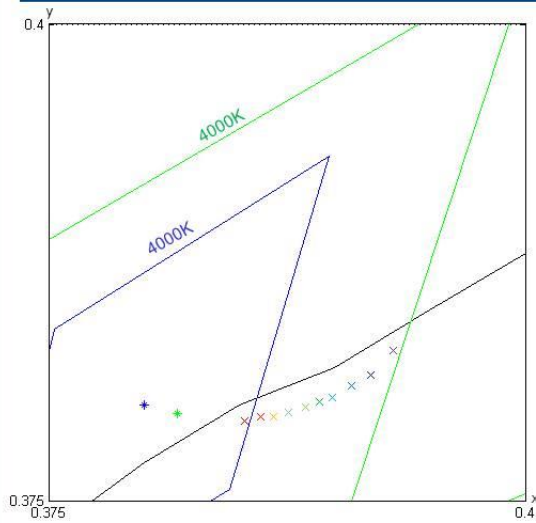
Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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8

Arieta 10M

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

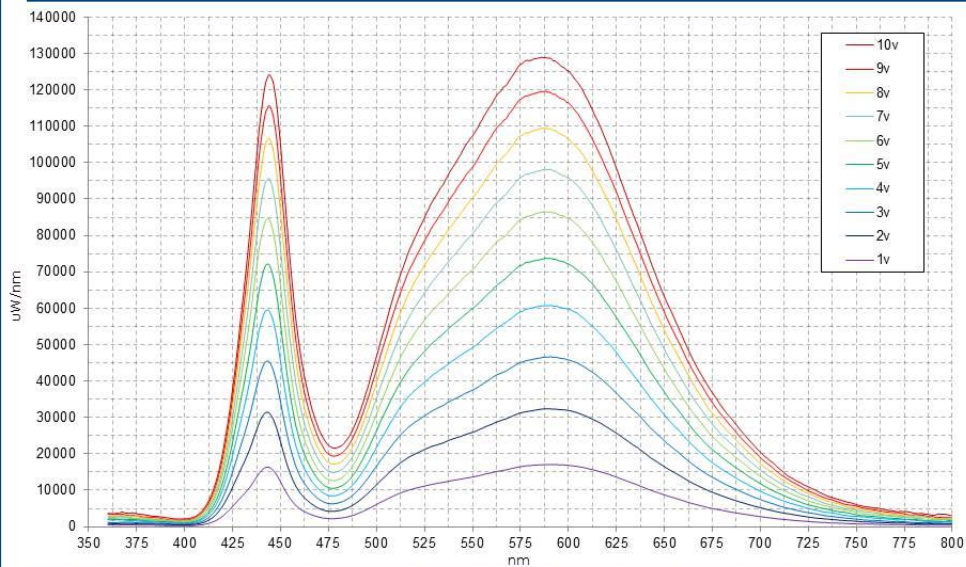
| | CIE X | CIE Y |
|---|--------|--------|
| ✖ | 0.3853 | 0.3792 |
| ✖ | 0.3861 | 0.3794 |
| ✖ | 0.3868 | 0.3794 |
| ✖ | 0.3876 | 0.3796 |
| ✖ | 0.3885 | 0.3799 |
| ✖ | 0.3892 | 0.3802 |
| ✖ | 0.3899 | 0.3804 |
| ✖ | 0.3909 | 0.3810 |
| ✖ | 0.3919 | 0.3816 |
| ✖ | 0.3931 | 0.3829 |

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9

Arieta 10M

Spectral Power Distribution



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10

8.2.2.2 Photometric report for Post-retrofit Luminaires, Leotek Arieta 15M:



VVNBH – Post-retrofit luminaires Leotek Arieta 10M, Arieta15M

Prepared for:
Bernhard Goesmann, Development Engineer
California Lighting Technology Center

Prepared by:
Tim Yu, Development Engineer
California Lighting Technology Center

Revised: August 22nd, 2013

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Notes – Integrating Sphere

- Power provided by a California Instruments 2253ix PSU.
- Power measurement taken with a Yokogawa PZ4000 PA.
THD measurements taken with PZ4000's harmonics mode.
- Photometric measurements made with a SMS-500 Spectrometer in a 2 meter integrating sphere with Labsphere software.
- Auxiliary correction applied for fixture self absorptions.

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1

Arieta 15M

Summary

| Voltage Signal | Power (W) | Power Factor | Light Output (lm) | CCT (Kelvin) | CRI | Efficacy (lm/W) |
|----------------|-----------|--------------|-------------------|--------------|------|-----------------|
| 10 | 126.9 | 0.96 | 11263 | 3898 | 75.7 | 88.8 |
| 9 | 126.9 | 0.96 | 11260 | 3899 | 75.7 | 88.7 |
| 8 | 126.3 | 0.96 | 11218 | 3898 | 75.7 | 88.8 |
| 7 | 109.7 | 0.95 | 10029 | 3873 | 75.7 | 91.4 |
| 6 | 94.0 | 0.94 | 8816 | 3846 | 75.8 | 93.8 |
| 5 | 77.9 | 0.91 | 7452 | 3823 | 75.8 | 95.7 |
| 4 | 62.6 | 0.88 | 6036 | 3802 | 75.9 | 96.4 |
| 3 | 46.9 | 0.82 | 4484 | 3777 | 76.0 | 95.6 |
| 2 | 31.0 | 0.58 | 2929 | 3761 | 76.1 | 94.5 |
| 1 | 16.1 | 0.43 | 1363 | 3739 | 76.2 | 84.7 |

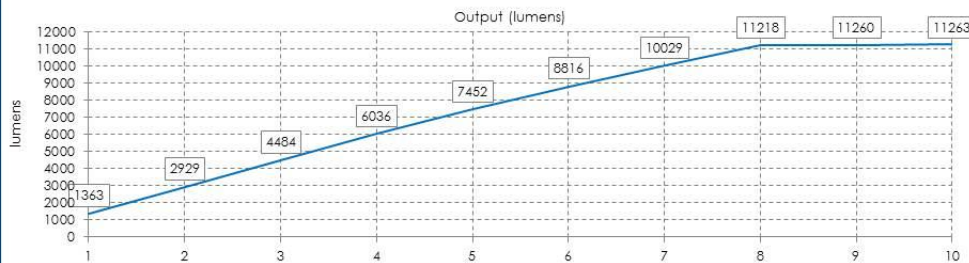
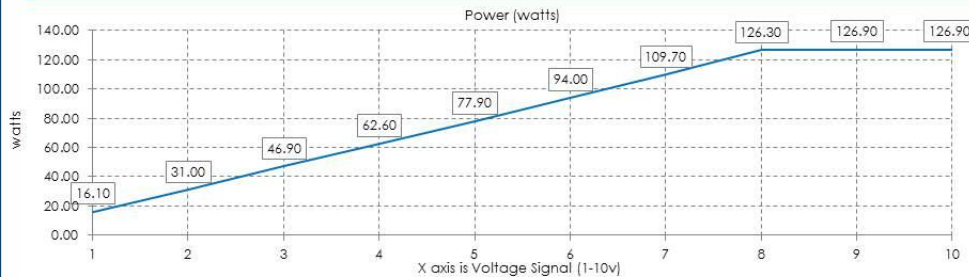
| Voltage Signal | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | RA |
|----------------|------|------|------|------|------|------|------|------|-------|------|------|------|------|------|------|
| 10 | 73.0 | 80.9 | 87.8 | 75.7 | 73.1 | 73.8 | 82.7 | 58.2 | -12.2 | 55.5 | 72.8 | 53.3 | 74.0 | 93.0 | 75.7 |
| 9 | 73.1 | 81.0 | 87.8 | 75.7 | 73.1 | 73.8 | 82.7 | 58.2 | -12.3 | 55.6 | 72.9 | 53.3 | 74.0 | 93.0 | 75.7 |
| 8 | 73.1 | 80.9 | 87.8 | 75.7 | 73.1 | 73.8 | 82.7 | 58.2 | -12.2 | 55.5 | 72.8 | 53.2 | 74.0 | 93.0 | 75.7 |
| 7 | 73.2 | 81.0 | 87.7 | 75.9 | 73.3 | 73.9 | 82.6 | 58.3 | -11.8 | 55.6 | 73.2 | 53.5 | 74.1 | 93.0 | 75.7 |
| 6 | 73.4 | 81.0 | 87.7 | 76.0 | 73.4 | 74.0 | 82.5 | 58.3 | -11.4 | 55.7 | 73.6 | 53.8 | 74.2 | 92.9 | 75.8 |
| 5 | 73.5 | 81.0 | 87.6 | 76.2 | 73.6 | 74.1 | 82.4 | 58.4 | -10.9 | 55.8 | 74.0 | 54.1 | 74.3 | 92.9 | 75.8 |
| 4 | 73.7 | 81.0 | 87.6 | 76.4 | 73.8 | 74.2 | 82.3 | 58.5 | -10.4 | 55.9 | 74.4 | 54.4 | 74.4 | 92.9 | 75.9 |
| 3 | 73.9 | 81.0 | 87.6 | 76.6 | 73.9 | 74.3 | 82.2 | 58.5 | -10.0 | 56.1 | 74.8 | 54.7 | 74.6 | 92.9 | 76.0 |
| 2 | 74.0 | 81.0 | 87.6 | 76.7 | 74.0 | 74.4 | 82.3 | 58.6 | -9.7 | 56.2 | 75.0 | 54.8 | 74.6 | 92.9 | 76.1 |
| 1 | 74.1 | 81.1 | 87.8 | 76.9 | 74.1 | 74.6 | 82.4 | 58.6 | -9.4 | 56.5 | 75.3 | 54.9 | 74.8 | 93.0 | 76.2 |

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12

Arieta 15M

Summary

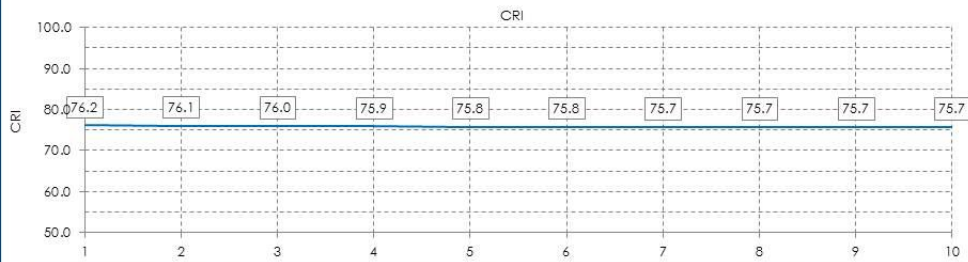
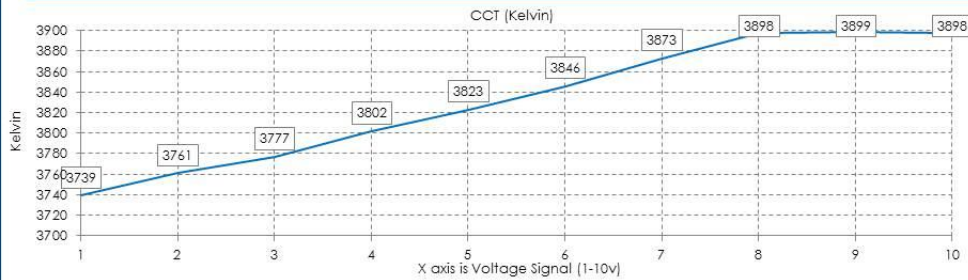


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13

Arieta 15M

Summary

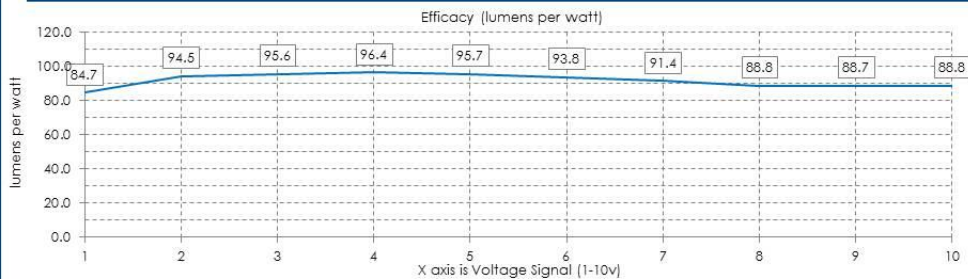


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14

Arieta 15M

Summary

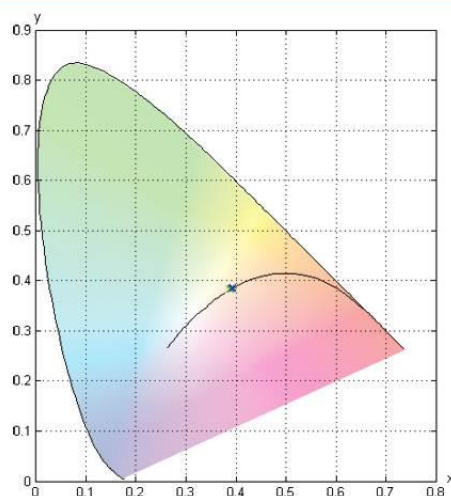


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15

Arieta 15M

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

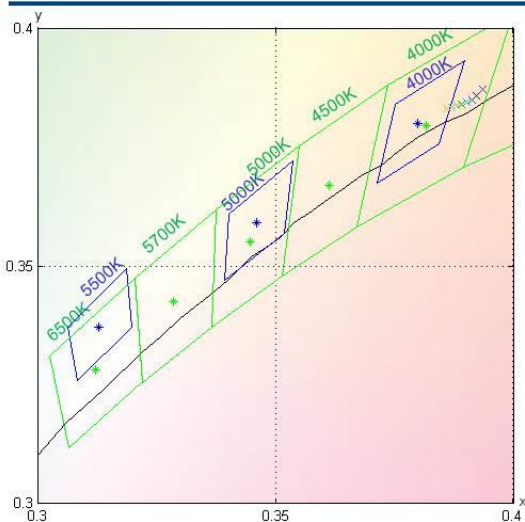
| | CIE X | CIE Y |
|---|--------|--------|
| ✖ | 0.3859 | 0.3830 |
| ✖ | 0.3860 | 0.3830 |
| ✖ | 0.3860 | 0.3830 |
| ✖ | 0.3870 | 0.3833 |
| ✖ | 0.3882 | 0.3837 |
| ✖ | 0.3892 | 0.3840 |
| ✖ | 0.3902 | 0.3845 |
| ✖ | 0.3913 | 0.3848 |
| ✖ | 0.3923 | 0.3858 |
| ✖ | 0.3935 | 0.3870 |

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16

Arieta 15M

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

| | CIE X | CIE Y |
|---|--------|--------|
| ✖ | 0.3859 | 0.3830 |
| ✖ | 0.3860 | 0.3830 |
| ✖ | 0.3860 | 0.3830 |
| ✖ | 0.3870 | 0.3833 |
| ✖ | 0.3882 | 0.3837 |
| ✖ | 0.3892 | 0.3840 |
| ✖ | 0.3902 | 0.3845 |
| ✖ | 0.3913 | 0.3848 |
| ✖ | 0.3923 | 0.3858 |
| ✖ | 0.3935 | 0.3870 |

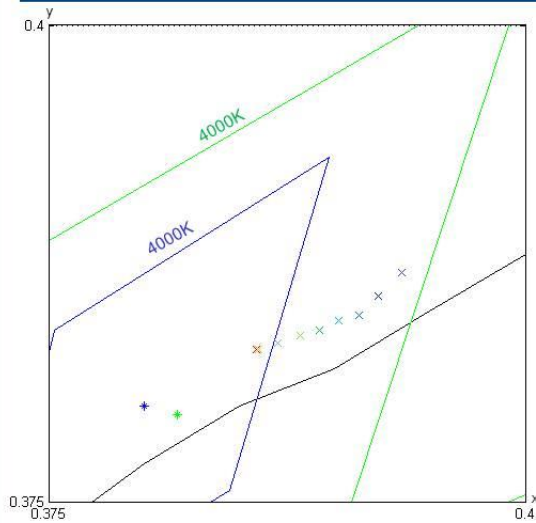
Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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17

Arieta 15M

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

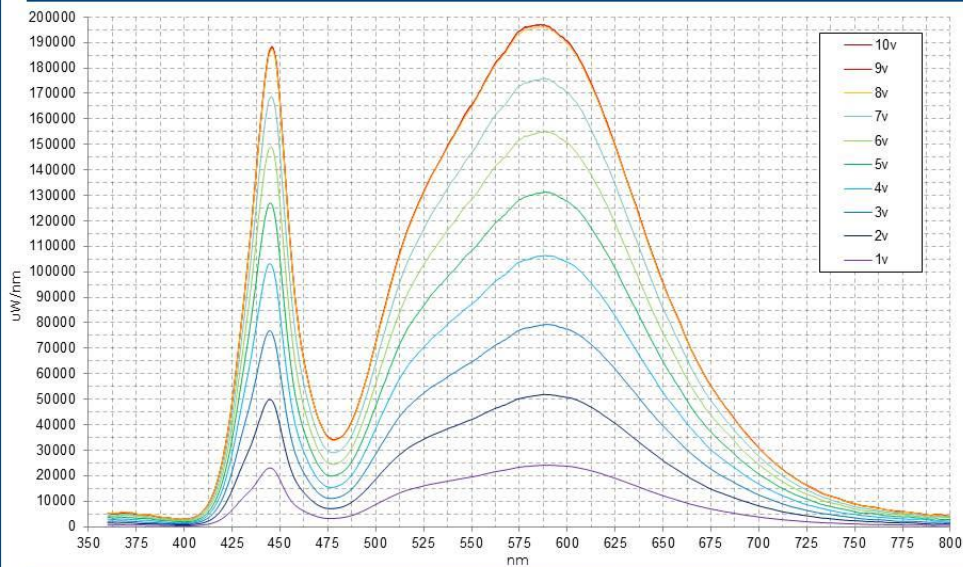
| | CIE X | CIE Y |
|---|--------|--------|
| ✖ | 0.3859 | 0.3830 |
| ✖ | 0.3860 | 0.3830 |
| ✖ | 0.3860 | 0.3830 |
| ✖ | 0.3870 | 0.3833 |
| ✖ | 0.3882 | 0.3837 |
| ✖ | 0.3892 | 0.3840 |
| ✖ | 0.3902 | 0.3845 |
| ✖ | 0.3913 | 0.3848 |
| ✖ | 0.3923 | 0.3858 |
| ✖ | 0.3935 | 0.3870 |

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18

Arieta 15M

Spectral Power Distribution



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8.2.2.3 Photometric report for Post-retrofit Luminaires, Daybrite WTL-90W:



VVNBH – Post-retrofit luminaires Daybrite WTL-90W, Gardco ELG

Prepared for:
Bernhard Goesmann, Development Engineer
California Lighting Technology Center

Prepared by:
Tim Yu, Development Engineer
California Lighting Technology Center

Revised: May 9th, 2014

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Notes – Integrating Sphere

- Power provided by a California Instruments 2253ix PSU.
- Power measurement taken with a Yokogawa PZ4000 PA.
THD measurements taken with PZ4000's harmonics mode.
- Photometric measurements made with a SMS-500 Spectrometer in a 2 meter integrating sphere with Labsphere software.
- Auxiliary correction applied for fixture self absorptions.

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1

DayBrite WTL-90W

Summary

Photometric and Electrical

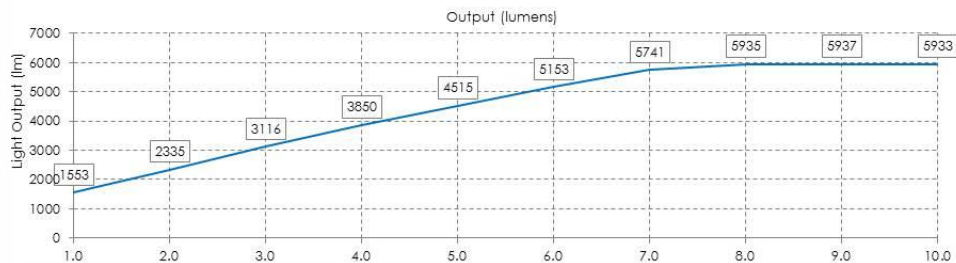
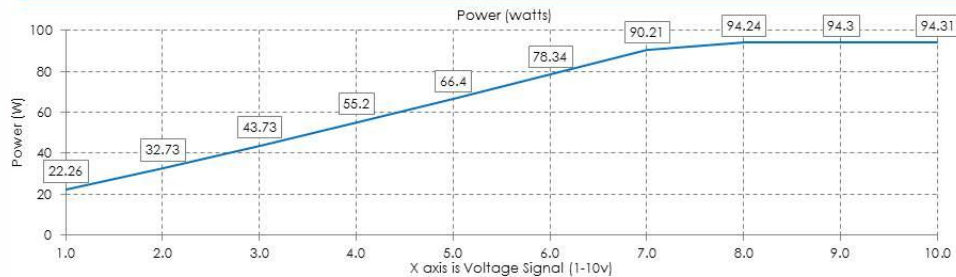
| Dimming (V) | Voltage (V) | Current (A) | Power (W) | Power Factor | Light Output (lm) | CCT (K) | Efficacy (lm/W) |
|-------------|-------------|-------------|-----------|--------------|-------------------|---------|-----------------|
| 10 | 276.95 | 0.3523 | 94.31 | 0.9669 | 5933 | 4181 | 62.9 |
| 9 | 276.94 | 0.3522 | 94.30 | 0.9669 | 5937 | 4181 | 63.0 |
| 8 | 276.94 | 0.3520 | 94.24 | 0.9668 | 5935 | 4181 | 63.0 |
| 7 | 276.93 | 0.3379 | 90.21 | 0.9641 | 5741 | 4174 | 63.6 |
| 6 | 276.94 | 0.2966 | 78.34 | 0.9537 | 5153 | 4167 | 65.8 |
| 5 | 276.95 | 0.2558 | 66.40 | 0.9374 | 4515 | 4141 | 68.0 |
| 4 | 276.97 | 0.2181 | 55.20 | 0.9137 | 3850 | 4121 | 69.7 |
| 3 | 276.97 | 0.1806 | 43.73 | 0.8744 | 3116 | 4099 | 71.3 |
| 2 | 276.84 | 0.1710 | 32.73 | 0.6889 | 2335 | 4078 | 71.3 |
| 1 | 276.58 | 0.1498 | 22.26 | 0.5375 | 1553 | 4055 | 69.8 |
| 0 | 276.58 | 0.0051 | 1.40 | 0.5375 | n/a | n/a | n/a |

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3

DayBrite WTL-90W

Summary

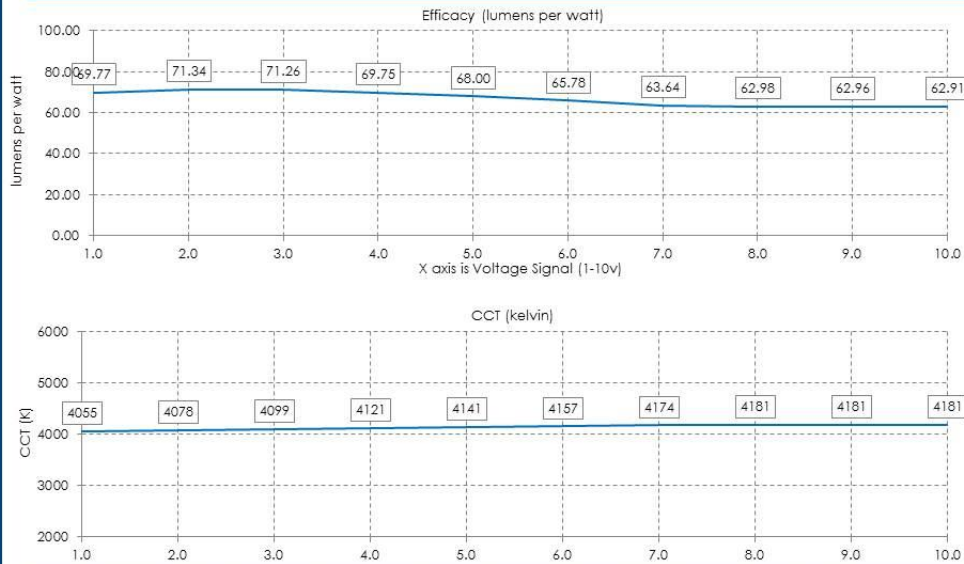


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4

DayBrite WTL-90W

Summary



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5

DayBrite WTL-90W

Summary

Color Rendering Index

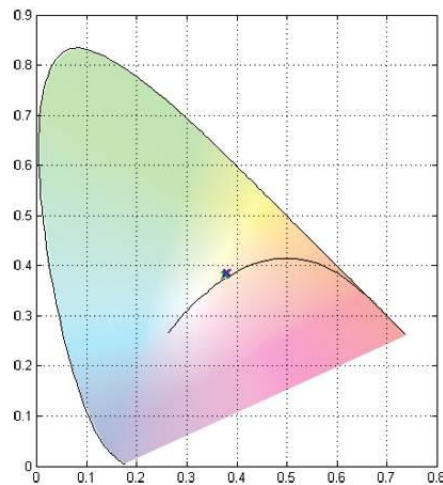
| Dim (V) | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | RA |
|---------|------|------|------|------|------|------|------|------|-------|------|------|------|------|------|------|
| 10 | 64.9 | 70.9 | 74.1 | 67.7 | 63.8 | 58.5 | 77.0 | 55.7 | -26.4 | 30.0 | 61.8 | 32.1 | 64.3 | 84.8 | 66.6 |
| 9 | 64.9 | 70.9 | 74.1 | 67.7 | 63.7 | 58.4 | 77.0 | 55.7 | -26.5 | 30.0 | 61.8 | 32.1 | 64.3 | 84.8 | 66.6 |
| 8 | 64.9 | 70.9 | 74.2 | 67.7 | 63.8 | 58.5 | 77.0 | 55.7 | -26.4 | 30.0 | 61.8 | 32.1 | 64.3 | 84.8 | 66.6 |
| 7 | 64.9 | 71.0 | 74.2 | 67.7 | 63.8 | 58.5 | 77.0 | 55.7 | -26.5 | 30.1 | 61.8 | 32.1 | 64.3 | 84.9 | 66.6 |
| 6 | 64.7 | 70.9 | 74.2 | 67.6 | 63.6 | 58.3 | 77.0 | 55.5 | -26.8 | 29.9 | 61.6 | 31.7 | 64.2 | 84.9 | 66.5 |
| 5 | 64.6 | 70.7 | 74.1 | 67.4 | 63.4 | 58.0 | 76.9 | 55.4 | -27.2 | 29.5 | 61.5 | 31.2 | 64.0 | 84.8 | 66.3 |
| 4 | 64.4 | 70.6 | 74.0 | 67.2 | 63.1 | 57.8 | 76.8 | 55.1 | -27.8 | 29.2 | 61.2 | 30.8 | 63.8 | 84.7 | 66.1 |
| 3 | 64.4 | 70.4 | 73.7 | 67.2 | 63.1 | 57.6 | 76.5 | 55.0 | -27.6 | 28.8 | 61.3 | 30.4 | 63.7 | 84.5 | 66.0 |
| 2 | 64.2 | 70.5 | 74.0 | 67.1 | 62.9 | 57.6 | 76.8 | 54.8 | -28.2 | 29.0 | 61.0 | 30.0 | 63.6 | 84.8 | 66.0 |
| 1 | 63.9 | 70.2 | 73.9 | 66.9 | 62.6 | 57.3 | 76.6 | 54.5 | -28.9 | 28.6 | 60.7 | 29.4 | 63.4 | 84.7 | 65.7 |
| 0 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

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6

DayBrite WTL-90W

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

Chromaticity

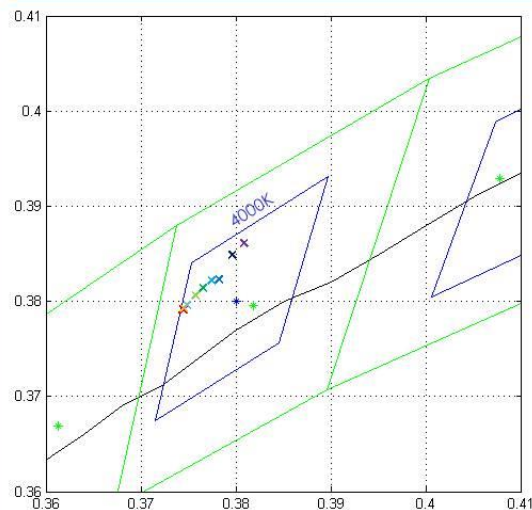
| Dimming (V) | Symbol | CIE X | CIE Y |
|-------------|--------|--------|--------|
| 10 | ✖ | 0.3744 | 0.3791 |
| 9 | ✖ | 0.3745 | 0.3792 |
| 8 | ✖ | 0.3745 | 0.3793 |
| 7 | ✖ | 0.3748 | 0.3796 |
| 6 | ✖ | 0.3757 | 0.3806 |
| 5 | ✖ | 0.3765 | 0.3814 |
| 4 | ✖ | 0.3774 | 0.3822 |
| 3 | ✖ | 0.3782 | 0.3823 |
| 2 | ✖ | 0.3796 | 0.3849 |
| 1 | ✖ | 0.3808 | 0.3861 |

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7

DayBrite WTL-90W

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

Chromaticity

| Dimming (V) | Symbol | CIE X | CIE Y |
|-------------|--------|--------|--------|
| 10 | ✖ | 0.3744 | 0.3791 |
| 9 | ✖ | 0.3745 | 0.3792 |
| 8 | ✖ | 0.3745 | 0.3793 |
| 7 | ✖ | 0.3748 | 0.3796 |
| 6 | ✖ | 0.3757 | 0.3806 |
| 5 | ✖ | 0.3765 | 0.3814 |
| 4 | ✖ | 0.3774 | 0.3822 |
| 3 | ✖ | 0.3782 | 0.3823 |
| 2 | ✖ | 0.3796 | 0.3849 |
| 1 | ✖ | 0.3808 | 0.3861 |

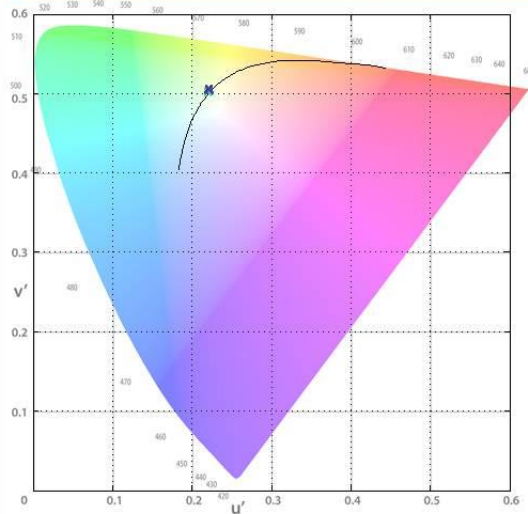
Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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8

DayBrite WTL-90W

Chromaticity



Chromaticity Diagram CIE 1976 UCS

Chromaticity

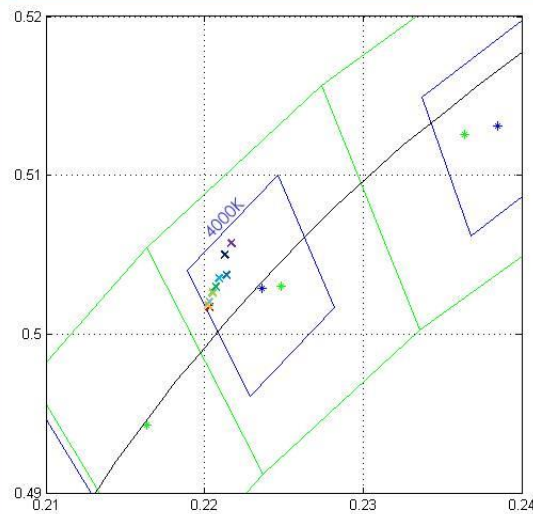
| Dimming (V) | Symbol | CIE u' | CIE v' |
|-------------|--------|----------|----------|
| 10 | ✖ | 0.2203 | 0.5017 |
| 9 | ✖ | 0.2202 | 0.5018 |
| 8 | ✖ | 0.2202 | 0.5018 |
| 7 | ✖ | 0.2203 | 0.5020 |
| 6 | ✖ | 0.2205 | 0.5026 |
| 5 | ✖ | 0.2207 | 0.5030 |
| 4 | ✖ | 0.2209 | 0.5035 |
| 3 | ✖ | 0.2214 | 0.5037 |
| 2 | ✖ | 0.2213 | 0.5050 |
| 1 | ✖ | 0.2217 | 0.5057 |

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9

DayBrite WTL-90W

Chromaticity



Chromaticity Diagram CIE 1976 UCS

Chromaticity

| Dimming (V) | Symbol | CIE u' | CIE v' |
|-------------|--------|----------|----------|
| 10 | ✖ | 0.2203 | 0.5017 |
| 9 | ✖ | 0.2202 | 0.5018 |
| 8 | ✖ | 0.2202 | 0.5018 |
| 7 | ✖ | 0.2203 | 0.5020 |
| 6 | ✖ | 0.2205 | 0.5026 |
| 5 | ✖ | 0.2207 | 0.5030 |
| 4 | ✖ | 0.2209 | 0.5035 |
| 3 | ✖ | 0.2214 | 0.5037 |
| 2 | ✖ | 0.2213 | 0.5050 |
| 1 | ✖ | 0.2217 | 0.5057 |

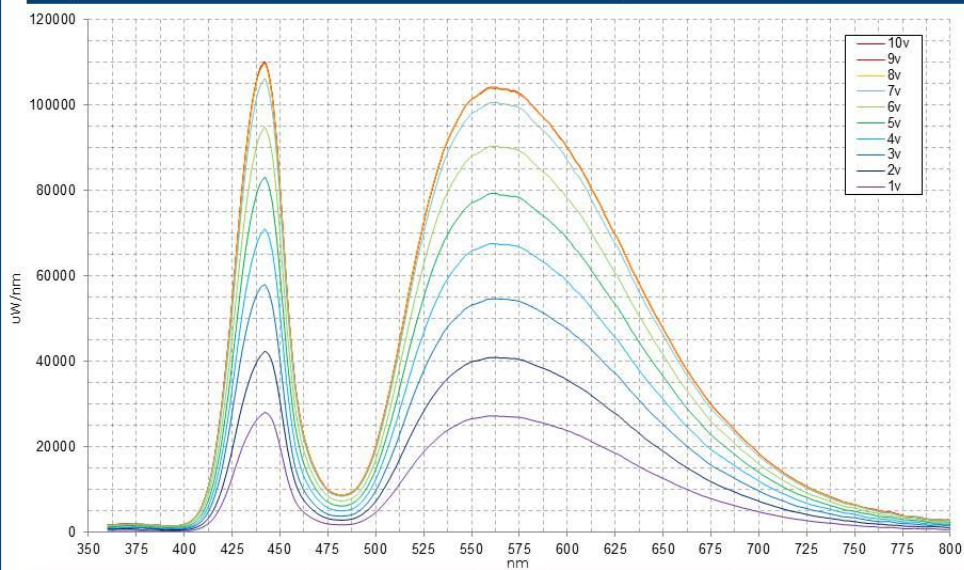
Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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10

DayBrite WTL-90W

Spectral Power Distribution



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8.2.2.4 Photometric report for Post-retrofit Luminaires, Gardco ELG:



VVNBH – Post-retrofit luminaires Daybrite WTL-90W, Gardco ELG

Prepared for:
Bernhard Goesmann, Development Engineer
California Lighting Technology Center

Prepared by:
Tim Yu, Development Engineer
California Lighting Technology Center

Revised: May 9th, 2014

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Notes – Integrating Sphere

- Power provided by a California Instruments 2253ix PSU.
- Power measurement taken with a Yokogawa PZ4000 PA.
THD measurements taken with PZ4000's harmonics mode.
- Photometric measurements made with a SMS-500 Spectrometer in a 2 meter integrating sphere with Labsphere software.
- Auxiliary correction applied for fixture self absorptions.

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1

Gardco ELG

Summary

Photometric and Electrical

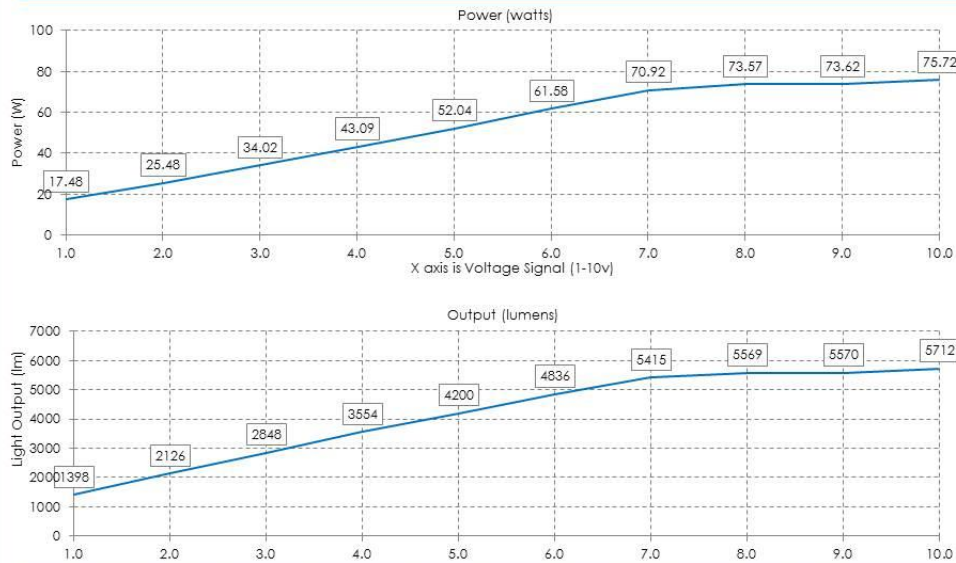
| Dimming (V) | Voltage (V) | Current (A) | Power (W) | Power Factor | Light Output (lm) | CCT (K) | Efficacy (lm/W) |
|-------------|-------------|-------------|-----------|--------------|-------------------|---------|-----------------|
| 10 | 119.97 | 0.6335 | 75.72 | 0.9972 | 5712 | 4091 | 75.4 |
| 9 | 119.89 | 0.6165 | 73.62 | 0.9961 | 5570 | 4091 | 75.7 |
| 8 | 119.87 | 0.6161 | 73.57 | 0.9961 | 5569 | 4091 | 75.7 |
| 7 | 119.87 | 0.5938 | 70.92 | 0.9964 | 5415 | 4091 | 76.4 |
| 6 | 119.93 | 0.5157 | 61.58 | 0.9956 | 4836 | 4083 | 78.5 |
| 5 | 119.94 | 0.4366 | 52.04 | 0.9938 | 4200 | 4075 | 80.7 |
| 4 | 119.96 | 0.3625 | 43.09 | 0.9908 | 3554 | 4067 | 82.5 |
| 3 | 119.98 | 0.2878 | 34.02 | 0.9850 | 2848 | 4059 | 83.7 |
| 2 | 119.99 | 0.2182 | 25.48 | 0.9734 | 2126 | 4049 | 83.4 |
| 1 | 119.94 | 0.1541 | 17.48 | 0.9463 | 1398 | 4034 | 80.0 |
| 0 | 119.94 | 0.0125 | 1.5 | 0.9463 | n/a | n/a | n/a |

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13

Gardco ELG

Summary

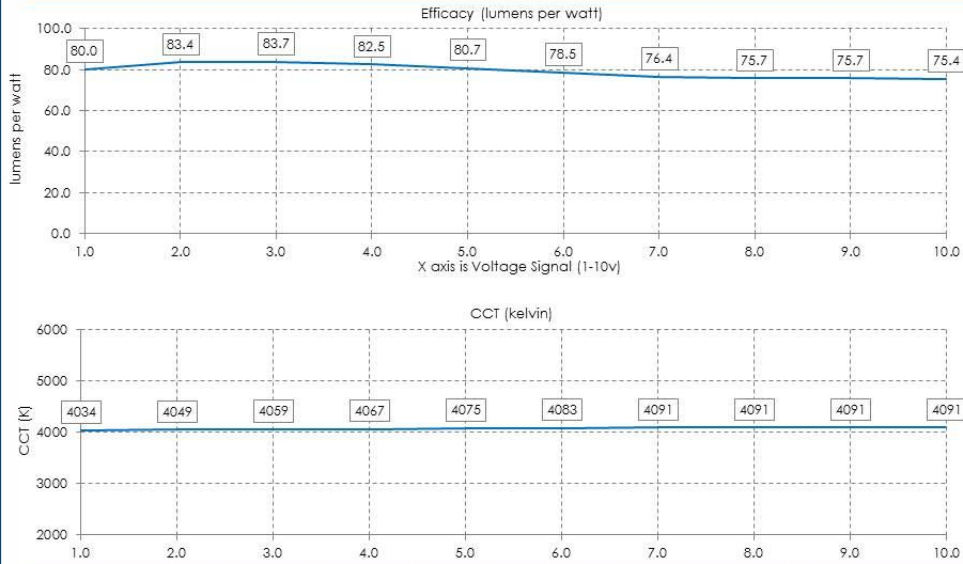


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14

Gardco ELG

Summary



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15

Gardco ELG

Summary

Color Rendering Index

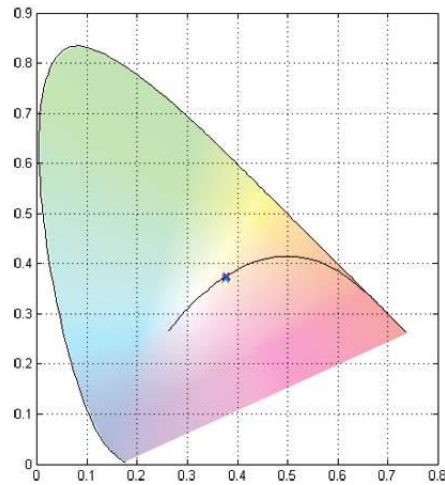
| Dim (V) | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 | RA |
|---------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 10 | 83.5 | 87.6 | 88.0 | 83.2 | 82.0 | 80.5 | 89.6 | 75.8 | 35.0 | 67.8 | 79.7 | 55.8 | 84.2 | 92.7 | 83.8 |
| 9 | 83.9 | 88.1 | 88.5 | 83.2 | 82.3 | 81.1 | 89.6 | 75.9 | 35.8 | 68.9 | 79.7 | 56.9 | 84.6 | 93.0 | 84.1 |
| 8 | 83.9 | 88.1 | 88.5 | 83.3 | 82.3 | 81.1 | 89.6 | 75.9 | 35.8 | 68.9 | 79.7 | 56.9 | 84.6 | 93.0 | 84.1 |
| 7 | 83.9 | 88.1 | 88.6 | 83.2 | 82.3 | 81.2 | 89.7 | 75.9 | 35.9 | 69 | 79.7 | 56.9 | 84.6 | 93.1 | 84.1 |
| 6 | 83.8 | 88.2 | 88.8 | 83.2 | 82.3 | 81.2 | 89.8 | 75.8 | 35.7 | 69.2 | 79.6 | 56.6 | 84.6 | 93.2 | 84.1 |
| 5 | 83.9 | 88.2 | 88.9 | 83.3 | 82.3 | 81.3 | 89.9 | 75.9 | 35.8 | 69.3 | 79.7 | 56.3 | 84.7 | 93.2 | 84.2 |
| 4 | 83.9 | 88.3 | 89.0 | 83.2 | 82.2 | 81.4 | 90.1 | 75.8 | 35.7 | 69.5 | 79.6 | 55.9 | 84.7 | 93.4 | 84.2 |
| 3 | 83.9 | 88.4 | 89.3 | 83.2 | 82.2 | 81.5 | 90.2 | 75.8 | 35.8 | 69.7 | 79.6 | 55.5 | 84.8 | 93.5 | 84.3 |
| 2 | 83.9 | 88.5 | 89.5 | 83.2 | 82.2 | 81.7 | 90.4 | 75.9 | 36.0 | 70.1 | 79.6 | 55.2 | 84.8 | 93.6 | 84.4 |
| 1 | 83.9 | 88.7 | 89.9 | 83.1 | 82.1 | 82.0 | 90.6 | 75.8 | 35.9 | 70.5 | 79.4 | 54.8 | 84.9 | 93.9 | 84.5 |
| 0 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

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Gardco ELG

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

Chromaticity

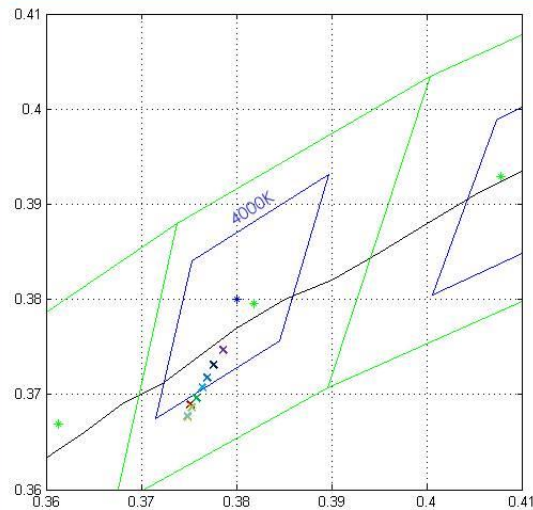
| Dimming (V) | Symbol | CIE X | CIE Y |
|-------------|--------|--------|--------|
| 10 | ✖ | 0.3751 | 0.3689 |
| 9 | ✖ | 0.3748 | 0.3676 |
| 8 | ✖ | 0.3748 | 0.3676 |
| 7 | ✖ | 0.3748 | 0.3677 |
| 6 | ✖ | 0.3753 | 0.3686 |
| 5 | ✖ | 0.3758 | 0.3696 |
| 4 | ✖ | 0.3764 | 0.3707 |
| 3 | ✖ | 0.3769 | 0.3718 |
| 2 | ✖ | 0.3776 | 0.3731 |
| 1 | ✖ | 0.3786 | 0.3747 |

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17

Gardco ELG

Chromaticity



Chromaticity Diagram CIE 1931, 2 Degree

Chromaticity

| Dimming (V) | Symbol | CIE X | CIE Y |
|-------------|--------|--------|--------|
| 10 | ✖ | 0.3751 | 0.3689 |
| 9 | ✖ | 0.3748 | 0.3676 |
| 8 | ✖ | 0.3748 | 0.3676 |
| 7 | ✖ | 0.3748 | 0.3677 |
| 6 | ✖ | 0.3753 | 0.3686 |
| 5 | ✖ | 0.3758 | 0.3696 |
| 4 | ✖ | 0.3764 | 0.3707 |
| 3 | ✖ | 0.3769 | 0.3718 |
| 2 | ✖ | 0.3776 | 0.3731 |
| 1 | ✖ | 0.3786 | 0.3747 |

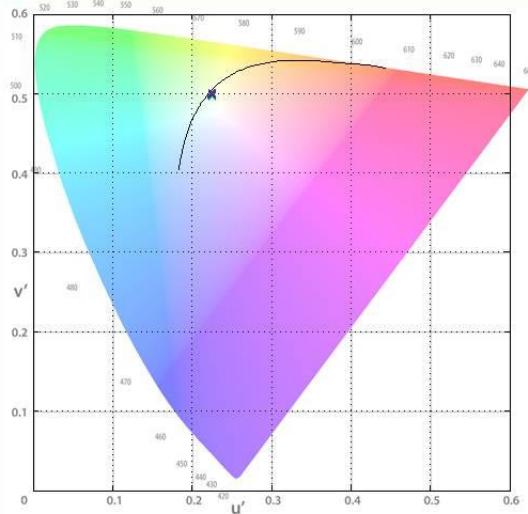
Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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18

Gardco ELG

Chromaticity



Chromaticity Diagram CIE 1976 UCS

Chromaticity

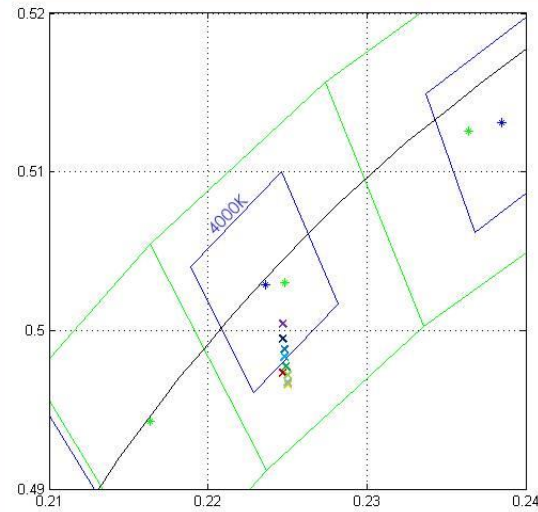
| Dimming (V) | Symbol | CIE u' | CIE v' |
|-------------|--------|----------|----------|
| 10 | ✖ | 0.2560 | 0.2247 |
| 9 | ✖ | 0.2576 | 0.2250 |
| 8 | ✖ | 0.2576 | 0.2250 |
| 7 | ✖ | 0.2575 | 0.2250 |
| 6 | ✖ | 0.2562 | 0.2250 |
| 5 | ✖ | 0.2546 | 0.2249 |
| 4 | ✖ | 0.2530 | 0.2248 |
| 3 | ✖ | 0.2513 | 0.2248 |
| 2 | ✖ | 0.2493 | 0.2247 |
| 1 | ✖ | 0.2468 | 0.2247 |

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19

Gardco ELG

Chromaticity



Chromaticity Diagram CIE 1976 UCS

Chromaticity

| Dimming (V) | Symbol | CIE u' | CIE v' |
|-------------|--------|----------|----------|
| 10 | ✖ | 0.2560 | 0.2247 |
| 9 | ✖ | 0.2576 | 0.2250 |
| 8 | ✖ | 0.2576 | 0.2250 |
| 7 | ✖ | 0.2575 | 0.2250 |
| 6 | ✖ | 0.2562 | 0.2250 |
| 5 | ✖ | 0.2546 | 0.2249 |
| 4 | ✖ | 0.2530 | 0.2248 |
| 3 | ✖ | 0.2513 | 0.2248 |
| 2 | ✖ | 0.2493 | 0.2247 |
| 1 | ✖ | 0.2468 | 0.2247 |

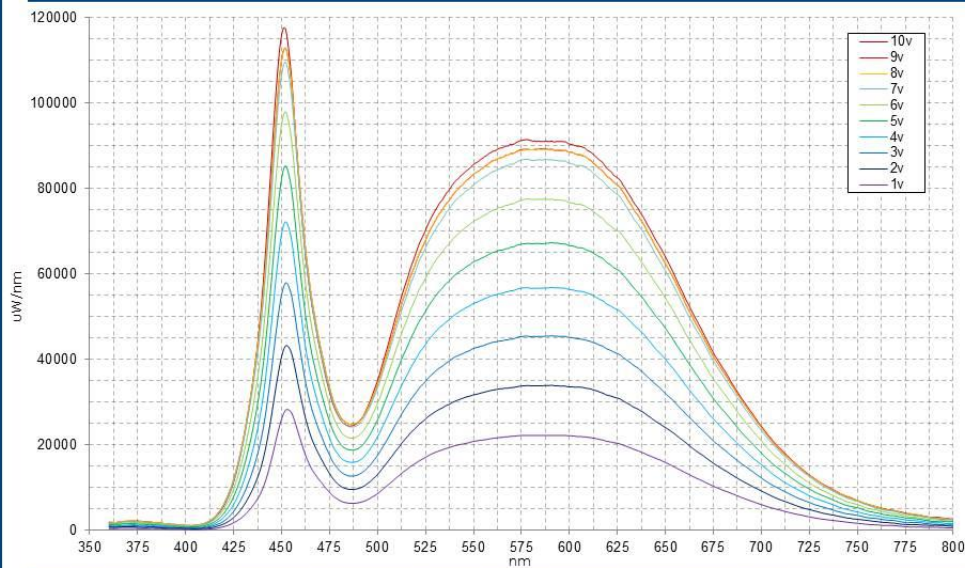
Green Quadrangles: 7-Step MacAdam Ellipse Equivalent
Blue Quadrangles: 4-Step MacAdam Ellipse Equivalent

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20

Gardco ELG

Spectral Power Distribution

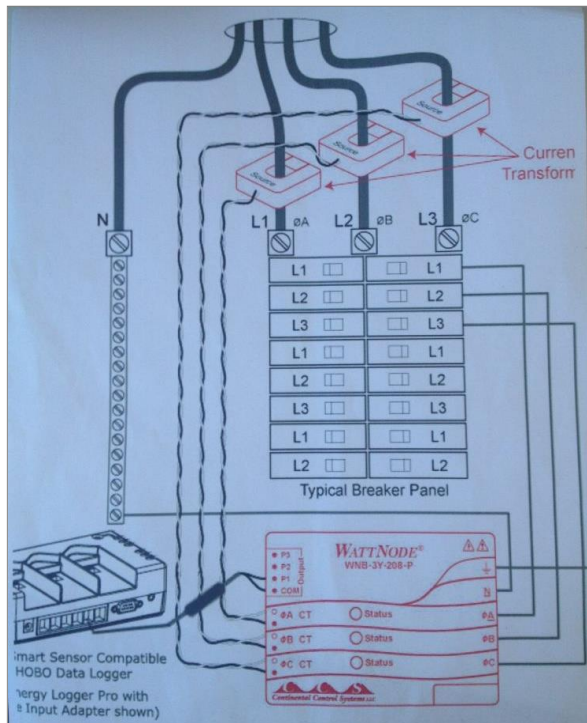


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8.3 M&V EQUIPMENT FOR ENERGY LOGGING


8.3.1 M&V – HARDWARE OVERVIEW



A total of eight breaker panel branches were recorded. The picture to the left depicts a simplified schematic of all the installation hardware deployed (208V system shown, 277V at site):

8.3.2 M&V - CURRENT TRANSFORMER (CT1, CTM-0360-020)

Five of the breaker panel branches were recorded using industry standard split core current transformers (CT) model "CTM-0360-020" (no serial#):



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CTM Series Split-Core Current Transformers

The CTM series CTs are optimized for branch circuit monitoring. They have a hinged opening mechanism for easy installation. The small size and low cost is ideal for monitoring many circuits in a panel.


- **Safe:** burden resistor built-in, 333 mVac voltage output at rated full scale current, no shunting blocks needed
- Full scale input current range: 5 amps to 70 amps
- Accuracy: $\pm 1\%$ from 10% to 100% of rated current
- Phase angle: $< 2^\circ$ degrees at 50% of rated current
- Approvals: UL recognized, CE mark, RoHS
- Lead wires: 8 ft. twisted-pair, 600 Vac rated
- Hinged for easy one-handed operation
- **Assembled in USA**, qualified under the Buy American provision in the American Recovery and Reinvestment Act of 2009 (ARRA).
- View Dimensional drawing
- Download CTM Split-Core CT Datasheet (PDF)

List prices for 1-3 piece quantities. Call for pricing on larger quantities.

| Model | Opening | Rated Amps (xxx) | Max. Amps | Max. Wire Gauge | MSRP |
|--------------|-------------------------------|-----------------------|-----------|-----------------|--------------|
| CTM-0360-xxx | 0.30" x 0.34" (7.5mm x 8.7mm) | 5, 15, 20, 30, 50, 70 | 100 | 8 AWG, 6" AWG | \$29.00 each |

To order, replace the CT-0360 part number suffix "xxx" with one of the available Rated Amps values.
 The "Max. Amps" is the highest continuous current that the CT can withstand without damage.
 The "Max Wire Gauge" is the largest wire gauge that should fit through this size of CT.
 * These sizes may or may not fit, depending on the insulation thickness.

Model List: CTM-0360-005, CTM-0360-015, CTM-0360-020, CTM-0360-030, CTM-0360-050, CTM-0360-070




Call Us Toll Free
888-928-8663
888-WATTNODE
Voice: 303-444-7422
FAX: 303-444-2903
sales@cccontrols.com

Continental Control Systems
3131 Indian Road
Boulder, CO 80301
USA

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Page updated 12 November 2013

8.3.3 M&V - CURRENT TRANSFORMER (CT2, ACT-0750-020)



Accu-CT[®]
SPLIT-CORE CURRENT TRANSFORMER

Revenue-Grade Accuracy, Unprecedented Linearity

0.75 Inch Window, 5 to 250 Amps

The Accu-CT revenue-grade, split-core current transformer offers outstanding accuracy and one-handed operation.

- **Exceptionally low phase angle error:** essential for accurate power and energy measurements
- **IEEE/ANSI C57.13 and IEC 60044-1 accuracy** over full temperature range and down to 1% of rated current
- **Glove-friendly** operation with one hand.

Specifications

- Accuracy: $\pm 0.75\%$ from 1% to 120% of rated primary current ($\pm 0.5\%$ with Option C0.6)
- Phase angle: ± 0.5 degrees (30 minutes) from 1% to 120% of rated current (With Option 0.6: ± 0.25 degrees from 1% to 120%, ± 0.50 degrees below 0.6% from 1% to 10% of rated current)
- **Accuracy standards:** IEEE C57.13 class 1.2 and IEC 60044-1 class 1.0 (Opt C0.6: class 0.6 and class 0.5S, respectively)
- **Primary rating:** 5 to 250 Amps, 600 Vac, 60 Hz nominal
- **Output:** 333.33 mVac or 1.00 Vac (with Option 1V) at rated current
- **Operating temperature:** -30°C to 55°C
- **Safe:** integral burden resistor, no shunting block needed, unless otherwise noted
- **Standard lead length:** 8 ft. (2.4 m), 18 AWG
- **UL recognized, CE mark, RoHS**
- **Assembled in USA:** qualified under Buy American provision in ARRA of 2009


| Models | Amps | MSRP |
|--------------|------|---------|
| ACT-0750-005 | 5 | \$43.50 |
| ACT-0750-020 | 20 | \$43.50 |
| ACT-0750-050 | 50 | \$43.50 |
| ACT-0750-100 | 100 | \$43.50 |
| ACT-0750-200 | 200 | \$43.50 |
| ACT-0750-250 | 250 | \$43.50 |

• **Non-stock:** 15, 30, 70, and 150 amp

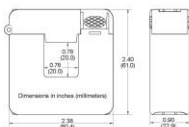
• **Option C0.6:** meets IEEE/ANSI C57.13 class 0.6 accuracy and IEC 60044-1 class 0.5 and 0.5 S accuracy - \$57

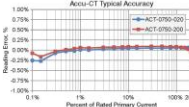
• **Option 1V:** 1.00 Vac full-scale output

• **Option 50Hz:** calibrate for 50 Hz operation

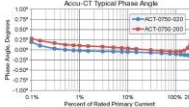


Patent pending





Accuracy vs. Percent of Rated Primary Current



Phase Angle vs. Percent of Rated Primary Current

• Graphs show typical performance at 23°C, 60 Hz

• Graph shows a positive phase angle when the output leads the primary current.

ACT-1.23.13: Specifications are subject to change

Page updated 12 November 2013

Three of the breaker panel branches recorded were monitored with advanced split core CTs, model "ACT-0750-020". (serial# C0018777A2, C0018778A2, C0018779A2)

8.3.4 M&V - WATTNODE (WNB-3Y-480-P-P3)

All split core current transformers feed pulses towards the WattNode. Three units of model type "WNB-3Y-480-P-P3" were used for this application (serial# 080749, 080750, 080751):

Continental Control Systems

THE WATTNODE is a true RMS AC watt-hour transducer with pulse output (solid state relay closure) proportional to kWH consumed. The WATTNODE provides accurate measurement at low cost to meet your needs for sub-metering, energy management and performance contract applications.

Easy Installation saves you time and money. The WATTNODE is small enough to fit entirely within a standard electrical panel and the screw terminals unplug for easy wiring.

The Advanced Output includes separate pulse channels for positive and negative power, for net metering and PV metering. Optional models are available with one pulse output channel per measurement phase, which can be used to monitor each phase independently or to monitor three separate single-phase circuits with one WattNode.

Our Diagnostic LEDs provide a per-phase indication of power (green flashing), negative power (red flashing), and advanced diagnostics (yellow flashing) to help troubleshoot connection problems, like swapped CTs, or excessive line voltage. See the User's Guide for a full description.

The Pulse Series family measures 1, 2, or 3 phases in 2, 3 or 4 wire configurations. With voltage ratings from 120 to 600 VAC and current transformer (CT) rating from 5 to 4000 amps, there is a WATTNODE combination to meet your AC power measurement requirements.

ACCURACY of the WATTNODE is 0.5% of reading over a wide range of power factors and harmonic content. You get true kWH measurements even with switching power supplies and variable speed drives.

Our Safe CTs, with internal burden resistors produce a voltage proportional to the load current. At rated current voltage is only 0.333 VAC. Split-core CTs quickly install on existing wiring and solid-core CTs cost less for new wiring.

WATTNODE®

Advanced Pulse Output AC Power Measurement

277/480 VAC
120/240



- **Advanced Pulse Output**
Separate pulse channels for positive and negative power. Optional models are available with one pulse output channel per measurement phase.
- **Small Size**
Can be installed in existing service panels or junction boxes.
- **Uses Safe CTs**
Output limited to one volt.
- **Line Powered**
No external power supply required.
- **Digital Signal Processing**
Accurate kWH measurement over a wide harmonic range.
- **Detachable Terminal Blocks**
Easy to install and remove.


(888) 928-8663

3131 Indian Road, Suite A
Boulder, CO 80301 USA
(888) 928-8663 Fax (303) 444-2903
sales@ccontrols.com
www.ccontrols.com

WattNode is a registered trademark of Continental Control Systems LLC

SPECIFICATIONS

Measurement Configurations

Single phase: 2-wire or 3-wire

Three phase: 3-wire or 4-wire

Electrical

Line Powered

Operating Voltage Range: +15%, -20% of nominal

Power Line Frequency: 50/60 Hz

CT Input: 0.333 VAC

Pulse Output

Optoisolated, solid state relay closures handle up to maximum 60 VDC & to 5mA

Standard: 4.00 Hz Bidirectional Output

Optional: 0.01 Hz to 600 Hz Bidirectional Output

Models

Optional: Per-Phase Output Models 0.01 Hz to 150 Hz available

Accuracy

Normal Operation: Line voltage: 80% - 115% of nominal

Power factor: 1.0

Frequency: 50- 60 Hz

Ambient Temperature: 25°C

Current: 5% - 100% of rated current

Accuracy: $\pm 0.5\%$ of reading

Environmental

Operating Temperature: -30°C to +55°C (-22°F to 131°F)

Operating Humidity: 5 to 90% (RH)

Mechanical

Enclosure: High impact, UL rated, ABS plastic

Size: 3.3" x 5.6" x 1.5"

Connectors: UL, CSA recognized, detachable, screw terminals (14AWG), 600V

Optional LCD Display

Display: Eight digits, each 0.43" high

Reset: Wired remote and configurable front panel button

Enclosure: Panel mount box, 2.95" x 1.52"

Battery: Lithium 2/3A, replace every four years

MADE IN THE USA

(888) 928-8663



Continental Control Systems

3131 Indian Road, Suite A

Boulder, CO 80301

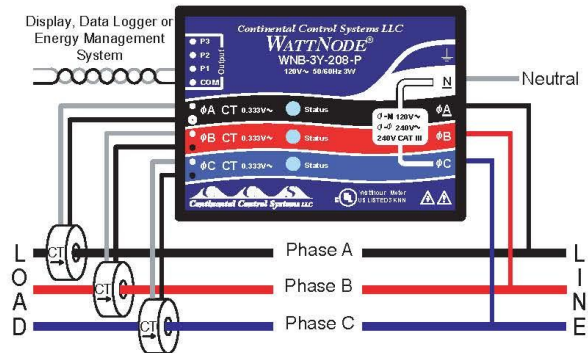
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sales@ccontrols.com

www.ccontrols.com

WATTNODE®

Advanced Pulse Output AC Power Measurement



WATTNODE

| Model | VAC | | Phases | Wires |
|--------------|-----------------|--------------|--------|-------|
| | Line To Neutral | Line To Line | | |
| WNB-3Y-208-P | 120 | 208-240 | 3 | 4 |
| WNB-3Y-400-P | 230 | 400 | 3 | 4 |
| WNB-3Y-480-P | 277 | 480 | 3 | 4 |
| WNB-3Y-600-P | 347 | 600 | 3 | 4 |
| WNB-3D-240-P | 120 | 208-240 | 3 | 3 |
| WNB-3D-400-P | 230 | 400 | 3 | 3 |
| WNB-3D-480-P | 277 | 480 | 3 | 3 |

LCD Displays

| Model | Displays | Units |
|---------|----------------|---------------------------|
| LCDA-E | Energy | WH, KWH, or MWH |
| LCDA-P | Power | W or kW |
| LCDA-EP | Energy & Power | WH, KWH, or MWH & W or kW |

OPENING CURRENT TRANSFORMERS (SPLIT-CORE)

| Model | Inside Diameter | Rated Amps |
|----------|-----------------|---------------------------------------|
| CTS-0750 | 0.75" | 5, 15, 30, 50, 70, 100, 150 |
| CTS-1250 | 1.25" | 70, 100, 150, 200, 250, 300, 400, 600 |
| CTS-2000 | 2.00" | 600, 800, 1000, 1200, 1500 |
| CTB | Bus Bar | 600, 800, 1200, 2000, 3000 (custom) |

TOROIDAL CURRENT TRANSFORMERS (SOLID-CORE)

| Model | Inside Diameter | Rated Amps |
|----------|-----------------|----------------------------------|
| CTT-0300 | 0.30" | 5, 15, 30 |
| CTT-0500 | 0.50" | 15, 30, 50, 60 |
| CTT-0750 | 0.75" | 30, 50, 70, 100 |
| CTT-1000 | 1.00" | 50, 70, 100, 150, 200 |
| CTT-1250 | 1.25" | 70, 100, 150, 200, 250, 300, 400 |

Current Transformer Output Voltage: 0 - 0.333 VAC @ rated current

8.3.5 M&V - PULSE ADAPTERS (PA) (S-UCC-M006)

Pulse Adapters (PA) transfer pulses from the WattNode to the logger. Eight Pas, model S-UCC-M006, were deployed. (serial#: 10335125, 10335126, 10335128, 10335129, 10335130, 10335132, 10365635, 10365636)

Pulse Input Adapters (Part #: S-UCC-M00x and S-UCD-M00x)

for use with HOBO® H21, H22, and U30 Series Data Loggers

The Pulse Input Adapters are used to log the number of switch closures per interval and are designed to work with smart sensor-compatible HOBO data loggers. The adapter has a plug-in modular connector that allows it to be added easily to these loggers.


Two versions are available:

- Mechanical contact closure (S-UCD-M00x)
Ideal for connecting tipping-bucket rain gauges to HOBO H21 series loggers or U30 series loggers.
- Solid-state electronic switches (S-UCC-M00x)
Used for connecting compatible pulse output sensors to HOBO H22 or U30 series loggers.



Inside this package


- Pulse Input Adapter
- 2 wire nuts

| Specification | Pulse Input Adapter | |
|---|---|--|
| | S-UCC-M00x for Electronic Switches | S-UCD-M00x for Contact Closures |
| Maximum Input Frequency | 120 Hz (120 pulses per second) | 2 Hz (2 pulses per second) |
| Measurement Range | 0 – 65,533 pulses per logging interval | |
| Resolution | 1 pulse | |
| Lockout time | 45 μ s \pm 10% | 327 ms \pm 10% |
| Recommended Input Type | Electronic solid state switch closure or CMOS-level digital output (example: FET, opto-FET or open collector) | Mechanical contact closure (example: reed switch in a tipping-bucket rain gauge) |
| Preferred Switch State [†] | Active low input | Normally open |
| Edge Detection | Falling edge, Schmitt Trigger buffer (logic levels: low \leq 0.6 V, high \geq 2.7 V) | |
| Minimum Pulse Width | 1 ms | |
| Input/Output Impedance | 100 K Ω | |
| Open Circuit Input Voltage | 3.3 V | |
| Maximum Input Voltage | 3.6 V | |
| User Connection | 24 AWG wires, 2 leads: white(+), black(-) | |
| Operating Temperature Range | -40° to 75°C (-40° to 167°F) | |
| Overall Cable Length | 6.5 m (21.3 ft.) or 1.57 m (5.1 ft.) | |
| Length of Smart Sensor Cable | 50cm (1.6 ft.) | |
| Housing | Weatherproof Xenoy housing protects input adapter electronics | |
| Housing Dimensions | 12.7 x 2.9 cm (5 x 1.13 in.) | |
| Weight | S-UCx-M001: 114 g (4 oz.); S-UCx-M006: 250 g (9 oz) | |
| Bits per Sample | 16 | |
| Number of Data Channels | 1 | |
| Measurement Averaging Option | No (reports the number of pulses over the logging interval) | |
| Part Number | S-UCC-M001 (1 m), S-UCC-M006 (6 m) | S-UCD-M001 (1 m), S-UCD-M006 (6 m) |
|  | The CE Marking identifies this product as complying with the relevant directives in the European Union (EU). | |

[†] For maximum battery life, the Pulse Input Adapters should be used with their preferred switch type. The adapters will work with active high inputs (S-UCC) and normally closed switches (S-UCD), but battery life will not be optimized.

8.3.6 M&V - ONSET HOBO MAN-H22

The Onset Hobo MAN-H22 is logs and stores the pulse data for later calculation. Two units of model H22-001 have been used (Serial# 10314791, 10314792).




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HOBO Energy Logger - H22-001

multi-channel data logger



IMPORTANT: The H22-001 Energy Logger requires HOBOWare software and part # ADAPT-SER-USB interface cables. See compatible items below.

The HOBO Energy Logger multi-channel data logger is a modular, re-configurable data logging system for energy and industrial monitoring applications.

The 15-channel system enables energy and facility management professionals to quickly and easily solve a broad range of monitoring applications without having to purchase a toolbox full of data loggers.

Innovative, snap-in FlexSmart™ signal conditioning modules convert signals from nearly any type of sensor. A suite of pre-defined plug-and-play smart sensors and powerful **HOBOWare® software** make set-up and deployment fast and easy. You can also expand your system capabilities with Ethernet or remote data access communications.

Features:

- Onset's most flexible data logger records up to 15 channels of over a dozen measurements
- Provides 12v excitation for third-party sensors
- Pre-configured smart sensors get you started fast
- Signal conditioning modules retain configurations until you change them, providing plug-and-play convenience for commonly used sensors
- Flexible power options include battery operation for AC power adapter

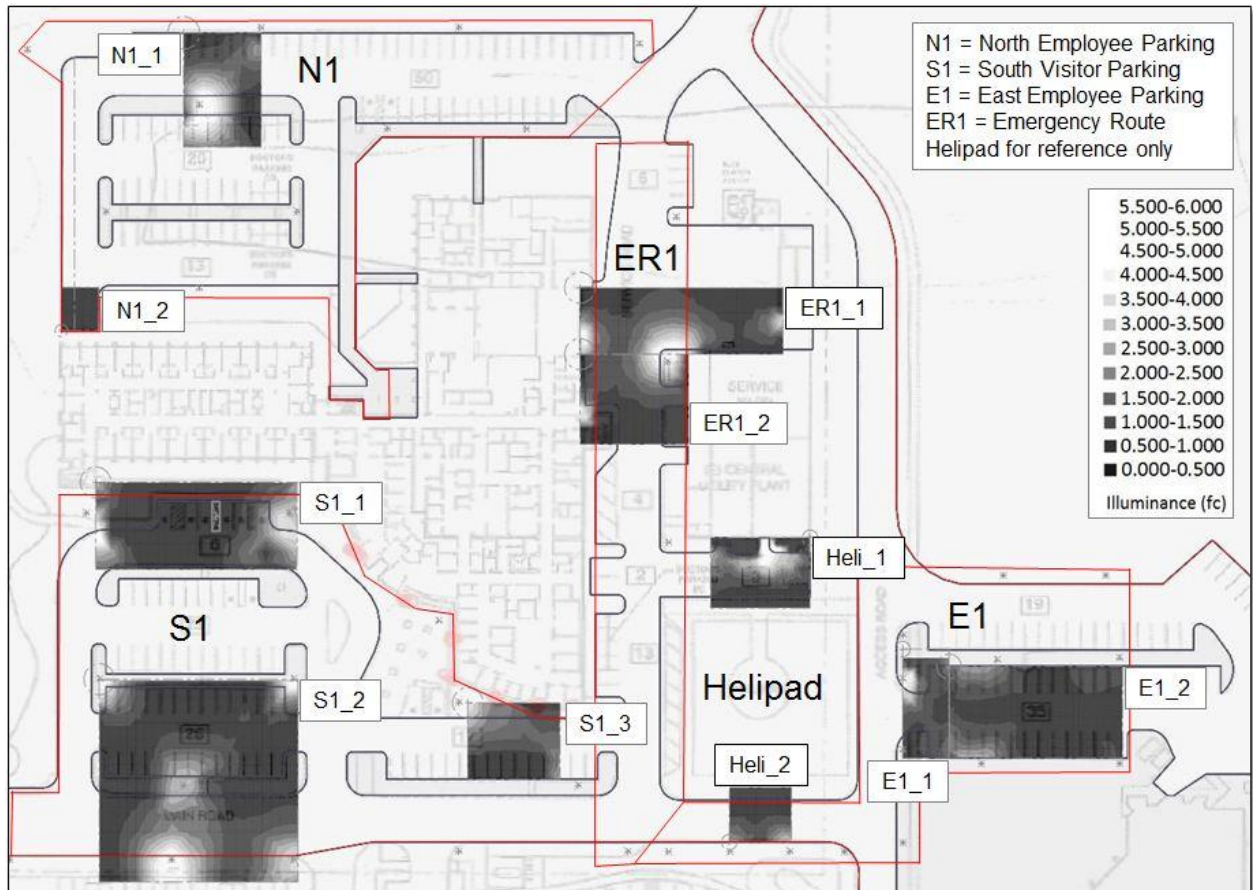
Environment:
The H22-001 Data Logger is for use in **Indoor** environments

Measurements:
The H22-001 Data Logger supports the following measurements (sensors sold separately):
Temperature, Relative Humidity, 4-20mA, AC Current, AC Voltage, Air Velocity [See more](#)

8.4 ILLUMINANCE FIELD MEASUREMENTS

Post-retrofit illuminance measurements of the eleven zones at VacaValley Hospital site are shown in below 2D-plot comparison graph:

8.4.1 OVERVIEW MAP & ZONE LOCATIONS, NAMING AND ILLUMINANCE KEY:



The following pages show one zone each as 2D plot series with Pre-retrofit, Post-retrofit-low and Post-high. All 2D-plots are have the geographical north-west in the top-left corner (A1)

Gridsize is noted, as well as date and time collected, weather conditions with temperature (if available) and engineering staff involved.

Footcandle (fc) grid values include MIN and MAX are highlighted. The average illuminance values are calculated values for the associated zone. The contrast ratios are calculated values. Denoted empty grid cells are due to obstructions at the time of data collection.

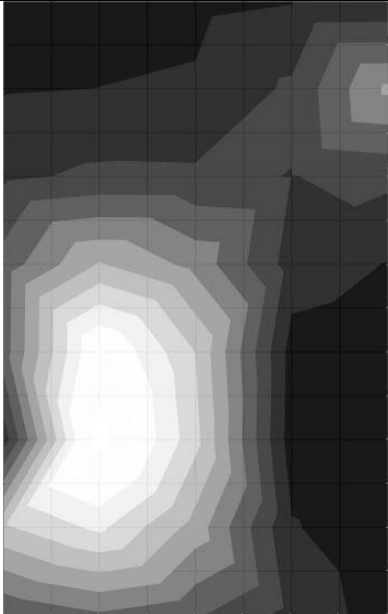
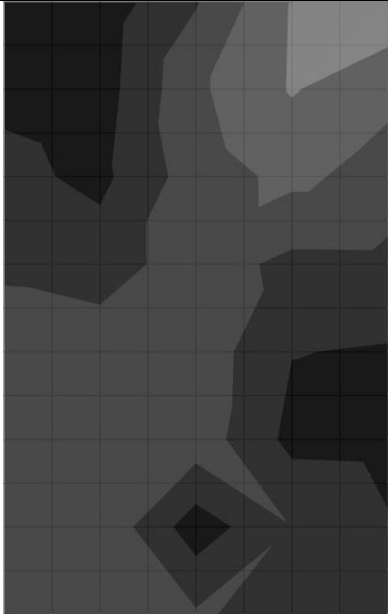
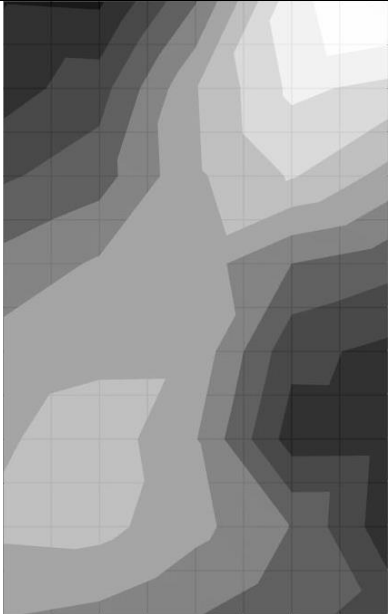
8.4.2 ZONE N1_1

Grid size, spacing: 10' cell / ^8x5> grid

Date collected: Pre: 2013.05.24/25; Post: 2014.03.13,14,15

CLTC staff involved: B.Goesmann, T.Patten, P.Arani, H.Nguyen

Other details: Pole N4 on corner A/B 5/6; Pole N3 on corner E1

| Zone | PRE retrofit | | | | | POST, low level | | | | | POST, high level | | | | |
|------|--|-------|-------|-------|-------|---|-------|-------|-------|-------|--|-------|-------|-------|-------|
| N1_1 |  | | | | |  | | | | |  | | | | |
| GRID | A | B | C | D | E | A | B | C | D | E | A | B | C | D | E |
| 1 | 0.255 | 0.198 | 0.376 | 0.475 | 0.500 | 0.246 | 0.207 | 0.958 | 2.024 | 2.387 | 0.467 | 0.409 | 1.956 | 4.310 | 5.180 |
| 2 | 0.463 | 0.504 | 0.558 | 1.090 | 2.612 | 0.375 | 0.265 | 1.407 | 2.039 | 1.647 | 0.770 | 1.288 | 2.970 | 4.110 | 3.860 |
| 3 | 0.902 | 1.097 | 1.080 | 0.990 | 1.120 | 0.646 | 0.374 | 1.255 | 1.632 | 1.266 | 1.428 | 1.779 | 2.920 | 3.550 | 2.830 |
| 4 | 1.711 | 3.040 | 2.340 | 0.772 | 0.480 | 0.900 | 0.762 | 1.254 | 0.869 | 0.879 | 2.169 | 2.571 | 2.740 | 1.998 | 1.682 |
| 5 | 1.747 | 5.140 | 3.490 | 0.293 | 0.142 | 1.313 | 1.277 | 1.317 | 0.514 | 0.459 | 2.710 | 2.852 | 2.860 | 1.143 | 0.870 |
| 6 | 0.707 | 5.730 | 3.660 | 0.238 | 0.060 | 1.232 | 1.356 | 1.294 | 0.360 | 0.334 | 2.930 | 3.310 | 2.530 | 0.760 | 0.773 |
| 7 | 3.420 | 4.120 | 2.790 | 0.540 | 0.158 | 1.208 | 1.409 | 0.220 | 0.985 | 0.544 | 3.110 | 3.160 | 2.648 | 1.982 | 0.689 |

| fc | Pre-Retrofit | Post-Retrofit Low | Post-Retrofit High |
|-----|--------------|-------------------|--------------------|
| Max | 5.730 | 2.387 | 5.180 |
| Min | 0.060 | 0.207 | 0.409 |
| Avg | 1.473 | 1.012 | 2.280 |

| Ratio : 1 | Target | Calculated | Target | Calculated | Target | Calculated |
|-----------|--------|------------|--------|------------|--------|------------|
| Max-Min | 15 | 95.5 | 15 | 11.5 | 15 | 12.7 |
| Avg-Min | 4 | 24.5 | 4 | 4.9 | 4 | 5.6 |

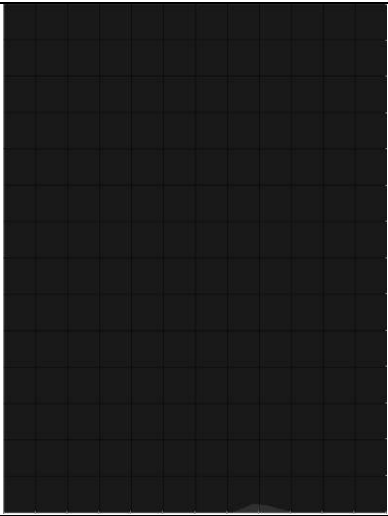
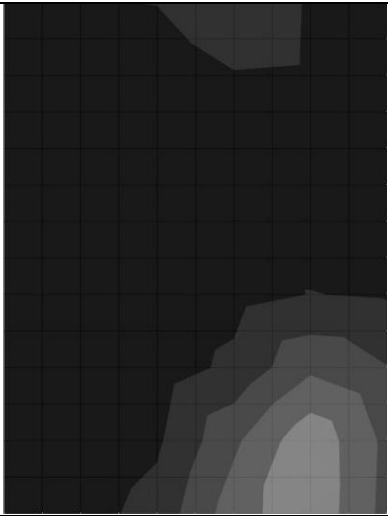
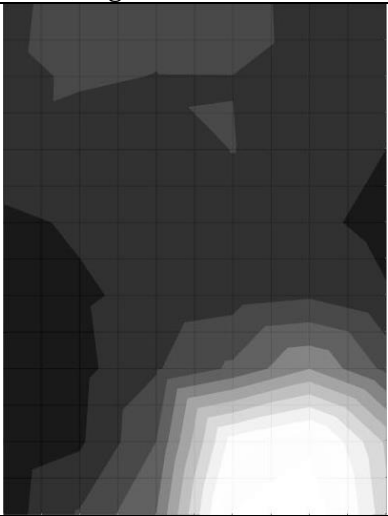
8.4.3 ZONE N1_2

Grid size, spacing: 4' cell / ^8x6> grid

Date collected: Pre: 2013.05.24/25; Post: 2014.03.13,14,15

CLTC staff involved: B.Goesmann, T.Patten, P.Arani, H.Nguyen

Other details: Pole N6 close by with 7 fc, behind tree 0.05 fc

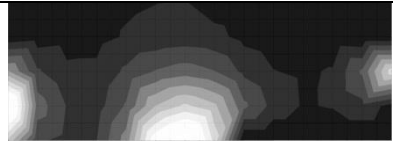

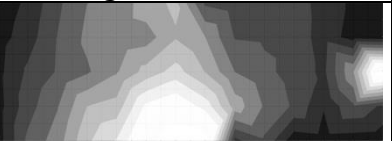
| Zone | PRE retrofit | | | | | | POST, low level | | | | | | POST, high level | | | | | |
|------|--|------|------|------|------|------|---|------|------|------|------|------|--|------|------|------|------|------|
| N1_2 |  | | | | | |  | | | | | |  | | | | | |
| GRID | A | B | C | D | E | F | A | B | C | D | E | F | A | B | C | D | E | F |
| 1 | 0.11 | 0.17 | 0.20 | 0.27 | 0.27 | 0.13 | 0.42 | 0.49 | 0.51 | 0.65 | 0.48 | 0.50 | 0.80 | 1.31 | 1.16 | 1.45 | 0.59 | 0.85 |
| 2 | 0.08 | 0.09 | 0.14 | 0.20 | 0.20 | 0.08 | 0.22 | 0.31 | 0.38 | 0.49 | 0.47 | 0.39 | 0.85 | 1.08 | 0.99 | 0.99 | 0.62 | 0.66 |
| 3 | 0.08 | 0.08 | 0.10 | 0.14 | 0.09 | 0.07 | 0.19 | 0.26 | 0.35 | 0.43 | 0.34 | 0.30 | 0.85 | 0.71 | 0.61 | 1.02 | 0.54 | 0.50 |
| 4 | 0.09 | 0.09 | 0.10 | 0.06 | 0.10 | 0.07 | 0.15 | 0.13 | 0.20 | 0.35 | 0.33 | 0.18 | 0.38 | 0.57 | 0.62 | 0.68 | 0.62 | 0.34 |
| 5 | 0.11 | 0.11 | 0.11 | 0.12 | 0.18 | 0.07 | 0.10 | 0.12 | 0.15 | 0.33 | 0.51 | 0.45 | 0.21 | 0.42 | 0.65 | 0.79 | 0.93 | 0.54 |
| 6 | 0.14 | 0.15 | 0.12 | 0.13 | 0.18 | 0.09 | 0.08 | 0.09 | 0.24 | 0.61 | 1.40 | 1.02 | 0.24 | 0.35 | 0.95 | 1.60 | 2.49 | 1.36 |
| 7 | 0.19 | 0.21 | 0.16 | 0.18 | 0.17 | 0.14 | 0.10 | 0.15 | 0.42 | 1.40 | 2.37 | 1.37 | 0.16 | 0.42 | 1.50 | 4.76 | 5.37 | 3.40 |
| 8 | 0.10 | 0.06 | 0.32 | 0.44 | 0.54 | 0.46 | 0.10 | 0.30 | 0.68 | 1.76 | 2.39 | 1.33 | 0.23 | 1.05 | 2.01 | 5.56 | 6.34 | 3.66 |

| fc | Pre-Retrofit | | | | | | Post-Retrofit Low | | | | | | Post-Retrofit High | | | | | |
|-----|--------------|--|--|--|--|--|-------------------|--|--|--|--|--|--------------------|--|--|--|--|--|
| Max | 0.542 | | | | | | 2.394 | | | | | | 6.340 | | | | | |
| Min | 0.061 | | | | | | 0.076 | | | | | | 0.158 | | | | | |
| Avg | 0.155 | | | | | | 0.541 | | | | | | 1.328 | | | | | |

| Ratio : 1 | Target | Calculated | Target | Calculated | Target | Calculated |
|-----------|--------|------------|--------|------------|--------|------------|
| Max-Min | 15 | 8.9 | 15 | 31.5 | 15 | 40.1 |
| Avg-Min | 4 | 2.5 | 4 | 7.1 | 4 | 8.4 |

8.4.4 ZONE ER1_1

Grid size, spacing: 10' cell / ^5x14> grid
 Date collected: Pre: 2013.05.24/25; Post: 2014.03.13,14,15
 CLTC staff involved: B.Goesmann, T.Patten, P.Arani, H.Nguyen
 Other details: A/B-1/2 had shadows from doorway

| Zone | PRE retrofit | POST, low level | POST, high level |
|-------|---|--|---|
| ER1_1 |  |  |  |

| PRE | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|---------|-------|-------|-------|-------|-------|
| 1 | 0.073 | 0.200 | 0.239 | 0.323 | 0.427 | 0.489 | 0.521 | 0.289 | 0.226 | 0.300 | 0.204 | 0.142 | 0.112 | 0.057 |
| 2 | 0.095 | 0.234 | 0.312 | 0.347 | 0.543 | 0.636 | 0.707 | 0.635 | 0.359 | 0.230 | 0.195 | 0.116 | 0.040 | 0.048 |
| 3 | 2.567 | 1.064 | 0.590 | 0.596 | 1.097 | 1.534 | 1.753 | 1.518 | 0.867 | 0.515 | 0.425 | 0.546 | 1.579 | 3.790 |
| 4 | 6.000 | 1.781 | 0.970 | 0.786 | 1.560 | 3.000 | 3.610 | 3.120 | 1.614 | 0.822 | 0.457 | 0.541 | 0.851 | 0.300 |
| 5 | 3.390 | 1.092 | 0.845 | 1.000 | 2.224 | 4.960 | 7.070 | 3.830 | Utility | Fence | --- | | | |

| POSTlow | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0.128 | 0.578 | 0.876 | 1.149 | 1.383 | 1.683 | 1.827 | 0.797 | 0.804 | 0.729 | 0.927 | 0.569 | 0.275 | 0.109 |
| 2 | 0.171 | 0.605 | 0.796 | 1.055 | 1.344 | 1.637 | 1.747 | 1.591 | 0.873 | 0.795 | 0.918 | 0.511 | 0.245 | 0.108 |
| 3 | 0.197 | 0.649 | 0.944 | 1.113 | 1.604 | 2.112 | 2.153 | 2.214 | 1.636 | 1.178 | 1.031 | 0.814 | 1.963 | 4.650 |
| 4 | 0.190 | 1.014 | 1.134 | 1.651 | 2.160 | 2.717 | 2.800 | 2.589 | 1.861 | 1.158 | 0.866 | 0.930 | 1.810 | 0.322 |
| 5 | 0.158 | 1.200 | 1.310 | 1.895 | 2.731 | 3.240 | 3.590 | 3.430 | 1.007 | 1.327 | 0.156 | 0.276 | 0.276 | 0.160 |

| POSThigh | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0.190 | 0.598 | 1.389 | 1.995 | 2.066 | 2.823 | 3.090 | 1.389 | 1.183 | 1.467 | 1.235 | 0.807 | 0.393 | 0.162 |
| 2 | 0.296 | 0.754 | 1.513 | 2.112 | 2.104 | 2.253 | 2.956 | 2.500 | 1.463 | 1.416 | 1.285 | 0.780 | 0.294 | 0.170 |
| 3 | 0.356 | 1.095 | 1.540 | 1.927 | 2.442 | 3.190 | 3.700 | 2.980 | 1.993 | 1.637 | 1.283 | 0.886 | 2.483 | 7.010 |
| 4 | 0.300 | 1.293 | 1.962 | 3.000 | 3.200 | 4.620 | 5.000 | 4.310 | 2.780 | 1.941 | 1.418 | 0.540 | 1.422 | 0.889 |
| 5 | 0.271 | 1.607 | 2.251 | 3.400 | 4.040 | 5.270 | 6.560 | 5.840 | 0.842 | 1.404 | 0.165 | 0.272 | 0.224 | 0.172 |

| | PRE retrofit | POST, low level | POST, high level |
|-----|--------------|-----------------|------------------|
| fc | | | |
| Max | 7.070 | 4.650 | 7.010 |
| Min | 0.040 | 0.108 | 0.162 |
| Avg | 1.193 | 1.264 | 1.946 |

| Ratio : 1 | Target | Calculated | Target | Calculated | Target | Calculated |
|-----------|--------|------------|--------|------------|--------|------------|
| Max-Min | 15 | 176.8 | 15 | 43.1 | 15 | 43.3 |
| Avg-Min | 4 | 29.8 | 4 | 11.7 | 4 | 12.0 |

8.4.5 ZONE ER1_2

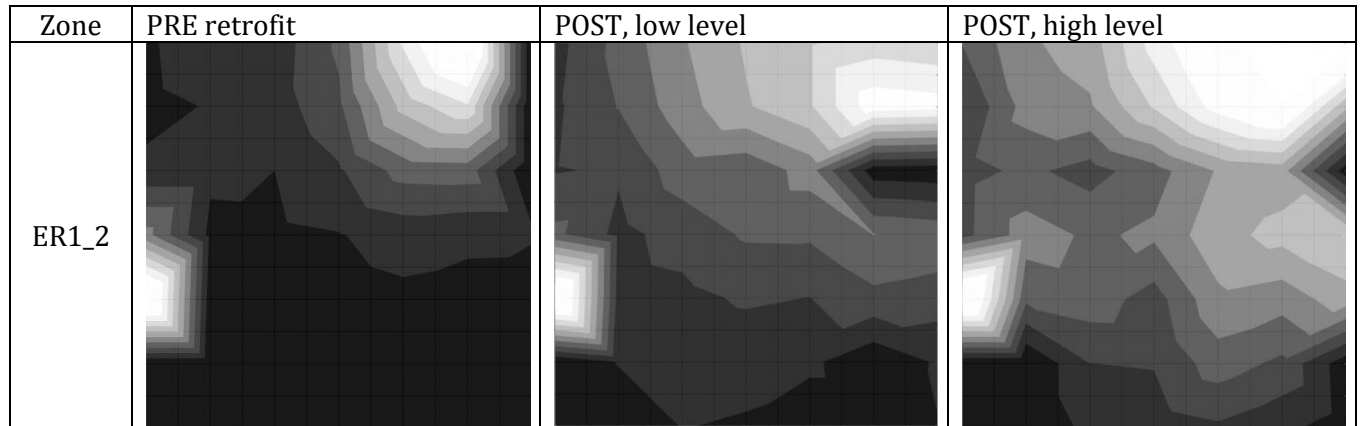
Grid size, spacing: 10' cell / ^7x7> grid

Date collected: Pre: 2013.05.24/25; Post: 2014.03.13,14,15

CLTC staff involved: B.Goesmann, T.Patten, P.Arani, H.Nguyen

Other details: A4/5 lid up by bay lighting, if closed will have lower values.

A6/7 building corner



| PRE | A | B | C | D | E | F | G |
|-----|------|------|------|------|------|------|------|
| 1 | 0.39 | 0.93 | 0.70 | 1.60 | 4.11 | 5.84 | |
| 2 | 0.34 | 0.54 | 0.76 | 1.40 | 3.19 | 3.95 | |
| 3 | 0.61 | 0.60 | 0.50 | 0.94 | 1.70 | 1.74 | |
| 4 | 2.19 | 0.38 | 0.40 | 0.48 | 0.69 | 0.59 | 0.58 |
| 5 | 6.36 | 0.19 | 0.19 | 0.31 | 0.40 | 0.35 | |
| 6 | | | 0.15 | 0.21 | 0.23 | 0.22 | |
| 7 | | | 0.09 | 0.10 | 0.11 | 0.10 | |

| POSTlow | A | B | C | D | E | F | G |
|---------|------|------|------|------|------|------|------|
| 1 | 0.81 | 1.66 | 2.45 | 3.06 | 3.44 | 3.72 | 3.59 |
| 2 | 0.91 | 1.52 | 2.29 | 2.95 | 3.44 | 4.83 | 4.73 |
| 3 | 0.96 | 1.06 | 1.76 | 1.65 | 2.20 | 0.22 | 0.15 |
| 4 | 1.63 | 0.86 | 1.20 | 1.57 | 1.58 | 2.01 | 1.87 |
| 5 | 6.66 | 0.79 | 0.87 | 1.06 | 0.99 | 1.37 | 1.25 |
| 6 | | | 0.64 | 0.69 | 0.61 | 0.10 | 0.56 |
| 7 | | | 0.52 | 0.44 | 0.17 | 0.17 | 0.48 |

| POSThigh | A | B | C | D | E | F | G |
|----------|------|------|------|------|------|------|------|
| 1 | 1.51 | 2.42 | 2.74 | 4.23 | 5.19 | 6.61 | 6.53 |
| 2 | 0.97 | 2.20 | 2.43 | 3.56 | 4.76 | 5.47 | 3.12 |
| 3 | 1.31 | 1.61 | 1.29 | 1.79 | 2.55 | 2.72 | 0.22 |
| 4 | 1.33 | 2.24 | 1.92 | 2.09 | 2.83 | 3.17 | 3.52 |
| 5 | 7.74 | 1.60 | 1.77 | 1.27 | 2.39 | 2.20 | 2.78 |
| 6 | | | 1.00 | 1.03 | 1.75 | 1.38 | 0.19 |
| 7 | | | 0.66 | 0.74 | 0.92 | 0.62 | 0.24 |

| | PRE retrofit | POST, low level | POST, high level |
|-----------|--------------|-----------------|------------------|
| fc | | | |
| Max | 6.360 | 6.660 | 7.740 |
| Min | 0.094 | 0.100 | 0.189 |
| Avg | 1.132 | 1.622 | 2.414 |

| Ratio : 1 | Target | Calculated | Target | Calculated | Target | Calculated |
|-----------|--------|------------|--------|------------|--------|------------|
| Max-Min | 15 | 67.7 | 15 | 66.6 | 15 | 41.0 |
| Avg-Min | 4 | 12.0 | 4 | 16.2 | 4 | 12.8 |


8.4.6 ZONE S1_1

Grid size, spacing: 10' cell / ^6x14> grid

Date collected: Pre: 2013.05.24/25; Post: 2014.03.13,14,15

CLTC staff involved: B.Goesmann, T.Patten, P.Arani, H.Nguyen

Other details: A1 is directly under Wall Pack. Pole S5 underneath M3

| Zone | PRE retrofit | POST, low level | POST, high level |
|------|---|--|---|
| S1_1 |  |  |  |

| PRE | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 3.060 | 0.906 | 0.361 | 0.088 | 0.070 | 0.055 | 0.051 | 0.075 | 0.133 | 0.226 | 0.302 | 0.679 | 0.808 | 2.231 |
| 2 | 0.516 | 0.780 | 0.136 | 0.036 | 0.049 | 0.056 | 0.048 | 0.082 | 0.127 | 0.309 | 0.642 | 1.162 | 1.849 | 2.505 |
| 3 | 3.650 | 0.267 | 0.118 | 0.064 | 0.063 | 0.043 | 0.033 | 0.084 | 0.142 | 0.312 | 0.731 | 2.267 | 3.940 | 3.020 |
| 4 | 6.550 | 0.315 | 0.048 | 0.046 | 0.063 | 0.069 | 0.081 | 0.122 | 0.213 | 0.401 | 0.907 | 2.125 | 3.600 | 3.800 |
| 5 | 2.903 | 2.455 | 0.689 | 0.082 | 0.078 | 0.091 | 0.113 | 0.221 | 0.390 | 0.842 | 1.609 | 0.152 | 1.424 | 2.870 |
| 6 | 1.202 | 1.227 | 0.689 | 0.399 | 0.132 | 0.102 | 0.129 | 0.246 | 0.349 | 0.631 | 0.987 | 0.716 | 0.840 | 1.292 |

| POSTlow | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 2.541 | 1.273 | 0.516 | 0.300 | 0.111 | 0.063 | 0.060 | 0.059 | 0.060 | 0.068 | 0.084 | 0.144 | 0.141 | 0.227 |
| 2 | 0.215 | 0.457 | 0.404 | 0.162 | 0.097 | 0.092 | 0.067 | 0.067 | 0.086 | 0.111 | 0.157 | 0.248 | 0.474 | 0.539 |
| 3 | 1.198 | 1.707 | 0.493 | 0.264 | 0.110 | 0.031 | 0.044 | 0.062 | 0.096 | 0.237 | 0.514 | 1.330 | 2.124 | 2.019 |
| 4 | 1.960 | 1.734 | 1.728 | 0.236 | 0.116 | 0.062 | 0.083 | 0.081 | 0.158 | 0.354 | 1.108 | 2.033 | 2.150 | 2.270 |
| 5 | 1.092 | 0.988 | 1.214 | 1.034 | 0.134 | 0.055 | 0.089 | 0.146 | 0.260 | 0.733 | 1.593 | 2.247 | 1.276 | 1.506 |
| 6 | 0.564 | 0.601 | 0.914 | 0.714 | 0.627 | 0.354 | 0.175 | 0.232 | 0.389 | 0.807 | 1.277 | 1.800 | 1.900 | 1.366 |

| POSThigh | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 3.330 | 0.973 | 0.321 | 0.175 | 0.062 | 0.072 | 0.065 | 0.069 | 0.085 | 0.106 | 0.165 | 0.227 | 0.362 | 0.393 |
| 2 | 0.476 | 3.630 | 0.149 | 0.183 | 0.130 | 0.085 | 0.066 | 0.090 | 0.141 | 0.213 | 0.362 | 0.597 | 0.993 | 1.040 |
| 3 | 4.730 | 3.420 | 0.618 | 0.070 | 0.059 | 0.054 | 0.084 | 0.111 | 0.238 | 0.405 | 1.172 | 3.110 | 4.760 | 4.220 |
| 4 | 4.280 | 3.280 | 2.824 | 0.068 | 0.053 | 0.084 | 0.099 | 0.152 | 0.325 | 0.743 | 2.332 | 4.840 | 4.800 | 4.620 |
| 5 | 2.467 | 2.277 | 2.273 | 0.053 | 0.071 | 0.093 | 0.146 | 0.218 | 0.507 | 1.500 | 2.580 | 4.150 | 2.600 | 2.751 |
| 6 | 1.505 | 1.496 | 2.055 | 1.330 | 0.836 | 0.367 | 0.311 | 0.291 | 0.776 | 1.363 | 2.102 | 3.010 | 2.268 | 1.912 |

| | PRE retrofit | POST, low level | POST, high level |
|-----------|--------------|-----------------|------------------|
| fc | | | |
| Max | 6.550 | 2.541 | 4.840 |
| Min | 0.033 | 0.031 | 0.053 |
| Avg | 0.872 | 0.681 | 1.279 |

| Ratio : 1 | Target | Calculated | Target | Calculated | Target | Calculated |
|-----------|--------|------------|--------|------------|--------|------------|
| Max-Min | 15 | 198.5 | 15 | 82.0 | 15 | 91.3 |
| Avg-Min | 4 | 26.4 | 4 | 22.0 | 4 | 24.1 |

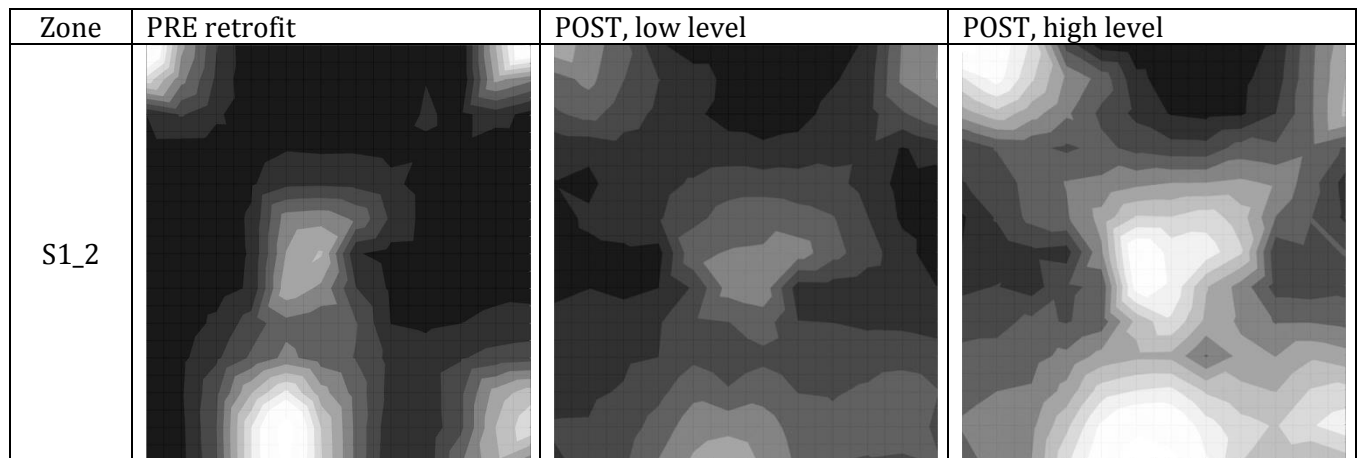
8.4.7 ZONE S1_2

Grid size, spacing: 10' cell / ^13x12> grid

Date collected: Pre: 2013.05.24/25; Post: 2014.03.13,14,15

CLTC staff involved: B.Goesmann, T.Patten, P.Arani, H.Nguyen

Other details: Several poles in vicinity see Pole-ID map for details



| PRE | A | B | C | D | E | F | G | H | I | J | K | L |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 6.170 | 2.660 | 1.037 | 0.046 | 0.068 | 0.055 | 0.051 | 0.060 | 0.346 | | 3.020 | 9.480 |
| 2 | 3.840 | 2.175 | 0.902 | 0.085 | 0.119 | 0.130 | 0.164 | 0.111 | 0.488 | | 2.645 | 2.115 |
| 3 | 0.499 | 1.050 | 0.600 | 0.137 | 0.230 | 0.204 | 0.243 | 0.196 | 0.561 | 0.373 | 0.752 | 0.299 |
| 4 | 0.277 | 0.260 | 0.245 | 0.253 | 0.470 | 0.432 | 0.442 | 0.378 | 0.436 | 0.376 | 0.094 | 0.114 |
| 5 | 0.113 | 0.142 | 0.218 | 0.431 | 0.888 | 0.921 | 0.863 | 0.608 | 0.318 | 0.146 | 0.133 | 0.107 |
| 6 | 0.108 | 0.122 | 0.265 | 0.558 | 2.248 | 2.345 | 1.909 | 0.910 | 0.325 | 0.205 | 0.124 | 0.116 |
| 7 | 0.114 | 0.135 | 0.205 | 0.548 | 2.521 | 3.060 | 0.550 | 0.303 | 0.269 | 0.063 | 0.180 | 0.192 |
| 8 | 0.164 | 0.175 | 0.275 | 0.572 | 2.840 | 2.395 | 1.015 | 0.416 | 0.211 | 0.312 | 0.390 | 0.363 |
| 9 | 0.198 | 0.235 | 0.607 | 1.229 | 1.843 | 1.620 | 1.531 | 0.490 | 0.412 | 0.495 | 0.607 | 0.668 |
| 10 | 0.272 | 0.385 | 0.908 | 1.582 | 2.137 | 1.754 | 1.475 | 0.839 | 0.714 | 0.955 | 1.196 | 1.300 |
| 11 | 0.317 | 0.434 | 1.379 | 2.970 | 4.140 | 2.720 | 1.802 | 0.796 | 0.695 | 1.389 | 2.713 | 3.290 |
| 12 | 0.208 | 0.380 | 1.497 | 4.000 | 6.420 | 3.500 | 1.863 | 0.638 | 0.640 | 1.391 | 3.010 | 3.900 |
| 13 | 0.127 | 0.350 | 1.428 | 4.000 | 5.800 | 3.550 | 1.866 | 0.585 | 0.691 | 1.913 | 2.890 | 2.135 |

| POSTlow | A | B | C | D | E | F | G | H | I | J | K | L |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 2.895 | 2.268 | 1.665 | 0.592 | 0.094 | 0.086 | 0.059 | 0.074 | 0.251 | 0.581 | 2.054 | 2.498 |
| 2 | 1.781 | 2.146 | 1.513 | 1.010 | 0.829 | 0.329 | 0.125 | 0.154 | 0.443 | 0.742 | 2.121 | 2.516 |
| 3 | 1.416 | 1.674 | 1.223 | 0.894 | 0.607 | 0.282 | 0.254 | 0.304 | 0.689 | 0.802 | 1.437 | 1.892 |
| 4 | 0.609 | 0.641 | 0.801 | 0.708 | 0.693 | 0.727 | 0.583 | 0.686 | 0.833 | 0.880 | 0.453 | 0.731 |
| 5 | 0.486 | 0.365 | 0.851 | 0.838 | 1.060 | 1.272 | 1.278 | 1.230 | 1.149 | 0.812 | 0.321 | 0.211 |
| 6 | 0.284 | 0.601 | 0.755 | 0.949 | 1.342 | 1.738 | 1.852 | 1.692 | 1.532 | 1.013 | 0.411 | 0.207 |
| 7 | 0.243 | 0.355 | 0.398 | 0.328 | 1.924 | 2.025 | 2.050 | 2.255 | 1.677 | 1.225 | 0.696 | 0.204 |
| 8 | 0.422 | 0.494 | 0.341 | 0.497 | 1.061 | 2.201 | 2.324 | 0.749 | 0.778 | 0.682 | 0.608 | 0.497 |
| 9 | 0.598 | 0.618 | 0.813 | 0.957 | 1.406 | 1.486 | 1.739 | 1.013 | 0.999 | 0.911 | 0.894 | 0.773 |
| 10 | 0.784 | 0.795 | 0.916 | 1.001 | 1.398 | 1.215 | 1.383 | 1.197 | 1.239 | 1.295 | 1.337 | 1.250 |
| 11 | 0.913 | 0.928 | 1.040 | 1.360 | 1.866 | 1.553 | 1.818 | 1.489 | 1.453 | 1.579 | 1.775 | 1.523 |
| 12 | 1.024 | 1.028 | 1.253 | 1.712 | 2.288 | 2.384 | 2.247 | 1.781 | 1.627 | 1.809 | 2.001 | 1.345 |
| 13 | 0.968 | 1.058 | 1.412 | 2.025 | 2.580 | 2.820 | 2.433 | 1.911 | 1.519 | 1.430 | 1.347 | 1.565 |

| POSThigh | A | B | C | D | E | F | G | H | I | J | K | L |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 6.260 | 4.910 | 3.910 | 1.261 | 0.218 | 0.094 | 0.097 | 0.096 | 0.221 | 0.607 | 1.855 | 2.820 |
| 2 | 3.930 | 4.730 | 3.590 | 2.410 | 1.823 | 0.651 | 0.212 | 0.126 | 0.380 | 0.751 | 1.898 | 3.002 |
| 3 | 2.761 | 3.350 | 2.713 | 2.091 | 1.379 | 0.874 | 0.457 | 0.364 | 0.418 | 0.998 | 1.915 | 3.130 |
| 4 | 1.032 | 1.542 | 1.607 | 1.412 | 1.644 | 1.340 | 1.180 | 1.164 | 1.720 | 1.593 | 1.869 | 1.442 |
| 5 | 0.980 | 1.176 | 1.735 | 2.024 | 2.100 | 2.351 | 2.493 | 2.501 | 2.594 | 2.418 | 1.725 | 0.801 |
| 6 | 0.430 | 1.058 | 1.659 | 1.940 | 2.670 | 3.550 | 3.520 | 3.770 | 3.230 | 1.988 | 1.523 | 0.899 |
| 7 | 0.513 | 0.678 | 0.885 | 0.787 | 2.421 | 5.120 | 4.330 | 4.290 | 3.580 | 1.133 | 1.374 | 1.526 |
| 8 | 0.887 | 1.020 | 0.765 | 1.427 | 1.586 | 4.760 | 4.420 | 3.040 | 2.296 | 1.294 | 1.231 | 1.339 |
| 9 | 1.317 | 1.323 | 1.630 | 1.461 | 1.727 | 3.130 | 3.910 | 2.876 | 2.403 | 1.955 | 1.965 | 1.842 |
| 10 | 1.617 | 1.692 | 1.834 | 2.121 | 2.677 | 2.890 | 2.870 | 1.953 | 2.663 | 2.491 | 2.916 | 2.690 |
| 11 | 1.872 | 1.997 | 2.044 | 2.667 | 3.740 | 4.020 | 4.130 | 3.430 | 3.130 | 2.980 | 3.540 | 3.690 |
| 12 | 2.047 | 2.181 | 2.379 | 3.380 | 4.600 | 5.260 | 5.100 | 4.210 | 3.680 | 3.460 | 3.950 | 4.290 |
| 13 | 1.760 | 2.262 | 2.501 | 3.870 | 4.920 | 6.200 | 5.680 | 4.560 | 3.520 | 3.130 | 2.936 | 3.280 |

| | PRE retrofit | POST, low level | POST, high level |
|-----|--------------|-----------------|------------------|
| fc | | | |
| Max | 9.480 | 2.895 | 6.260 |
| Min | 0.046 | 0.059 | 0.094 |
| Avg | 1.136 | 1.140 | 2.334 |

| Ratio : 1 | Target | Calculated | Target | Calculated | Target | Calculated |
|-----------|--------|------------|--------|------------|--------|------------|
| Max-Min | 15 | 206.1 | 15 | 49.1 | 15 | 66.6 |
| Avg-Min | 4 | 24.7 | 4 | 19.3 | 4 | 24.8 |

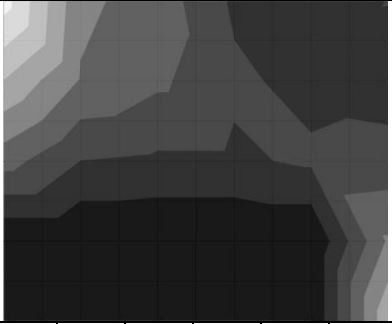
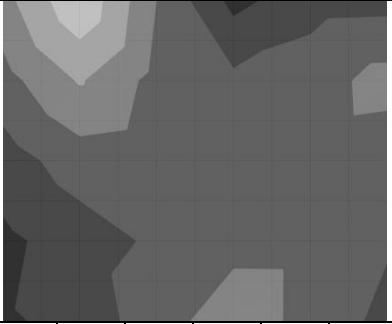
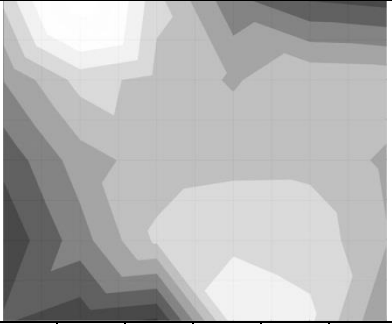
8.4.8 ZONE S1_3

Grid size, spacing: 10' cell / ^5x6> grid

Date collected: Pre: 2013.05.24/25; Post: 2014.03.13,14,15

CLTC staff involved: B.Goesmann, T.Patten, P.Arani, H.Nguyen

Other details: Pre-retrofit had a car parked near the pole contributing to the low light levels

| Zone | PRE retrofit | | | | | | POST, low level | | | | | | POST, high level | | | | | |
|------|---|------|------|------|------|------|--|------|------|------|------|------|---|------|------|------|------|------|
| S1_3 |  | | | | | |  | | | | | |  | | | | | |
| | A | B | C | D | E | F | A | B | C | D | E | F | A | B | C | D | E | F |
| 1 | 4.23 | 2.10 | 1.79 | 0.91 | 0.53 | 1.01 | 2.32 | 3.43 | 2.00 | 0.85 | 1.30 | 1.33 | 3.61 | 6.30 | 3.65 | 2.14 | 1.47 | 1.30 |
| 2 | 2.99 | 1.96 | 1.60 | 1.09 | 0.85 | 0.78 | 1.81 | 2.55 | 1.83 | 1.62 | 1.77 | 2.19 | 2.51 | 3.69 | 3.34 | 2.94 | 3.43 | 3.37 |
| 3 | 1.72 | 1.00 | 0.91 | 0.91 | 1.08 | 1.18 | 1.25 | 1.76 | 1.66 | 1.73 | 1.75 | 1.68 | 1.64 | 2.76 | 3.26 | 3.35 | 3.36 | 2.90 |
| 4 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 2.07 | 0.89 | 1.24 | 1.59 | 1.91 | 1.91 | 1.57 | 1.09 | 2.28 | 3.60 | 3.94 | 3.82 | 3.03 |
| 5 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 2.91 | 0.96 | 1.09 | 1.87 | 2.16 | 1.91 | 1.33 | 1.56 | 1.17 | 0.94 | 4.24 | 4.09 | 2.49 |

| | PRE retrofit | | | | | | POST, low level | | | | | | POST, high level | | | | | |
|-----|--------------|--|--|--|--|--|-----------------|--|--|--|--|--|------------------|--|--|--|--|--|
| fc | | | | | | | | | | | | | | | | | | |
| Max | 4.230 | | | | | | 3.430 | | | | | | 6.300 | | | | | |
| Min | 0.080 | | | | | | 0.849 | | | | | | 0.937 | | | | | |
| Avg | 1.081 | | | | | | 1.709 | | | | | | 2.909 | | | | | |

| Ratio : 1 | Target | Calculated | Target | Calculated | Target | Calculated |
|-----------|--------|------------|--------|------------|--------|------------|
| Max-Min | 15 | 52.9 | 15 | 4.0 | 15 | 6.7 |
| Avg-Min | 4 | 13.5 | 4 | 2.0 | 4 | 3.1 |

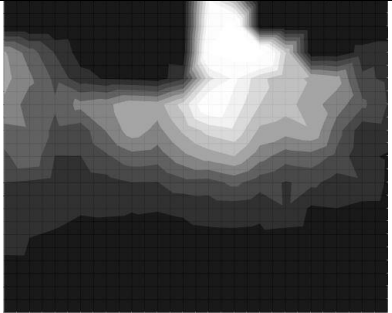
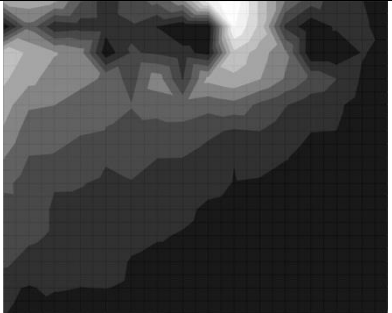
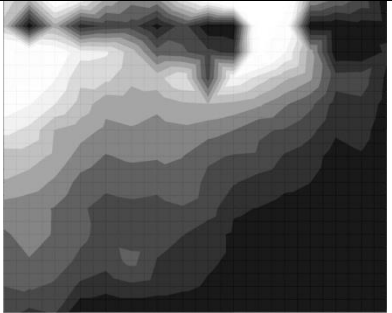
8.4.9 ZONE HELI_1

Grid size, spacing: 5' cell / ^13x16> grid

Date collected: Pre: 2013.05.24/25; Post: 2014.03.13,14,15

CLTC staff involved: B.Goesmann, T.Patten, P.Arani, H.Nguyen

Other details: Foliage close to wall makes it difficult to collect data - high Contrast ratios there

| Zone | PRE retrofit | POST, low level | POST, high level |
|--------|---|--|---|
| Heli_1 |  |  |  |

| PRE | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | | | | 0.319 | 0.233 | | | | 4.500 | 3.120 | | | | | | |
| 2 | | | | 0.073 | 0.065 | | | | 4.910 | 5.900 | | | | | | |
| 3 | 2.578 | 1.759 | 0.964 | 0.275 | 0.158 | 0.294 | 0.182 | 0.098 | 5.530 | 6.000 | 6.000 | 3.520 | 0.060 | 0.093 | 0.700 | 0.867 |
| 4 | 2.683 | 2.099 | 1.377 | 0.674 | 0.445 | 0.377 | 0.237 | 0.899 | 3.840 | 4.610 | 3.660 | 3.090 | 2.960 | 2.700 | 1.109 | 0.900 |
| 5 | 2.403 | 1.780 | 1.574 | 2.186 | 2.371 | 2.860 | 2.770 | 3.700 | 5.130 | 4.300 | 3.500 | 3.220 | 2.690 | 2.253 | 1.616 | 0.972 |
| 6 | 1.853 | 1.935 | 1.365 | 1.214 | 2.035 | 2.780 | 2.333 | 3.090 | 3.680 | 3.900 | 2.890 | 2.730 | 2.960 | 1.728 | 0.676 | 0.779 |
| 7 | 1.356 | 1.930 | 0.985 | 0.989 | 1.415 | 1.818 | 1.727 | 2.355 | 2.740 | 2.990 | 2.209 | 1.717 | 1.793 | 1.364 | 0.609 | 0.442 |
| 8 | 0.992 | 0.920 | 0.805 | 0.737 | 0.811 | 0.997 | 0.984 | 1.320 | 1.287 | 1.637 | 1.210 | 0.962 | 1.125 | 0.792 | 0.922 | 0.429 |
| 9 | 0.764 | 0.646 | 0.601 | 0.538 | 0.558 | 0.547 | 0.522 | 0.568 | 0.708 | 0.740 | 0.648 | 0.971 | 0.413 | 0.492 | 0.331 | 0.321 |
| 10 | 0.966 | 0.517 | 0.473 | 0.390 | 0.377 | 0.223 | 0.340 | 0.377 | 0.408 | 0.416 | 0.391 | 0.330 | 0.282 | 0.272 | 0.214 | 0.245 |
| 11 | 0.372 | 0.385 | 0.320 | 0.289 | 0.271 | 0.224 | 0.218 | 0.290 | 0.261 | 0.266 | 0.297 | 0.213 | 0.175 | 0.176 | 0.192 | 0.215 |
| 12 | | | | | | | | | 0.188 | 0.174 | | | | | | |

| POSTlow | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 2.692 | 2.809 | 2.624 | 1.553 | 0.691 | 1.317 | 1.637 | 2.372 | 4.300 | 4.840 | 3.380 | 2.000 | 1.234 | 0.756 | 0.515 | 0.074 |
| 2 | 0.077 | 1.858 | 0.606 | 0.745 | 0.718 | 0.923 | 0.483 | 0.063 | 0.089 | 4.560 | 3.370 | 0.900 | 0.113 | 0.580 | 0.644 | 0.141 |
| 3 | 3.320 | 2.920 | 2.541 | 2.257 | 0.161 | 1.045 | 0.926 | 0.661 | 0.318 | 3.400 | 2.730 | 2.107 | 0.057 | 0.060 | 0.532 | 0.362 |
| 4 | 3.100 | 2.660 | 2.260 | 2.159 | 1.928 | 1.260 | 2.292 | 0.962 | 2.646 | 2.880 | 2.524 | 1.959 | 1.412 | 1.007 | 0.431 | 0.284 |
| 5 | 2.764 | 2.064 | 2.005 | 1.770 | 1.540 | 1.521 | 1.687 | 1.824 | 1.676 | 1.829 | 1.383 | 1.030 | 0.681 | 0.587 | 0.292 | 0.179 |
| 6 | 2.447 | 1.738 | 1.660 | 1.534 | 1.492 | 1.360 | 1.326 | 1.317 | 1.104 | 0.929 | 1.004 | 0.763 | 0.509 | 0.497 | 0.250 | 0.117 |
| 7 | 2.036 | 1.485 | 1.466 | 1.334 | 1.055 | 1.107 | 1.007 | 1.003 | 0.814 | 0.512 | 0.679 | 0.535 | 0.306 | 0.228 | 0.175 | 0.074 |
| 8 | 1.654 | 1.247 | 1.036 | 1.032 | 0.901 | 0.983 | 0.844 | 0.763 | 0.660 | 0.479 | 0.449 | 0.274 | 0.195 | 0.179 | 0.095 | 0.047 |
| 9 | 1.218 | 1.277 | 0.928 | 0.851 | 0.772 | 0.801 | 0.599 | 0.622 | 0.397 | 0.342 | 0.274 | 0.188 | 0.091 | 0.082 | 0.066 | 0.055 |
| 10 | 1.278 | 1.124 | 0.928 | 0.787 | 0.816 | 0.601 | 0.544 | 0.464 | 0.338 | 0.240 | 0.187 | 0.126 | 0.076 | 0.054 | 0.048 | 0.050 |
| 11 | 1.132 | 0.794 | 0.689 | 0.657 | 0.654 | 0.471 | 0.361 | 0.352 | 0.266 | 0.185 | 0.163 | 0.102 | 0.057 | 0.049 | 0.047 | 0.051 |
| 12 | 0.589 | 0.462 | 0.588 | 0.494 | 0.511 | 0.442 | 0.341 | 0.260 | 0.213 | 0.230 | 0.131 | 0.071 | 0.048 | 0.044 | 0.045 | 0.042 |

| | | | | | | | | | | | | | | | | |
|----|-------|-------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| 13 | 0.527 | 0.317 | | | | | | | | | | | | | | |
|----|-------|-------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|

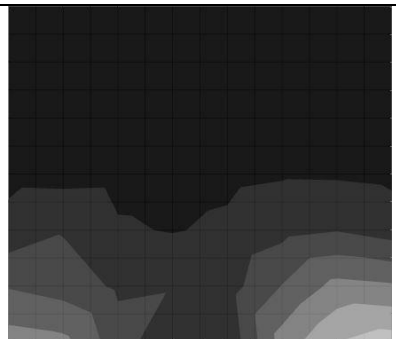
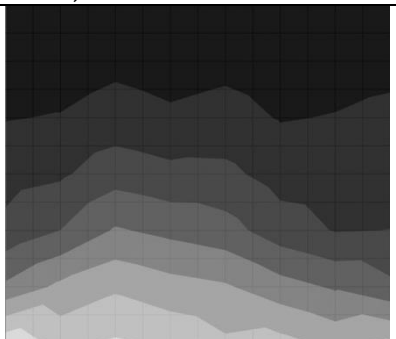
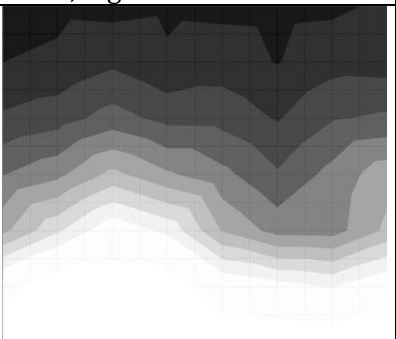
| POSThigh | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 3.830 | 3.060 | 5.180 | 4.250 | 2.881 | 2.178 | 2.333 | 3.920 | 4.890 | 7.370 | 8.390 | 6.160 | 2.507 | 1.878 | 1.326 | 0.159 |
| 2 | 3.350 | 0.108 | 2.829 | 0.699 | 1.118 | 1.256 | 0.309 | 1.257 | 0.117 | 0.091 | 7.590 | 5.260 | 0.076 | 0.040 | 0.258 | 0.311 |
| 3 | 5.720 | 5.190 | 4.980 | 4.190 | 4.080 | 3.270 | 1.710 | 1.599 | 1.110 | 0.879 | 5.720 | 4.560 | 2.750 | 0.115 | 0.062 | 0.599 |
| 4 | 5.150 | 5.070 | 4.560 | 3.600 | 3.630 | 3.140 | 3.310 | 4.010 | 1.281 | 4.500 | 3.790 | 3.110 | 2.602 | 1.209 | 1.276 | 0.387 |
| 5 | 4.840 | 4.540 | 4.010 | 3.330 | 2.640 | 2.700 | 2.630 | 2.920 | 2.980 | 2.860 | 2.590 | 2.065 | 1.627 | 0.796 | 0.881 | 0.307 |
| 6 | 4.180 | 3.870 | 2.980 | 2.720 | 2.394 | 2.463 | 2.293 | 2.379 | 2.212 | 2.001 | 1.554 | 1.458 | 1.140 | 0.581 | 0.691 | 0.191 |
| 7 | 3.210 | 3.230 | 2.890 | 2.289 | 1.963 | 2.103 | 2.057 | 2.008 | 1.590 | 1.459 | 1.421 | 0.943 | 0.724 | 0.287 | 0.455 | 0.117 |
| 8 | 2.967 | 2.781 | 2.408 | 1.831 | 1.607 | 1.686 | 1.649 | 1.874 | 1.355 | 1.047 | 0.775 | 0.599 | 0.505 | 0.197 | 0.271 | 0.066 |
| 9 | 2.271 | 2.148 | 1.971 | 1.559 | 1.348 | 1.398 | 1.341 | 1.460 | 1.259 | 0.552 | 0.484 | 0.359 | 0.323 | 0.086 | 0.142 | 0.074 |
| 10 | 1.925 | 2.189 | 1.965 | 1.608 | 1.325 | 1.201 | 1.172 | 1.026 | 0.687 | 0.421 | 0.378 | 0.248 | 0.102 | 0.054 | 0.053 | 0.061 |
| 11 | 1.579 | 1.973 | 1.752 | 1.397 | 1.201 | 1.673 | 0.982 | 0.549 | 0.575 | 0.420 | 0.295 | 0.251 | 0.064 | 0.059 | 0.048 | 0.057 |
| 12 | 1.499 | 1.564 | 1.420 | 0.892 | 0.693 | 0.886 | 0.770 | 0.621 | 0.442 | 0.307 | 0.349 | 0.208 | 0.070 | 0.050 | 0.042 | 0.044 |
| 13 | 1.234 | 0.880 | 1.044 | | | | | | | | | | | | | |

| | PRE retrofit | POST, low level | POST, high level |
|-----|--------------|-----------------|------------------|
| fc | | | |
| Max | 6.0 | 4.8 | 8.4 |
| Min | 0.06 | 0.04 | 0.04 |
| Avg | 1.4 | 1.0 | 1.9 |

| Ratio : 1 | Target | Calculated | Target | Calculated | Target | Calculated |
|-----------|--------|------------|--------|------------|--------|------------|
| Max-Min | 15 | 100.0 | 15 | 115.2 | 15 | 209.8 |
| Avg-Min | 4 | 24.0 | 4 | 23.9 | 4 | 46.5 |

8.4.10 ZONE HELI_2

Grid size, spacing: 5' cell/ ^7x8> grid
Date collected: Pre: 2013.05.24/25; Post: 2014.03.13,14,15
CLTC staff involved: B.Goesmann, T.Patten, P.Arani, H.Nguyen
Other details: Pole N6 close by with 7fc, behind tree 0.05fc

| Zone | PRE retrofit | POST, low level | POST, high level |
|--------|---|--|---|
| Heli_2 |  |  |  |

| PRE | A | B | C | D | E | F | G | H |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0.091 | 0.093 | 0.094 | 0.101 | 0.102 | 0.136 | 0.137 | 0.126 |
| 2 | 0.139 | 0.145 | 0.197 | 0.118 | 0.195 | 0.161 | 0.178 | 0.187 |
| 3 | 0.223 | 0.217 | 0.238 | 0.242 | 0.260 | 0.296 | 0.277 | 0.254 |
| 4 | 0.354 | 0.335 | 0.355 | 0.340 | 0.393 | 0.453 | 0.442 | 0.389 |
| 5 | 0.681 | 0.960 | 0.555 | 0.471 | 0.586 | 0.846 | 0.970 | 0.763 |
| 6 | 1.459 | 1.280 | 0.920 | 0.971 | 0.784 | 1.520 | 2.160 | 2.064 |
| 7 | 2.240 | 2.131 | 1.218 | 0.642 | 0.604 | 2.215 | 3.000 | 3.260 |

| POSTlow | A | B | C | D | E | F | G | H |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0.096 | 0.172 | 0.154 | 0.197 | 0.162 | 0.170 | 0.153 | 0.213 |
| 2 | 0.229 | 0.234 | 0.380 | 0.280 | 0.366 | 0.246 | 0.308 | 0.362 |
| 3 | 0.475 | 0.528 | 0.707 | 0.582 | 0.674 | 0.472 | 0.521 | 0.611 |
| 4 | 0.798 | 0.924 | 1.288 | 1.137 | 1.119 | 0.799 | 0.731 | 0.707 |
| 5 | 1.138 | 1.505 | 2.053 | 1.866 | 1.698 | 1.226 | 0.974 | 1.006 |
| 6 | 2.092 | 2.617 | 2.915 | 2.690 | 2.558 | 2.200 | 1.936 | 1.612 |
| 7 | 3.830 | 3.350 | 3.570 | 3.400 | 3.090 | 3.170 | 2.851 | 3.090 |

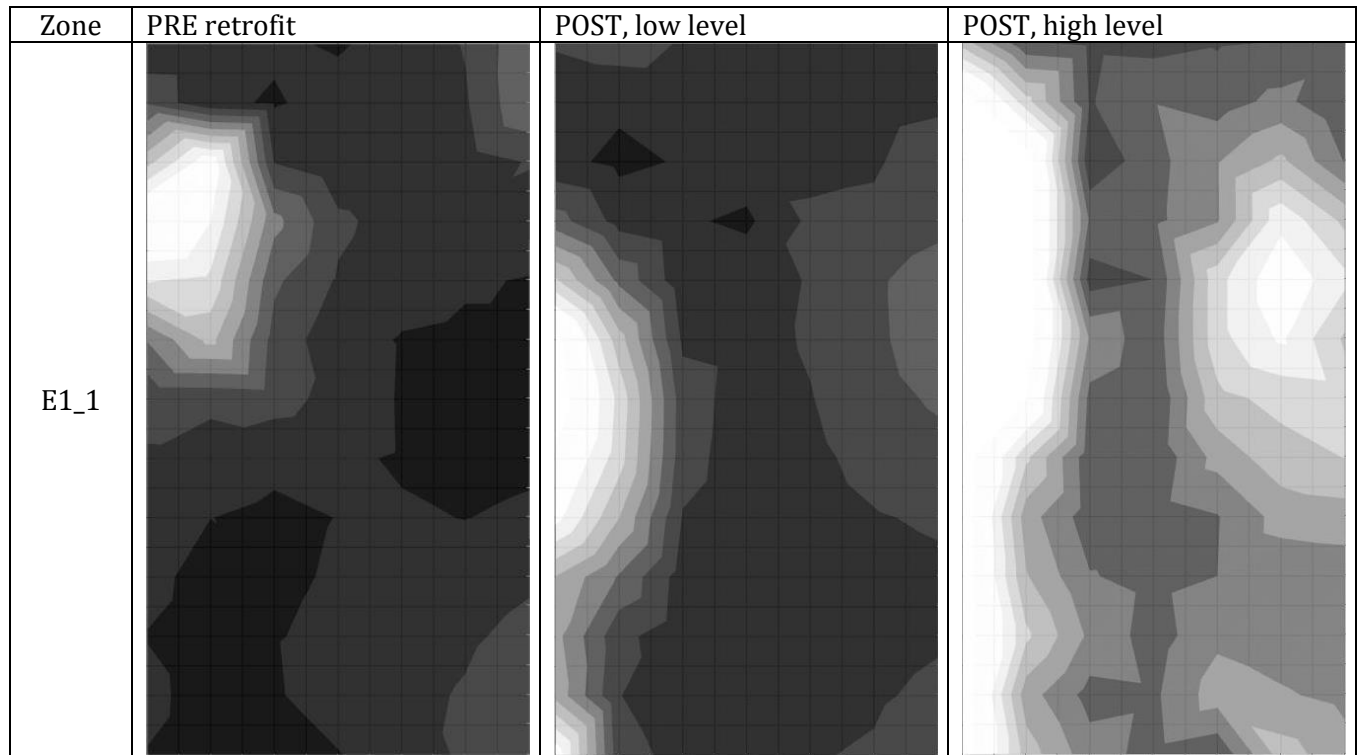
| POSThigh | A | B | C | D | E | F | G | H |
|----------|-------|--------|-------|-------|-------|-------|-------|--------|
| 1 | 0.242 | 0.373 | 0.331 | 0.410 | 0.379 | 0.356 | 0.396 | 0.590 |
| 2 | 0.497 | 0.595 | 0.894 | 0.571 | 0.745 | 0.476 | 0.807 | 0.765 |
| 3 | 1.074 | 1.274 | 1.706 | 1.337 | 1.322 | 0.954 | 1.458 | 1.583 |
| 4 | 1.977 | 2.358 | 3.140 | 2.576 | 2.140 | 1.557 | 2.168 | 2.816 |
| 5 | 2.860 | 3.910 | 4.910 | 4.380 | 2.960 | 2.309 | 2.277 | 3.110 |
| 6 | 5.260 | 6.660 | 6.890 | 6.300 | 5.010 | 4.730 | 4.480 | 5.050 |
| 7 | 9.730 | 11.890 | 7.250 | 8.110 | 7.570 | 8.720 | 7.730 | 10.080 |

| | PRE retrofit | POST, low level | POST, high level |
|-----|--------------|-----------------|------------------|
| fc | | | |
| Max | 3.3 | 3.8 | 11.9 |
| Min | 0.09 | 0.1 | 0.2 |
| Avg | 0.7 | 1.3 | 3.2 |

| Ratio : 1 | Target | Calculated | Target | Calculated | Target | Calculated |
|-----------|--------|------------|--------|------------|--------|------------|
| Max-Min | 15 | 35.8 | 15 | 39.9 | 15 | 49.1 |
| Avg-Min | 4 | 7.8 | 4 | 13.4 | 4 | 13.3 |

8.4.11 ZONE E1_1

Grid size, spacing: 5' cell / ^13x7> grid
 Date collected: Pre: 2013.05.24/25; Post: 2014.03.13,14,15
 CLTC staff involved: B.Goesmann, T.Patten, P.Arani, H.Nguyen
 Other details: N/A



| PRE | A | B | C | D | E | F | G |
|-----|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0.597 | 0.554 | 0.567 | 0.451 | 0.680 | 1.032 | 1.920 |
| 2 | 1.395 | 0.590 | 0.457 | 0.670 | 0.579 | 0.948 | 1.968 |
| 3 | 3.310 | 4.900 | 0.973 | 0.610 | 0.518 | 0.790 | 1.029 |
| 4 | 5.520 | 4.510 | 2.160 | 1.107 | 0.773 | 0.918 | 0.810 |
| 5 | 4.030 | 3.890 | 1.595 | 0.944 | 0.680 | 0.551 | 0.471 |
| 6 | 2.020 | 3.160 | 1.308 | 0.686 | 0.470 | 0.421 | 0.420 |
| 7 | 1.092 | 1.103 | 1.188 | 0.831 | 0.455 | 0.338 | 0.365 |
| 8 | 0.969 | 0.795 | 0.621 | 0.564 | 0.463 | 0.350 | 0.414 |
| 9 | 0.605 | 0.506 | 0.394 | 0.509 | 0.538 | 0.493 | 0.573 |
| 10 | 0.736 | 0.204 | 0.455 | 0.525 | 0.644 | 0.654 | 0.891 |
| 11 | 0.473 | 0.140 | 0.486 | 0.560 | 0.679 | 0.898 | 1.197 |
| 12 | 0.702 | 0.169 | 0.470 | 0.642 | 0.812 | 1.062 | 1.463 |
| 13 | 0.469 | 0.137 | 0.210 | 0.486 | 0.655 | 1.107 | 1.481 |

| POSTlow | A | B | C | D | E | F | G |
|---------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 1.077 | 1.260 | 0.956 | 0.740 | 0.630 | 0.685 | 0.628 |
| 2 | 0.538 | 0.584 | 0.642 | 0.664 | 0.678 | 0.731 | 0.869 |
| 3 | 0.639 | 0.389 | 0.540 | 0.790 | 0.840 | 0.919 | 1.391 |
| 4 | 1.717 | 0.818 | 0.571 | 0.404 | 1.103 | 1.153 | 1.356 |
| 5 | 3.580 | 1.873 | 0.663 | 0.836 | 1.025 | 1.430 | 1.743 |
| 6 | 5.770 | 3.220 | 0.912 | 0.817 | 1.053 | 1.414 | 1.756 |
| 7 | 6.230 | 3.850 | 1.222 | 0.778 | 0.976 | 1.330 | 1.566 |
| 8 | 5.330 | 3.730 | 1.197 | 0.718 | 0.884 | 1.160 | 1.338 |
| 9 | 4.700 | 3.010 | 0.965 | 0.674 | 0.780 | 0.965 | 1.064 |
| 10 | 2.983 | 1.943 | 0.748 | 0.636 | 0.714 | 0.818 | 0.897 |
| 11 | 2.673 | 1.146 | 0.672 | 0.640 | 0.729 | 0.805 | 0.936 |
| 12 | 2.860 | 1.013 | 0.729 | 0.710 | 0.846 | 0.936 | 1.113 |
| 13 | 4.920 | 1.167 | 0.859 | 0.762 | 0.965 | 1.052 | 1.324 |

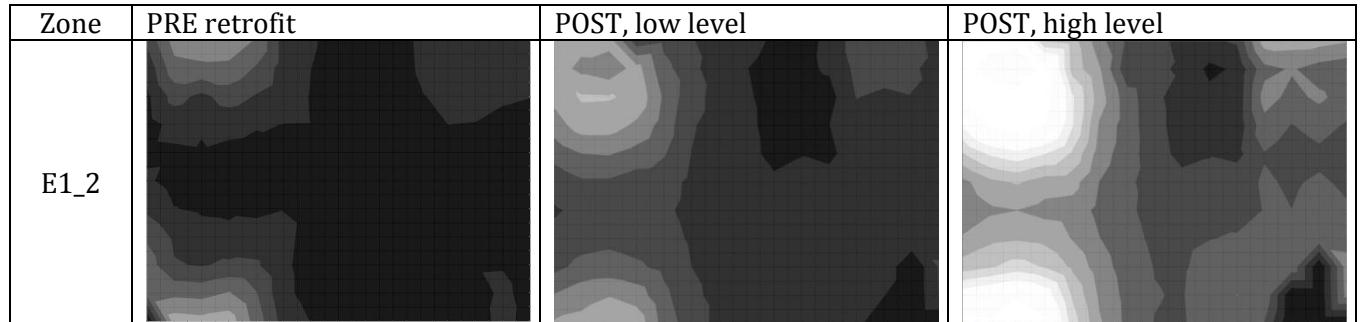
| POSThigh | A | B | C | D | E | F | G |
|----------|--------|-------|-------|-------|-------|-------|-------|
| 1 | 1.336 | 1.067 | 1.482 | 1.426 | 1.451 | 1.514 | 1.755 |
| 2 | 1.267 | 1.168 | 1.276 | 1.541 | 1.772 | 2.148 | 1.521 |
| 3 | 3.230 | 1.536 | 1.367 | 1.320 | 2.459 | 3.100 | 1.966 |
| 4 | 7.120 | 3.690 | 1.457 | 1.974 | 2.444 | 4.360 | 3.370 |
| 5 | 13.910 | 6.400 | 1.083 | 1.833 | 3.830 | 4.910 | 4.130 |
| 6 | 16.170 | 8.390 | 1.911 | 1.881 | 3.830 | 4.580 | 3.420 |
| 7 | 12.300 | 8.810 | 1.268 | 1.507 | 3.360 | 3.650 | 3.760 |
| 8 | 10.820 | 7.160 | 2.435 | 1.638 | 2.680 | 3.300 | 3.510 |
| 9 | 7.080 | 5.530 | 1.845 | 1.510 | 1.971 | 2.690 | 2.770 |
| 10 | 6.870 | 3.610 | 1.667 | 1.602 | 2.000 | 2.159 | 2.205 |
| 11 | 8.600 | 2.736 | 1.727 | 1.759 | 2.384 | 2.228 | 2.075 |
| 12 | 14.240 | 3.040 | 2.028 | 1.848 | 2.753 | 2.558 | 2.359 |
| 13 | 15.450 | 3.610 | 2.394 | 1.769 | 1.593 | 3.220 | 2.693 |

| | PRE retrofit | POST, low level | POST, high level |
|-----------|--------------|-----------------|------------------|
| fc | | | |
| Max | 5.5 | 6.2 | 16.2 |
| Min | 0.1 | 0.4 | 1.1 |
| Avg | 1.0 | 1.4 | 3.6 |

| Ratio : 1 | Target | Calculated | Target | Calculated | Target | Calculated |
|-----------|--------|------------|--------|------------|--------|------------|
| Max-Min | 15 | 40.3 | 15 | 16.0 | 15 | 15.2 |
| Avg-Min | 4 | 7.4 | 4 | 3.6 | 4 | 3.4 |

8.4.12 ZONE E1_2

Grid size, spacing: 6'x8' cell / ^11x15> grid
 Date collected: Pre: 2013.05.24/25; Post: 2014.03.13,14,15
 CLTC staff involved: B.Goesmann, T.Patten, P.Arani, H.Nguyen
 Other details: Pole N6 close by with 7 fc, behind tree 0.05 fc



| PRE | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 1.109 | 2.212 | 2.295 | 2.332 | 1.963 | 0.784 | 0.532 | 0.400 | 0.164 | 0.377 | 0.545 | 0.745 | 0.830 | 0.795 | 0.755 |
| 2 | 0.640 | 1.837 | 1.905 | 1.881 | 1.444 | 0.775 | 0.502 | 0.390 | 0.247 | 0.367 | 0.535 | 0.680 | 0.756 | 0.707 | 0.650 |
| 3 | 0.400 | 1.196 | 0.873 | 1.234 | 0.959 | 0.696 | 0.478 | 0.378 | 0.305 | 0.345 | 0.481 | 0.573 | 0.627 | 0.555 | 0.510 |
| 4 | 0.333 | 0.642 | 0.539 | 0.644 | 0.540 | 0.493 | 0.491 | 0.378 | 0.299 | 0.311 | 0.401 | 0.501 | 0.488 | 0.393 | 0.357 |
| 5 | 0.407 | 0.433 | 0.465 | 0.383 | 0.354 | 0.395 | 0.400 | 0.360 | 0.307 | 0.274 | 0.361 | 0.397 | 0.381 | 0.284 | 0.277 |
| 6 | 0.569 | 0.339 | 0.360 | 0.326 | 0.287 | 0.377 | 0.343 | 0.326 | 0.297 | 0.290 | 0.320 | 0.328 | 0.333 | 0.221 | 0.210 |
| 7 | 0.888 | 0.514 | 0.434 | 0.412 | 0.369 | 0.481 | 0.347 | 0.242 | 0.195 | 0.263 | 0.292 | 0.305 | 0.318 | 0.281 | 0.184 |
| 8 | 1.415 | 0.915 | 0.686 | 0.629 | 0.760 | 0.645 | 0.307 | 0.176 | 0.160 | 0.112 | 0.320 | 0.332 | 0.355 | 0.349 | 0.164 |
| 9 | 1.776 | 1.036 | 0.964 | 1.091 | 1.060 | 0.606 | 0.265 | 0.159 | 0.123 | 0.112 | 0.099 | 0.083 | 0.441 | 0.455 | 0.175 |
| 10 | 1.677 | 1.867 | 1.820 | 2.043 | 1.528 | 0.604 | 0.334 | 0.178 | 0.129 | 0.116 | 0.112 | 0.134 | 0.162 | 0.669 | 0.210 |
| 11 | | 2.760 | 2.686 | 2.780 | 1.774 | 0.783 | 0.484 | 0.175 | 0.117 | 0.115 | 0.125 | 0.153 | 0.070 | 0.806 | 0.150 |

| POSTlow | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 2.600 | 2.708 | 2.729 | 1.154 | 1.377 | 1.050 | 0.669 | 0.545 | 0.482 | 0.425 | 0.546 | 1.304 | 1.393 | 1.311 | 0.677 |
| 2 | 2.770 | 2.357 | 2.141 | 2.710 | 1.644 | 1.211 | 0.550 | 0.515 | 0.269 | 0.399 | 0.562 | 1.130 | 1.235 | 1.087 | 0.791 |
| 3 | 2.640 | 3.060 | 3.040 | 2.900 | 1.920 | 1.167 | 0.835 | 0.553 | 0.353 | 0.278 | 0.312 | 1.020 | 0.893 | 0.982 | 0.861 |
| 4 | 2.253 | 2.750 | 2.740 | 2.402 | 1.780 | 1.039 | 0.828 | 0.559 | 0.412 | 0.295 | 0.492 | 0.791 | 0.598 | 0.797 | 0.705 |
| 5 | 1.681 | 1.999 | 2.037 | 1.816 | 1.544 | 0.994 | 0.805 | 0.591 | 0.419 | 0.487 | 0.414 | 0.705 | 0.518 | 0.672 | 0.551 |
| 6 | 1.171 | 1.429 | 1.425 | 1.235 | 1.206 | 0.894 | 0.781 | 0.626 | 0.550 | 0.594 | 0.648 | 0.746 | 0.695 | 0.748 | 0.687 |
| 7 | 0.943 | 1.115 | 1.168 | 1.065 | 1.085 | 0.866 | 0.776 | 0.646 | 0.587 | 0.644 | 0.660 | 0.698 | 0.686 | 0.763 | 0.730 |
| 8 | 1.129 | 1.312 | 1.378 | 1.290 | 1.187 | 0.937 | 0.806 | 0.676 | 0.637 | 0.729 | 0.760 | 0.794 | 0.803 | 0.862 | 0.834 |
| 9 | 1.358 | 1.642 | 1.697 | 1.584 | 1.379 | 1.003 | 0.842 | 0.709 | 0.677 | 0.808 | 0.837 | 0.850 | 0.855 | 0.035 | 1.052 |
| 10 | 2.035 | 2.334 | 2.481 | 2.277 | 1.627 | 1.096 | 0.872 | 0.714 | 0.689 | 0.864 | 0.937 | 0.836 | 0.514 | 0.052 | 1.019 |
| 11 | 2.571 | 2.640 | 2.840 | 2.849 | 1.787 | 1.238 | 0.866 | 0.690 | 0.678 | 0.844 | 0.880 | 0.658 | | | |

| POSTHigh | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 5.490 | 5.770 | 5.770 | 3.450 | 3.230 | 2.182 | 1.384 | 1.143 | 0.875 | 0.897 | 1.077 | 2.758 | 2.720 | 2.696 | 2.554 |
| 2 | 6.130 | 5.140 | 4.740 | 5.850 | 3.310 | 2.540 | 1.141 | 1.064 | 0.951 | 0.378 | 0.583 | 1.849 | 2.047 | 1.780 | 1.651 |
| 3 | 5.810 | 6.510 | 6.650 | 6.510 | 4.080 | 2.731 | 1.716 | 1.160 | 0.683 | 0.656 | 0.635 | 2.203 | 1.861 | 2.093 | 1.787 |
| 4 | 4.540 | 5.610 | 5.970 | 5.500 | 4.060 | 2.431 | 1.747 | 1.165 | 0.782 | 0.632 | 0.666 | 1.833 | 1.477 | 1.701 | 1.441 |
| 5 | 3.460 | 4.080 | 4.350 | 4.020 | 3.430 | 2.247 | 1.718 | 1.219 | 0.845 | 0.961 | 0.843 | 1.476 | 1.190 | 1.392 | 1.134 |
| 6 | 2.341 | 2.870 | 3.050 | 2.743 | 2.699 | 1.989 | 1.604 | 1.270 | 1.165 | 1.193 | 1.348 | 1.543 | 1.454 | 1.559 | 1.427 |
| 7 | 2.070 | 2.408 | 2.496 | 2.334 | 2.277 | 1.866 | 1.580 | 1.348 | 1.251 | 1.342 | 1.328 | 1.515 | 1.503 | 1.629 | 1.551 |
| 8 | 2.566 | 2.870 | 2.939 | 2.854 | 2.475 | 2.012 | 1.662 | 1.408 | 1.362 | 1.486 | 1.544 | 1.639 | 1.726 | 1.832 | 1.769 |
| 9 | 3.220 | 3.440 | 3.710 | 3.460 | 2.911 | 2.226 | 1.764 | 1.484 | 1.431 | 1.710 | 1.751 | 1.786 | 1.852 | 0.069 | 2.247 |
| 10 | 4.850 | 5.100 | 5.420 | 4.910 | 3.440 | 2.408 | 1.840 | 1.522 | 1.463 | 1.834 | 2.005 | 1.894 | 0.057 | 0.097 | 2.179 |
| 11 | 5.650 | 5.590 | 6.030 | 5.690 | 3.770 | 2.560 | 1.864 | 1.489 | 1.435 | 1.814 | 1.902 | 1.484 | | | |

| | PRE retrofit | POST, low level | POST, high level |
|-----|--------------|-----------------|------------------|
| fc | | | |
| Max | 2.8 | 3.1 | 6.7 |
| Min | 0.07 | 0.03 | 0.06 |
| Avg | 0.6 | 1.1 | 2.4 |

| Ratio : 1 | Target | Calculated | Target | Calculated | Target | Calculated |
|-----------|--------|------------|--------|------------|--------|------------|
| Max-Min | 15 | 39.7 | 15 | 87.4 | 15 | 116.7 |
| Avg-Min | 4 | 8.9 | 4 | 32.6 | 4 | 42.7 |

8.4.13 TOTAL SITE ILLUMINANCE VALUES AND CONTRAST RATIOS

Total site overview of maximum, minimum and average Illuminance levels:

| VVNBH Illuminance map comparison | PRE- Retrofit | POST low | POST high | PRE- Retrofit | POST low | POST high | PRE- Retrofit | POST low | POST high |
|--|------------------|-------------|--------------|------------------|-------------|--------------|------------------|-----------|--------------|
| | Max | Max | Max | Min | Min | Min | Avg | Avg | Avg |
| | fc | fc | fc | fc | fc | fc | fc | fc | fc |
| IES recommended | 0.5 - 3.0 | 0.5 - 3.0 | 0.5 - 3.0 | 0.5 - 3.0 | 0.5 - 3.0 | 0.5 - 3.0 | 0.5 - 3.0 | 0.5 - 3.0 | 0.5 - 3.0 |
| N1_1 | 5.73 | 2.39 | 5.18 | 0.06 | 0.21 | 0.41 | 1.47 | 1.01 | 2.28 |
| N1_2 | 0.54 | 2.39 | 6.34 | 0.06 | 0.08 | 0.16 | 0.16 | 0.54 | 1.33 |
| ER1_1 | 7.07 | 4.65 | 7.01 | 0.04 | 0.11 | 0.16 | 1.19 | 1.26 | 1.95 |
| ER1_2 | 6.36 | 6.66 | 7.74 | 0.09 | 0.10 | 0.19 | 1.13 | 1.62 | 2.41 |
| S1_1 | 6.55 | 2.54 | 4.84 | 0.03 | 0.03 | 0.05 | 0.87 | 0.68 | 1.28 |
| S1_2 | 9.48 | 2.89 | 6.26 | 0.05 | 0.06 | 0.09 | 1.14 | 1.14 | 2.33 |
| S1_3 | 4.23 | 3.43 | 6.30 | 0.08 | 0.85 | 0.94 | 1.08 | 1.71 | 2.91 |
| Heli_1 | 6.00 | 4.84 | 8.39 | 0.06 | 0.04 | 0.04 | 1.44 | 1.00 | 1.86 |
| Heli_2 | 3.26 | 3.83 | 11.89 | 0.09 | 0.10 | 0.24 | 0.71 | 1.29 | 3.22 |
| E1_1 | 5.52 | 6.23 | 16.17 | 0.14 | 0.39 | 1.07 | 1.02 | 1.40 | 3.60 |
| E1_2 | 2.78 | 3.06 | 6.65 | 0.07 | 0.04 | 0.06 | 0.62 | 1.14 | 2.43 |
| Max (Site) | 9.48 | 6.66 | 16.17 | 0.14 | 0.85 | 1.07 | 1.47 | 1.71 | 3.60 |
| Min (Site) | 0.54 | 2.39 | 4.84 | 0.03 | 0.03 | 0.04 | 0.16 | 0.54 | 1.28 |
| Avg (Site) | 5.23 | 3.90 | 7.89 | 0.07 | 0.18 | 0.31 | 0.98 | 1.16 | 2.33 |

Total site overview of resulting Max-Min and Avg-Min contrast ratios:

| VVNBH Illuminance map comparison | PRE- Retrofit | POST low | POST high | PRE- Retrofit | POST low | POST high |
|--|------------------|--------------|--------------|------------------|--------------|--------------|
| | Max-Min | Max-Min | Max-Min | Avg-Min | Avg-Min | Avg-Min |
| | (ratio, x:1) | (ratio, x:1) | (ratio, x:1) | (ratio, x:1) | (ratio, x:1) | (ratio, x:1) |
| IES recommended | 15 | 15 | 15 | 4 | 4 | 4 |
| N1_1 | 95.5 | 11.5 | 12.7 | 24.5 | 4.9 | 5.6 |
| N1_2 | 8.9 | 31.5 | 40.1 | 2.5 | 7.1 | 8.4 |
| ER1_1 | 176.8 | 43.1 | 43.3 | 29.8 | 11.7 | 12.0 |
| ER1_2 | 67.7 | 66.6 | 41.0 | 12.0 | 16.2 | 12.8 |
| S1_1 | 198.5 | 82.0 | 91.3 | 26.4 | 22.0 | 24.1 |
| S1_2 | 206.1 | 49.1 | 66.6 | 24.7 | 19.3 | 24.8 |
| S1_3 | 52.9 | 4.0 | 6.7 | 13.5 | 2.0 | 3.1 |
| Heli_1 | 100.0 | 115.2 | 209.8 | 24.0 | 23.9 | 46.5 |
| Heli_2 | 35.8 | 39.9 | 49.1 | 7.8 | 13.4 | 13.3 |
| E1_1 | 40.3 | 16.0 | 15.2 | 7.4 | 3.6 | 3.4 |
| E1_2 | 39.7 | 87.4 | 116.7 | 39.7 | 32.6 | 42.7 |
| Min Contrast Ratio | 8.9 | 4.0 | 6.7 | 2.5 | 2.0 | 3.1 |
| Max Contrast Ratio | 206.1 | 115.2 | 209.8 | 39.7 | 32.6 | 46.5 |