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Tomorrow's Luminaires: San Diego's Vision for Turning Streetlights from Cost Centers to Efficient Smart Infrastructure

Outdoor lighting is a necessary investment for any municipality, academic institution, or large private company with a substantial physical footprint. The light that pedestrian and parking luminaires provide is essential for nighttime operations and safety, and accounts for significant cost in terms of physical infrastructure and energy use as well as maintenance and service. Worldwide, lighting is responsible for 19 percent of all electricity use, and for the average city, streetlights account for around one quarter of total electricity use and are often the largest single line item on the energy bill.[i]

But there is a revolution underway in the lighting world. Light-Emitting Diode (LED) technology is advancing by leaps and bounds, producing more energy efficient lamps with significantly longer lifespans and minimal maintenance requirements. The cost of LED lighting continues to decrease as the technology advances, reducing the amount of capital needed to make the switch. On top of this, new systems for light metering, dimming, wireless adaptive controls and advanced diagnostics are adding further energy efficiency, GHG reductions, and operational efficiency and functional value to the equation. The result is that payback times for these upgrades are becoming shorter and efficient lighting programs are taking off across the country as public and private organizations realize their potential to deliver better quality light, reduce emissions and create savings within tight budgets.

The City of San Diego is a national leader on climate change, as evidenced in its ambitious Climate Action Plan.[ii] The government is undertaking a wide range of efficiency and renewable energy work in order to meet state GHG reduction targets of 15 percent below business as usual (BAU) by 2020 and 49 percent below BAU by 2035, even as the City's population continues to grow. San Diego has developed its Smart City Infrastructure project to work toward climate change mitigation while also reaping the economic benefits of energy and operational efficiency, system control, and other possibilities for future wireless functionalities and services.

[i] http://thecleanrevolution.org/_assets/files/LED_report_web1.pdf
[ii] http://www.sandiego.gov/planning/genplan/cap/pdf/sd_working_cap_020714.pdf

Project Initiation and Strategic Partnerships

San Diego began working on efficient lighting in 2009 through the Street Light Working Group (SLWG), a group comprised of 18 cities of San Diego County, the Port of San Diego and San Diego Gas & Electric (a Sempra Energy utility). The SLWG formed through the Local Government Energy Efficiency Partnership Program at SDG&E, and is facilitated by nonprofit industry group CleanTech San Diego that acts as a neutral intermediary to foster clean technology collaborations between these public agencies and companies offering best-in-class energy efficiency solutions. The SLWG is led by Marty Turock, Greening San Diego Manager at CleanTech San Diego, who explained that one of the keys to the SLWG's success has been remaining technology-agnostic when choosing vendors in order to ensure that all viable options are considered. The group has developed a set of specifications which all qualified suppliers must meet, and is helping each city to find the technologies that best fit its specific needs.

Ted Reguly, Director of Customer Programs and Projects at SDG&E says that in 2009 the Local Government Partnerships program was mostly focused on bidding practices. However, when funding became available for energy efficiency work through the American Recovery and Reinvestment Act in the form of Energy Efficiency and Conservation Block Grants, the SLWG formed and turned its attention to San Diego's street luminaires. Over time the focus of the SLWG has turned from lighting technology selection to new frontiers of adaptive controls, sensors, wireless communications and data analytics, and the group has begun to leverage the expertise of business affiliates General Electric and Qualcomm — both major innovators in these markets. San Diego already had a strong business relationship with General Electric, which had been providing lighting products for the City for around 30 years, according to Mark Wilbur, Design Manager at GE Lighting. GE also had an existing relationship with SDG&E, which helped streamline work on the project through the SLWG. Qualcomm's role has been to share its vision of what is possible in terms of applying next-generation wireless functionality to the City's outdoor lighting infrastructure.

The Technology

While the majority of traditional street and highway lighting is high-pressure sodium (HPS), Light-Emitting Diode (LED) technology has recently undergone a rapid evolution, enabling efficiencies, functionalities, and price points which were impossible even a few years ago. When San Diego originally began this work in 2009 it chose induction lighting as a replacement for HPS because of color temperature considerations (to accommodate "dark sky" needs of astronomers at the Palomar Observatory) as well as pricing and warranty. This induction lighting was also at least 50 percent more efficient than the old HPS fixtures. However, LED technology and markets have matured considerably since the initial phases of the project, and the City has now switched from induction to LED installations because of higher efficiency, better control capability, and significant comparative price decreases in LED technology. So far San Diego has installed 3,000 LED pedestrian streetlights in the downtown area with adaptive controls.

The LED luminaires that San Diego has installed use about 60 percent less energy than the HPS fixtures they have replaced and overall the upgrades are projected to save San Diego $254,000 or more annually in energy costs with a payback period of less than 13 years.[iii, iv] Additionally, San Diego has installed GE's LightGrid™ adaptive controls system with these upgrades. LightGrid™ uses wireless connectivity, utility-grade metering, and built-in GPS in each fixture for automatic commissioning and enhanced maintenance.[v] City managers are also able to monitor the lighting grid remotely and quickly diagnose any problems as well as implement advanced dimming schedules to reduce energy use, emissions, and operational costs even further in the future. Wilbur explains that most of the technical challenges involved in the project were predicted and addressed early on. Simplifying the commissioning process, for example, was a top priority for GE, and this challenge was primarily met by including a GPS device in the hardware of each fixture.

Engaging Public Support

San Diego did extensive public outreach as it was piloting the project, and made sure to engage stakeholders including local businesses in the downtown areas where it was installing the new luminaires. The City and CleanTech San Diego invited the public to compare lighting quality from both old and new streetlights and solicited feedback.[vi] Project Manager Lorie Cosio-Azar at the City of San Diego says the project has been very well received downtown, with many residents asking when the new fixtures will be installed on their blocks. Color rendering is far better under the broad-spectrum light from LEDs, and Wilbur also commented on the comparative attractiveness of LED light vs. the light from HPS. During the public field surveys, participants rated the ability to distinguish color under the LED light as "far superior."

Lessons From The Cutting Edge

Cosio-Azar believes it is important that others who are considering lighting efficiency upgrades think longer-term with regard to the infrastructure. Specifically, she mentioned installing adaptive controls initially even if organizations are not currently thinking of dimming the lights. Professor Michael Siminovitch at the California Lighting Technology Center (CLTC) at UC Davis shares Cosio-Azar's views, pointing to the lost opportunity to realize further savings when municipalities install un-retrofittable LED lighting without adaptive controls. He estimates that an extra 40-50 percent in savings potential can be realized through the dynamic dimming and demand response functionalities that these modest additional investments enable.[vii] The city of San Diego has already found significant operational savings associated with LED lighting and adaptive control technologies, in some cases equal to the benefits in energy savings.

[iii] http://www.gelighting.com/LightingWeb/na/solutions/evolve-led-post-top-avery-streetdreams.jsp

[iv] http://www.gelighting.com/LightingWeb/na/images/33808-GE-LED-Roadway-Lighting-San-Diego-Sales-Slick_tcm201-67210.pdf

[v] http://pressroom.gelighting.com/news/san-diego-to-save-more-than-a-quarter-of-a-million-dollars-annually-with-ge-smart-lighting-technology#.U15rFcdoN-N

[vi] Alternative Routes, *LD+A*, Illuminating Engineering Society, September 2010 pp. 54-59.

[vii] http://cltc.ucdavis.edu/sites/default/files/files/publication/siminovitch-streetlighting.pdf

Cosio-Azar said that the concept of dimming often creates confusion for those considering LED lighting upgrades, and stressed that dimming does not mean that lighting is being reduced below safety standards. San Diego has been partnering with the CLTC on investigating and validating lighting policy and standards in the state with regard to evolving technologies. Broad-spectrum light from LEDs may well change the standards of lighting because of the far better color rendering that it allows when compared with HPS. For this reason pedestrians and motorists can actually see better under dimmer light levels from LED fixtures.

The City of San Diego is now working with SDG&E to move from a flat payment rate for its streetlights (based on the number of poles and energy ratings for the lamps) to an interim arrangement based on its lower wattage LED luminaires operating at a dimmed rate. While the details regarding reporting and scheduling are still being determined, in the future the metering and controls hardware in the new fixtures may allow for measurement and billing of actual energy use from each individual streetlight, and take into account dynamic dimming schedules during hours of low activity and demand response events.

A Bright Future

San Diego is currently applying for additional funding (through California Energy Commission Loans and Grants) in support of plans to expand the Smart City Infrastructure project by replacing a further 10,000 roadway and pedestrian lights as well as 10,000 parking lot light fixtures with adaptive controlled LED luminaires. As it plans for the future the City is also considering possible additions to its next generation infrastructure in order to transform street lighting from a cost center to a revenue generator. Cosio-Azar envisions possible business arrangements in which cellular carriers looking to expand local coverage (via small cells) might lease streetlight poles for this type of use, or others might connect to them as secure, broadband-enabled wireless hubs.

Strategic business affiliate Qualcomm is very interested in evolving lighting communications to add new capabilities to San Diego's smart streetlight infrastructure. Qualcomm Staff Manager of Business Development Jason Ellis views this infrastructure as prime real estate for growing machine-to-machine connectivity to expand the City's wireless services. He explained: "What I'd like to do is turn every light pole into the center of the smart city. It's not just a streetlight anymore." Ellis hopes to work with San Diego and other municipalities by using connected light poles to help various devices deliver services like traffic monitoring, responsive traffic light timing, wirelessly guiding cars directly to open parking spaces. These smart infrastructure functionalities could help cities like San Diego to ease traffic congestion, reduce auto fuel use and associated emissions, and boost local economies by freeing up more time for leisure. Environmental sensors (e.g. air quality, acoustic) could also be connected via these hubs to the cloud, enabling further improvements in city operations and resource management.

San Diego hopes that other municipalities in California will benefit from the work that the SLWG has done. The group has written "piggybacking" language into its contracts and is sharing project documentation, allowing other cities and agencies to take advantage of the same business agreements

and competitive bidding it has negotiated without going through an extensive evaluation process (which can often be prohibitively expensive and time-consuming, especially for smaller municipalities). Turock has championed this strategy for amplifying and propagating efficiency upgrades, and believes that others could save as much as two years by piggybacking off of the work that the SLWG has done in San Diego. Already the cities of Encinitas, La Mesa, Lemon Grove, Oceanside and Carlsbad have taken advantage of this opportunity, with hopefully more will follow. Demonstrated success in California could lead to adoption of piggybacking contract models in other states and accelerated implementation of smart city infrastructure improvements nationwide.

It is clear that LED lighting and advanced controls systems have come into their own as energy-efficient technologies, and cities like San Diego are already reaping the huge financial and climate benefits of this work. These upgrades represent significant and easily harvested low-hanging fruit, and have the potential to make public and private organizations alike leaner, more sustainable, and more economically sound.

About ACCO

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