LED WATCH

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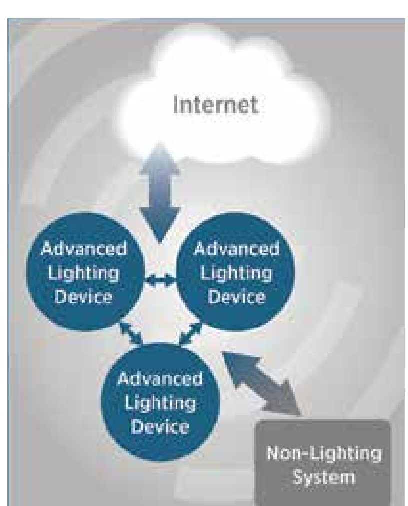
UNLOCKING THE FULL POTENTIAL OF INDOOR SYSTEMS

A source that is controllable for light output, CCT and chromaticity is the promise of SSL

It seems that everywhere you turn these days, there's another article about what the lighting of the future will look like. Invariably, these articles discuss how solid-state lighting (SSL) systems are already evolving and doing more than just lighting a space. The increasing sophistication of future lighting systems will likely change the paradigm for how we design, install, configure and maintain them, but there are many factors that could prevent them from achieving their full potential. Some of the knottiest of those challenges center on incorporating SSL and lighting control technologies into the existing lighting infrastructure.

Lighting control has long held the potential to deliver significant energy savings by adjusting the amount of light to the real-time needs of a particular space and its occupants. But while myriad products for controlling light have been commercially available for quite some time, their deployment and resulting energy savings have been limited. SSL products are poised to be the catalyst that unlocks that potential. SSL technology offers an unprecedented ability to design light sources that are controllable—not only for light output, but also for correlated color temperature and even chromaticity. While fluorescent sources have long been capable of delivering variable light output when paired with dimming ballasts, the limited performance and significant cost premium those ballasts entail have been significant barriers to adoption.

In contrast, SSL sources capable of delivering variable light output, down to relative levels of 1 percent or below, are already available at little or no cost premium, with many such products offering controllability as a standard feature. Further, the microelectronic nature of SSL sources enables the straightforward and (in volume) low-cost integration of other functionality—including intelligence, sensors and network interfaces—that can drastically improve the energy performance of lighting and other building systems, and that can even offer other non-energy benefits. Thus, the deployment of future SSL systems stands to both realize the potential of lighting control and improve our ability to manage energy consumption in buildings.



System integration at work.

MAJOR BARRIERS

Right now, much of that potential is still on the table. There are a number of reasons for that, in addition to the limited or cost-prohibitive controllability of conventional light sources:

- Installation, start-up and commissioning complexity, which have limited the ability of building owners and operators to leverage the full capability of installed systems or adapt them (by either re- or retro-commissioning) to changes in space configuration or occupant activity.
- Lack of interoperability between system components offered by different vendors, which has limited the ability of building owners and operators to modify the installed systems (e.g., by installing new or better sensors, or software with a better user interface) to accommodate changes in space configuration or occupant activity, or to merely expand them if the original vendor has changed technologies or protocols, or has exited the market.

- Limited ability to quantify and report performance—in particular, energy consumption, which has driven some owners and operators (and, in some cases, energy efficiency programs) to implement expensive and time-consuming Measurement & Verification (M&V) programs.

The paradigms that have limited the success of lighting control systems are likely to be changed by several developments that are bringing to bear new (or, in some cases, old but repurposed) technology and new players to the lighting world, resulting in an increased urgency to realize the full potential of future SSL systems. The advent of the Internet of Things (IoT), which aims to connect all manner of electronic devices to communication networks, is expected to facilitate an unprecedented exchange of data between lighting and other building systems, the Internet and other devices (e.g., mobile phones). This growing availability of new and different types of data will facilitate the development of higher-performing algorithms, which in turn will enable better device and system performance as well as data-driven energy management of lighting and other building systems.

BUILDINGS TO CITIES

As the lighting infrastructure is eventually replaced with SSL technology, driven by energy and maintenance savings, lighting could even become the platform for the IoT—not only in buildings, but in cities as well. Lighting is a pervasive powered infrastructure, and intelligent, networked SSL devices offer attractive integration points for the sensors and data collectors that will power the IoT. Although SSL

THE BIG THREE

How a lighting system performs depends on how the devices that comprise it interact with one another, which in turn depends on their compatibility, interoperability and interchangeability. These three characteristics are not the same. *Compatibility* is the ability of two or more devices, applications, networks or systems to operate in the same physical environment without interfering with one another; *interoperability* is their ability to reliably and securely exchange and use data that has a shared meaning; and *interchangeability* is their ability to replace each other and provide a defined level of similar performance without additional configuration.

When a new technology is first introduced into the built environment, compatibility is often a concern, and significant design revisions are frequently required to ensure that the new devices don't interfere with the old ones and vice versa. For retrofit lighting products, and lamps in particular, consumers typically assume that there's full interchangeability between various light-source technologies offered in the same form factor. Replacement products are expected to not only match the lighting performance of the incumbents, but also to be compatible with legacy control devices, such as phase-cut dimmers. However, enabling compatibility with the full range of legacy dimmer designs requires a more complex and costly LED driver, and often compromises source efficacy to boot. Successful retrofit products balance the benefits offered by familiar function and form factor with any necessary design and performance trade-offs. Frequently, however, these trade-offs limit the achievable performance to something that falls significantly short of the technology's potential.

THE 'I' HAS IT

While ensuring compatibility and interchangeability typically requires some sort of compromise that often limits potential, interoperability is about unlocking that potential. The exchange of data between devices and systems can enable significantly improved performance. Specifically, application-level interoperability is needed to ensure that devices and systems cannot only hear each other talk, but can also understand what's being said. Many existing lighting protocols focus on lower-level interoperability—which is akin to ensuring that multiple parties can dial in to a teleconference without first making sure that they all speak a common language. If they don't, information cannot be exchanged without a translator.

Efforts to bring more interoperability to lighting systems are already underway within the Zigbee Alliance, the TALQ Consortium, the Connected Lighting Alliance and others, and the U.S. Department of Energy is focused on helping these groups unlock the full potential of future systems.

is still developing and so far represents only a tiny portion of the installed base, there's now near-universal acknowledgement that it will eventually become the dominant technology for most lighting applications. As a result, lighting product developers are already starting to consider how they'll continue to innovate and leverage this opportunity.

However, the pace of technology development, coupled with the growing list of stakeholders who have vested interests in how IoT technologies are adopted, makes it difficult to predict whether those technologies will live up to their potential. The coupling of big data and advanced analytics has already resulted in the improved performance of many systems, and the IoT promises to bring those same improvements to building systems that have long operated in isolation. The potential offered by the IoT has become a hot topic. Just as SSL technology brought many new players (e.g., semiconductor manufacturers and microelectronic system developers) to the lighting industry, the coming intersection of lighting, communication networks, big data and advanced analytics—all facilitated by the IoT—will significantly alter the lighting industry landscape.

The potential for a device or system to improve its performance is directly tied to its ability to access data from other devices and systems—and, ideally, to exchange data with them. Specifically, application-level interoperability is required to ensure that devices and systems can not only hear each other talk, but can also understand what's being said (see sidebar). For the IoT to deliver improved energy performance, energy will have to be a viable topic of conversation between devices and systems.

The U.S. Department of Energy is working with industry partners to help identify and evaluate ways to leverage the broad availability of energy data, and to identify cost-effective techniques for measuring the energy consumption of installed lighting systems. Efforts focused on maximizing application-level interoperability and the exchange of energy data promise to increase the likelihood that IoT systems built on lighting platforms will deliver on the inherent potential to optimize energy consumption—on both a building and a citywide level. And importantly, the value of additional services delivered to owners and operators of networked lighting devices will offset, and maybe even exceed, the cost of connectivity, potentially eliminating the historical cost barrier to the implementation of adaptive lighting and the associated realization of significant energy savings.

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