The Next Generation of Lighting,
When Everything Changes

LEDs 1.0 →2.0

It doesn't take a long memory to recognize that the initial promise of LEDs was simply to deliver better efficiency in lighting. With many homes and more than a few businesses still employing traditional incandescent or halogen lighting, which only convert about 5-10% of the energy they consume into light, the initial efficiency bar wasn't all that hard to reach. At the same time, halogen lighting was also considered to be the gold standard in terms of quality of light, in the sense that the glowing filament is close to the color of fire, historically the primary light source other than the sun until the 19th century. Because earlier LEDs were not bright enough to serve in the A-lamp or PAR form-factor, the LED industry set its initial sights on commercial outdoor lighting applications, such as street lighting where efficiency and maintenance were the main drivers for success; and thus progressed "LEDs 1.0".

The by-product of this initial market focus was that LED lighting found itself competing with high pressure sodium lamps that were typically not delivering a very high quality of light. With those targets clearly in sight, LED developers wasted no time in continuously improving the efficiency of their devices, while merely meeting the minimal standard of mediocre quality of light. Efficiency skyrocketed while the overall quality of the light, at best, plodded along. We were achieving more efficient light, but not necessarily better light, and certainly not more natural light.

As warm white LEDs continued their technical progress, they eventually reached output levels that opened the door to more compact form factors required for interior lighting, including track-heads and other luminaires that were never aesthetically amenable to fluorescents or CFLs, and which continued to be served by halogen or metal halides, which suffered from poor efficiency, short lifetimes, or both. LEDs found themselves facing, really for the first time, the challenge of delivering both higher efficiency and higher quality light. The LED industry quickly added quality of light to its list of must-do's on the path towards "LEDs 2.0".

In recent years, manufacturers have delivered on a whole new promise, with a generation of LEDs which offer efficacy higher than any of the incumbent technologies, as well as quality of light that meets or exceeds those incumbents in virtually all lighting scenarios. Xicato's Corrected Cold Phosphor Technology® delivered a pioneering solution to this challenge to provide more natural, higher efficiency, light. While the improved quality of light solutions come with a higher acquisition cost than the incumbents, the benefits of vastly improved efficiency, lower maintenance and increasing flexibility and control has made a compelling case wherever quality of light mattered. The addition of efficiency mandates and incentives, including increasingly broad incandescent bulb restrictions, as well as the natural price decreases that most advancing technologies enjoy, has allowed a rapidly increasing adoption rate for luminaires and lamps enabled by LEDs 2.0.

Connected Lighting

While LEDs 2.0 has enabled quality-oriented luminaire manufacturers to deliver more natural and controllable light, this is really just the first step in bringing us to a whole new paradigm in lighting; what we'll call Lighting 2.0.

Lighting 2.0 is, quite simply, lighting that communicates and interacts with the environment around it, and the users that it serves. If history provides us with an accurate model, this revolution will happen in what seems like a blink of the eye compared to the pace of the technologies that led to it. A current model for this revolution can be observed in our mobile communications. For many decades, telephones were analog, wired devices that served a single, utilitarian function. At some point, the technology moved from analog to digital, and then to wireless with the same utilitarian paradigm. The real revolution came about when digital wireless telephony combined with high-speed wireless data access and "suddenly" our wireless phone had become our gateway to connect to, and interact with, apps and the growing connectivity of everything. Everything changed, and we began to tap into the Internet of Things.

Lighting 2.0 will make this same move from its traditional role as a utility to a fully connected application. We have already seen commercial examples of connected lighting, in which users apply smartphone apps to connect to their home lighting systems locally, as well as remotely, controlling such things as color or brightness, as well as creating fun visual effects or triggering if/then events, including lights on or off as the user and their phone arrives or departs the neighborhood. While plenty of these lighting apps may be purely for amusement, the core capability highlights the key concepts of controllability and user interactivity.

Lighting connected to the user experience

Light is one of the few elements of the human experience that can be considered "fundamental". Light or the absence of it, defines our ability to accomplish a given task, or navigate ourselves through this world of ours. It also has a profound effect on our mood or impressions. No one has to be asked twice about the effect of a failing fluorescent light in the vicinity of their workspace, with the flickering creating distraction, and eventually, irritation. Similarly, the intimate mood of a warmly lit restaurant, or the effect of stunning sunset, is an undeniable, and common, human experience.

Lighting 2.0 is lighting that is involved with the users of a space at an emotional level. In a sense, data connectivity will enable emotional connectivity to a space by employing a wide variety of sensing technologies that determine how the lighting should respond. This becomes especially important in hospitality and retail spaces, where people's moods and impressions can directly influence the bottom line. Hospitality and gaming operators have long known that warmer tones of light tend to make people look healthier and feel better about themselves; and how people feel influences the entire mood of the space. Bright light may logically seem more festive, but it won't necessarily make people feel more festive, and happier people stay longer and spend more money.

Retail environments present one of the most profound opportunities for Lighting 2.0, as it combines the dynamics of mood with the presentation and branding of products. While 80% of music is now being purchased online, only 14% of clothing and just 11% of health and beauty products are purchased over the internet. For those products, a first-hand shopping experience is key to the user's buying decisions. "How will this makeup look in the office, or at the nightclub?" a customer may ask. "Let's change the light and see…" is a much better answer than, "I'm sure it will look fine."

The days of one-size-fits-all lighting have come to an end, and both retail operators and merchandizers are going to be demanding solutions that will allow them to configure, and reconfigure, the lighting to create livelier, engaging and even theatrical presentations of the products on display. Lighting 2.0 will not only meet that need, but will also respond to the space and provide a smooth transition between different types of lighting producing a complimentary, rather than contrasting, effect between nearby displays.

The user experience is also about product impression, with color or tone being just part of the impression criteria. If the message is "soft and supple" or "luxurious feel" the item will need to look the part before the buyer moves to stop and actually feel it. Lighting 2.0 will allow merchandizers to extend their brand image by incorporating carefully engineered color solutions that are dreamed up at the factory, tested in focus groups and which will need to be deployed on the sales floor. Manufacturers will be insisting upon "their" color of white light that testing has confirmed to be of the highest appeal. And none of us should be surprised when that evolves to "testing in situ" in which lighting can be varied in real-time with the response being measured not just in sales numbers, but in dwell time and eventually even detected facial response data that is acquired by the lighting's sensor systems.

All this is why Xicato has invested in research and color scientists to understand how people react to lighting, what they prefer and what draws their attention and then uses that knowledge in conjunction with new technologies to produce better and more efficient light. We visit with retailers, hoteliers, lighting designers and architects to understand environments, needs and objectives. By designing and tuning the light, we enable people to see far more than they had expected and give them a visual experience that they hadn't imagined but definitely prefer, and this is only the beginning. Lighting 2.0 will take every bit of this to new and exciting levels.

Lighting gets smarter

In the process of creating more user-centric illumination, Lighting 2.0 will necessarily bring more and more sensing and intelligence to the luminaires. The by-product of this will be ever increasing control and management capability at both the lighting system level, and at the level of the individual luminaires.

One easy to visualize example of the advantage could come from a demand-response system, in which the utility directs a needed real-time reduction in energy usage at the campus level. Rather than the campus-level energy management system simply making pre-programmed wholesale cutbacks at the building level, it could pass the reduction goal to the individual building management systems which

then passes the request along to the autonomous subsystems. Luminaire groups will act in concert, based upon the data and response input of individual luminaires which can account for available daylighting, occupancy and current activity determinations, to offer the least intrusive cutbacks available.

Another effect will be manifested in the detailed process of planning, specifying, installing and commissioning lighting, which has remained a painstaking mix of science and art. It can be expected that lighting system autonomy will extend seamlessly into those realms, with expert systems carrying out large amounts of the initial lighting system planning. Management of lighting systems will move to the cloud as new installations will literally be able to "read" the configuration of the space, assessing the reflectivity of materials, location of furnishings and walls, and the availability of outside light, to arrive at optimal illumination levels that can be intuitively adjusted by the users of the space. Where lighting now goes on/off, and maybe dim, in banks, Lighting 2.0 will allow an individual user to control their individual space with the ease of a waved hand. Real-time operational data streaming from the lighting systems will also enable self-validating systems that support evolving rebate and incentive programs tied into demand-response scenarios. All of these advances will be a direct result of the move to Lighting 2.0.

<u>Lighting as a service to be depended upon</u>

As lighting moves from a being looked upon as a utility to being viewed as a critical service that is responsible for the human functionality of the spaces it serves, reliability will be key. That reliability will extend far beyond whether a lamp is "burned out" to becoming much more about the dependability of the system to deliver the right kind of light in a seamless fashion. That dependability will come from experience. While the theory of Lighting 2.0 is straightforward, the implementation will need to operate in the real world, where things will sometimes go wrong. Experience will both dictate how to avoid the pitfalls, as well as how to handle the challenges when a problem does arise.

Xicato has become a recognized leader in enabling high quality, dependable light and is now leveraging that experience to create a whole new generation of technology solutions that enable Lighting 2.0. The future of lighting will be incredibly dynamic as it becomes the focal point for user-oriented environmental design and Xicato will be there, reimagining how people enhance, enable and engage with light.