

## Choosing Natural Light

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Wherever users of a space have had a choice in the type of lighting or where the professionals have deemed that better lighting would have a beneficial effect on the bottom line, there continues to be an almost universal preference for more *natural lighting*. With the introduction of Xicato's Artist Series of LED modules, luminaire manufacturers and lighting designers gained access to light sources that were both efficient and natural. It's important to understand both the need and fundamentals of natural light, as well as how Xicato has enabled the lighting industry to deliver on this previously unrealized promise of LED lighting.

### Recognizing the Need

Vision is an incredibly powerful sense, both in terms of how precise and how sensitive our eyes are to differences in light. While our eyes can recognize very subtle differences in lighting, we accept significant deficiencies in light without much thought. Our conscious attention to light is often the result of a specific activity, such as trying to distinguish between a black and a blue sock, or because the lighting has moved to some extreme, usually negatively. When lighting is really good, we often have no conscious awareness of it at all, yet it has the potential to affect our mood and our purchasing behavior.

With vision being both powerful and fundamental, it seems counter-intuitive that there has been relatively little progress toward making good light our standard expectation. One can only imagine the workplace outcry if an office is plagued by an HVAC system that sounds like a jackhammer, or the cafeteria dumpster being housed beside the conference room. Yet, since the first widespread energy-efficient lighting was introduced to replace incandescent and halogen lighting, the users of many commercial spaces have quietly settled for barely acceptable lighting. This has taken a continuous and subtle toll on our perception, and perhaps our moods, for decades.

### Natural Light

When we talk in terms of "natural light," what we're really doing is framing our perceptions relative to a reference point. With the advent of electric lighting, the incandescent bulb's illumination rapidly came to be the light people were comfortable and felt good with. In 1931, the lighting industry standardized on certain definitions concerning natural light and for color rendering based on the glow of a blackbody radiator, which happens to be nearly identical to the glow from an



*Dining under Artist Series Light*

incandescent bulb. This became our reference for natural light and remains the comparison point for all lighting technologies that have followed.

A great test of natural lighting can be simply to observe skin tones under different light sources. Under incandescent or halogen light, we tend to agree that skin tones look like they are supposed to. Contrast that to skin tones under a compact fluorescent lamp (CFL), or many ceramic metal halide (CMH) lamps, and the differences are apparent. Incandescent illumination has been generally recognized as the gold-standard for “natural” electric lighting, due to both its full spectrum and its color “temperature,” which strikes a general mid-point between a very warm candle flame (or sunset/sunrise) and the bright white of daylight.

The unfortunate drawback to general incandescent and halogen lighting is that they are severely limited when it comes to energy efficiency and longevity. While fluorescent and CMH lighting have proven to be more efficient and longer-lived in both area and spot applications than their incandescent counterparts, they have also become the standard-bearers of mediocre light quality. We’ve become used to lower-quality light, but the tradeoff between efficiency and quality is no longer necessary.

## **Aesthetics and Efficiency: The Goal of Natural Lighting**

Quality, natural lighting matters in almost any space we can think of. An obvious example would be a museum or art gallery, where the visual experience is almost always the most important factor. Restaurants are generally expected to have a comfortable and natural feel, with dimmable lighting to best suit the time of day. Retail products need to be displayed in a light that brings out the natural textures and bright colors. (Just ask shoppers about clothing or makeup that didn’t look right when they brought it home, and you’ll understand the importance of natural light.) A walk through any of those venues will reveal that even with the advent of improved-quality CFLs, much of the space is still illuminated by incandescent sources. Natural lighting remains a higher priority than energy efficiency.

At the start of this century, light-emitting diode (LED) technology was clearly poised to meet the challenge of providing energy-efficient natural lighting. The very nature of LEDs allows the process of light generation to be more finely tuned than any technology that has come before. Carefully selecting the properties of both the LED and the phosphor that the emitter activates enables LEDs to more efficiently generate light, as well as to craft the actual spectrum they produce. Unfortunately, existing technologies and expectations have set the “quality-of-light”



*Sheraton Grand Hotel and Spa lit with Xicato's Artist Series  
by Projection Lighting. ©McAteer*

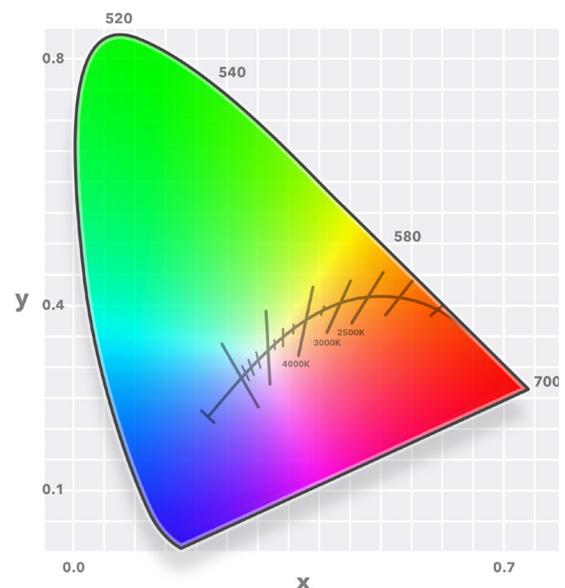
bar so low that the focus for most in the LED industry has been limited to maximizing efficacy while sacrificing light quality. It's effectively been a race to the bottom, making cost and efficiency the only priority. Even important industry standards have often *kept* the quality-of-light bar low, focusing on efficiency and making allowances for incumbent technologies such as CFLs, rather than insisting we take advantage of LED technology's unique ability to deliver both more efficient *and* more natural light.

Fortunately, some have taken the longer view – rather than pursue the relatively simple replacement of existing light sources, they have chosen to innovate and improve upon existing solutions, enabling natural, broader-spectrum lighting to become an easily achievable reality. As demonstrated by Xicato's Artist Series, a properly designed LED source can produce a natural lighting result with efficiencies that are many times those of halogen sources. The Artist Series is proof that an LED source designed with the singular objective of producing natural lighting realizes the promise of LED lighting: that high-efficiency lighting can be every bit as good as the halogen lighting it replaces. The Artist Series proves that energy savings, decreased maintenance costs, and natural light can all be combined and delivered in a cost-effective manner. Taken as a whole, Xicato's Artist Series can fairly be described as "better" lighting than the halogen it replaces.

## Characterizing Lighting

To understand how (and which) LED lighting can deliver on the promise of better natural lighting, it's important to understand how we characterize light sources. One important metric is the correlated color temperature (CCT) scale, which represents a chromaticity curve based upon the temperature of a blackbody radiator. While a lot of physics can go into describing precisely what that means, the result is relatively easy to observe in the flame on a gas stove. When something that responds like a blackbody radiation source is heated up, it changes the color it emits from red/orange at lower temperatures to more white/blue at higher temperatures. The CCT of the perfect blackbody radiator, if described in the absolute temperature scale, will be a specific number of degrees Kelvin (K). A candle flame or sunset falls around 1850K, while normal sunlight ranges around 5500-6500K. Not surprisingly, the color of white light from a halogen

**CIE 1931 x y Chromaticity Diagram**



*The blackbody curve transitions from high CCT on the left in the blue region to lower CCTs on the right in the red region.*

source is typically 2800-3400K, falling pretty much in the middle between the “mood” of firelight or a sunset, and the “bright” light of a midday sun.

In addition to CCT, which is generally seen as the key lighting criterion associated with the atmosphere or mood of a space, another important characterization is the color rendering index, or CRI. CRI essentially compares a series of colored swatches under one light source to how they would appear under a blackbody source. For standard CRI measurements, eight relatively unsaturated color references, designated R<sub>1</sub> through R<sub>8</sub>, are assigned a value up to 100 based upon how accurately they are depicted by the source. If the colors appear as they would in the reference light, then the averaged result, R<sub>a</sub>, would be 100. Halogen and other incandescent sources, being derived from those glowing metal filaments as they are, often earn a perfect score of 100 or very near to that. Typical R<sub>a</sub> performance from common fluorescents varies from 60-80, while tri-phosphor cool-white fluorescents come in at a fairly good R<sub>a</sub> 89, with metal halide tending to land in the 80s.

As an additional consideration in comparing light sources, our world also includes saturated colors, and while CRI is useful as a basic comparison between two light sources, it really only describes the color rendering of the specific colors used in the standardized test. While incumbent sources, such as fluorescents that are reaching a CRI of 89, represent a solid performance, the challenge comes in that very limited set of comparison points. In much the same way that “teaching to the test” can yield a high score without actual understanding of a subject, adding phosphors that peak on the specific R<sub>1</sub> through R<sub>8</sub> colors may yield a high R<sub>a</sub>, but it won’t necessarily produce a broad spectrum or a natural light. While the standard CRI averages only R<sub>1</sub> through R<sub>8</sub>, the CRI palette actually comprises a total of 15 reference colors; including, among others, strong yellow, strong green, strong red and strong blue. The latter two, carrying the designations of R<sub>9</sub> red and R<sub>12</sub> blue, are often considered especially important to perceiving the naturalness of light in many of our day-to-day environments. If you perform your own skin tone test under two sources – both with high CRI, but only one with a high R<sub>9</sub> – you will notice the difference.

	R <sub>a</sub>	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	R <sub>4</sub>	R <sub>5</sub>	R <sub>6</sub>	R <sub>7</sub>	R <sub>8</sub>	R <sub>9</sub>	R <sub>10</sub>	R <sub>11</sub>	R <sub>12</sub>	R <sub>13</sub>	R <sub>14</sub>	R <sub>15</sub>
<b>Xicato Artist Series</b>	98	98	99	98	98	98	97	98	98	96	99	98	88	98	98	98
<b>Typical CMH</b>	82	90	94	69	82	81	81	87	71	27	59	62	55	93	78	88
<b>Typical CFL</b>	87	91	93	86	91	89	90	88	70	17	76	91	81	93	92	81
<b>IR Halogen Dichroic</b>	98	98	99	99	99	98	98	99	97	92	97	98	97	98	99	97
<b>Black Body Radiator</b>	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

*R<sub>a</sub> in the first column is the average of the first eight samples R<sub>1</sub> – R<sub>8</sub>. It’s clear that considering all fifteen samples which include saturated colors and skin-tone representations would yield lower results for CMH and CFL.*

In selecting LED lighting that will appear natural, it's important to dig deeper than just selecting the CCT or CRI in a spec sheet. For example, Xicato provides the color comparisons to all 15 CRI R-values, which includes those saturated colors found all around us in our environment. As you can see, virtually all of the values fall in the high 90s, which stands in marked contrast to the results seen from CMH or CFL sources.

## Choosing Your Lighting

All lighting comes with choices and tradeoffs. While we may be alert and productive in a midday, sunlit environment, sunlight isn't a constant. If you want sunlight in your facility, you'll also get rosy-red sunrises and sunsets, as well as an average of 12 hours of darkness, all at no extra charge. And while a low CCT source may be the perfect setting for a romantic dinner for two, it might not be the best choice for the more productive and fast-paced kitchen environment. So how does one know when LED-based natural lighting, such as that offered by Xicato's Artist Series, is the best choice?



*Artist Series vs. Halogen in one of Xicato's many side-by-side challenges*

One simple test is to look at the lighting that is currently installed in a space. If halogen or another incandescent source is still in use for your application, it's pretty clear that natural-looking quality of lighting is a high priority. This is especially true in spaces that have taken a layered approach to lighting. A common example is a retail environment where the broad ambient lighting is typically served by fluorescent sources, while spot lighting, typically a dimmable halogen, is used to highlight product displays or specialized areas (think cosmetics). Similar layered applications can be seen in the produce and deli sections of grocery stores, where the product must appear natural to be valued as fresh or appetizing.

If high-efficiency unnatural lighting, such a CFL or CMH, has already been deployed in a space, it's apparent that efficiency or maintenance was the primary concern. In that case, it's important to ask whether the value of the space will be enhanced by more natural lighting. The local warehouse or parking garage probably doesn't benefit much from a move to natural lighting, as the primary lighting function is almost strictly limited to maximizing the lumen output, casting as much functional light as needed from the fewest number of fixtures. On the other hand, the value proposition of virtually every hospitality space, from hotel lobbies to

restaurants, depends upon people feeling comfortable. Natural lighting is comfortable lighting, and natural lighting that can offer energy and maintenance efficiency is a “natural” fit.

## **Delivering Natural Lighting**

Recognizing that many lighting applications can benefit from more natural light, Xicato has engineered its Artist Series to deliver lighting that is as good as halogen, with the added benefits of the energy efficiency and long lifetimes that really are the promise of LED lighting. By employing patented Corrected Cold Phosphor Technology®, which separates the heat-generating components and carefully matches the wide-spectrum remote phosphor to the exact wavelength of the LED emitter, Xicato is able to assure you not only tightly controlled CCT and CRI, but also stable color output over the full lifetime of the module.

Decades ago, the initial requirements of more energy efficient lighting included little concern for how natural that light might appear, so it makes sense that we might have to change a few paradigms when evaluating our higher-efficiency lighting for the future. While there were well-intentioned efforts to establish a CRI that could adequately describe the ability of a lamp or luminaire to reproduce colors accurately, the fact that the scale had a finite series of steps allowed lamps to be tuned to the test. Rather than presenting a broad, natural spectrum, they concentrated their output on the test points, producing an unnatural lighting result. While CCT and CRI can be of descriptive help for some objective data points in evaluating a light source, the more subjective portions are often left undescribed. It’s clear that we must distance ourselves from our longstanding habit of accepting mediocre light, focusing on natural light as the goal, and insisting that energy efficiency and longevity are threshold values relating to the payback of any lighting decision. When it comes to delivering natural lighting, Xicato’s Artist Series has pioneered critical technology approaches that have finally enabled LED lighting to live up to its promise of a better, naturally lit, energy-efficient future.

## **Xicato’s Light Portfolio**

*Xicato’s portfolio of light enables lighting designers, interior designers and others to choose the type of light that’s preferred for each application or presentation.*

*The Artist Series provides natural light, improves visual fidelity and a richer feel. Colors are brighter, particularly reds, and this contributes to making the Artist Series superior to halogen lamps for color, feel and consistency of appearance.*

*The Vibrant Series brings out vivid, saturated colors and the details of texture for compelling and eye-catching visuals. People can see more saturated colors, which research has shown they often prefer. Blues, reds, whites and textures are more brilliant and detailed than under any other LED light source.*

# XICATO

*The Standard Series light provides comfortable and functional light, and colors look right to the viewer. The quality of light, consistency, efficiency and longevity make the Standard Series light superior to light from ceramic metal halide and fluorescent lamps.*

*All three forms of light are incorporated into our module portfolio so that the lighting community can bring the right light — the perfect light — to every project*