COLOR KINETICS

Optibin

Where consistency begins

Technical Overview

Photography: Nagieb Azhar and WCT Construction

Optibin

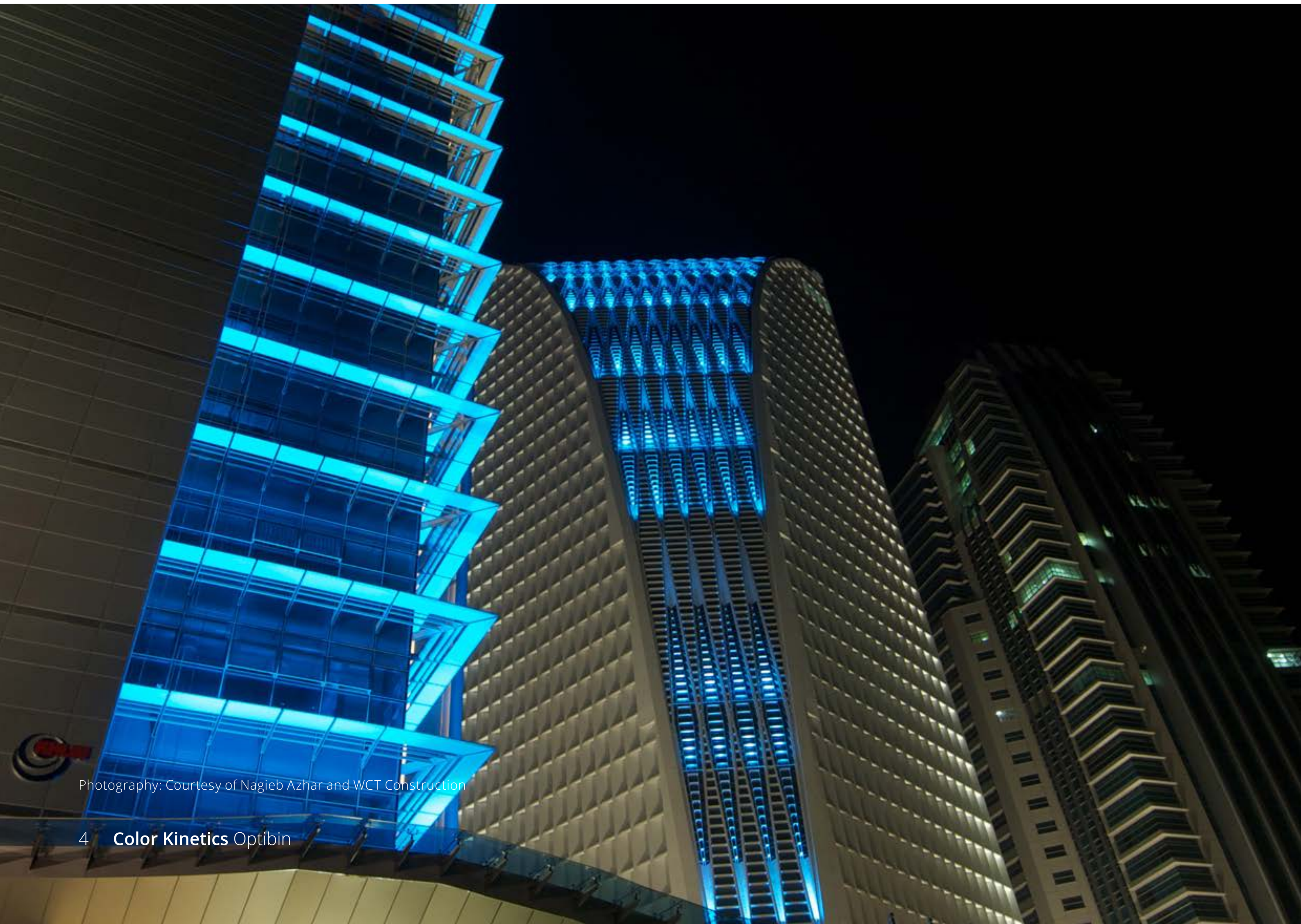
Achieves color consistency with industry-leading LED optimization

Color consistency is an indicator of light quality for both color and white-light LEDs. Where white light is concerned, correlated color temperature, or CCT, describes whether white light appears warm (reddish), neutral, or cool (bluish). The standard definitions of CCT allow a range of variation in chromaticity that can be readily discerned by viewers even when the CCT value is the same. Ensuring color consistency is a major concern of LED manufacturers, who must create methods to keep color variations under tight control.

Optibin® is a proprietary binning optimization process developed by Color Kinetics to achieve exceptional color consistency with advanced LED optimization. Optibin uses an advanced bin selection formula that exceeds industry standards for chromaticity to guarantee uniformity and consistency of hue and color temperature.

Exploring Correlated Color Temperature

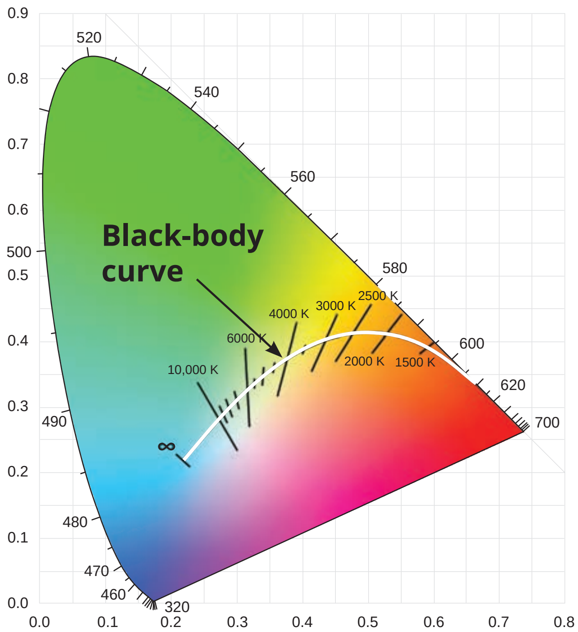
Technically speaking, the “temperature” in correlated color temperature (CCT) refers to black-body* radiation—the light emitted by a solid object with certain properties, heated to the point of incandescence—and is expressed in degrees K (Kelvin), a standard measurement of absolute temperature. As a black body gets hotter, the light it emits progresses through a sequence of colors, from red to orange to yellow to white to blue. This is very similar to what happens to a piece of iron heated in a blacksmith’s forge.



Photography: Courtesy of Nagieb Azhar and WCT Construction

The sequence of colors describes a curve within a color space. The diagram below shows the CIE 1931 color space, created by the International Commission on Illumination (CIE) to define the entire range of colors visible to the average viewer, with the black-body curve superimposed on it.

An incandescent lamp emits light with a color of roughly 2700 K, which is toward the warm or reddish end of the scale. Because an incandescent bulb uses a filament that is heated until it emits light, the temperature of the filament is also the color temperature of the light.



The black-body curve defines the range of color temperatures, from warm (reddish) to cool (bluish), within the CIE 1931 color space. CCT measures how hot black body radiation is when it reaches a specific color. The corresponding light source would equal the color emitted by the black-body radiation at that specific temperature, or CCT.

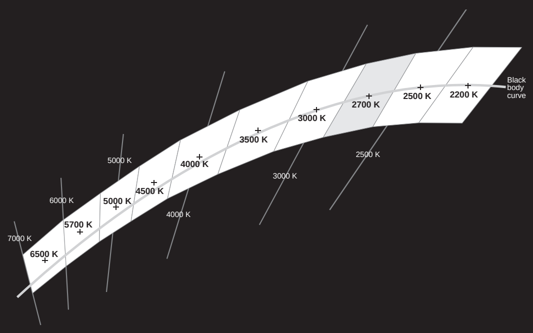
Spectral analysis of visible light makes it possible to define color temperatures for non-incandescent white light sources, such as fluorescent tubes and LEDs. The actual temperature of a 2700 K LED source is typically around 80° C, even though the LED source emits light of the same color as a filament heated to a temperature of 2700 K.

The American National Standards Institute (ANSI) has produced a series of standards that define the chromaticity of different types of light sources. For LED light sources, chromaticity standard C78.377-2015, defines 10 nominal CCTs ranging from 2200 K (warm) to 6500 K (daylight). For consistency across light source types, six of these CCTs correspond to the chromaticity specifications for compact fluorescent lamps (defined in the ANSI C78.376 standard, published in 2001). Since LED sources can be manufactured to produce any color temperature within the range, ANSI C78.277 defines four additional CCTs (2200 K, 2500 K, 4500 K and 5700 K) to fill in gaps along the black-body curve which are not accounted for by the CFL chromaticity standard.

* A black body is an object that absorbs all electromagnetic radiation falling on it. Because it reflects no light, a black body appears black. No perfect black bodies exist, but certain metals offer good approximations.

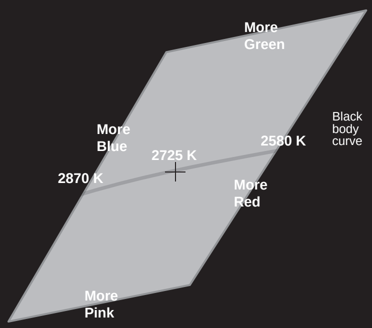
Photography: © Darius Kuzmickas

Warm and inviting 3000 K white light creates an inviting outdoor space.



Allowable variations both along and perpendicular to the black-body curve define a quadrangle within the color space for each color temperature.

Nominal 2700 K CCT



In practice, this means that the measured CCT and Duv of LED light sources can vary considerably and still be described as having a nominal CCT of 2700 K.

Consistent 4000 K white light illuminates the 120 m, (393 ft) office building.

Allowable variations in CCT

Each nominal CCT has an allowable range of variation, or tolerance, both along the black-body curve and perpendicular to it.

Variations that lie along the black-body curve make a light source appear more reddish or bluish. Variations above and below the black-body curve make a light source appear more greenish or pinkish.

Variations along the black-body curve are measured in degrees K, while variations perpendicular to the black-body curve are notated as Duv. Duv ranges are defined on the CIE 1976 color space, rather than the 1931 color space, because the 1976 color space (also known as the CIELUV color space) is better suited for evaluating color differences of light sources: it uses a uniform scale in which a distance measured anywhere on the color space represents the same degree of perceptual difference in color.

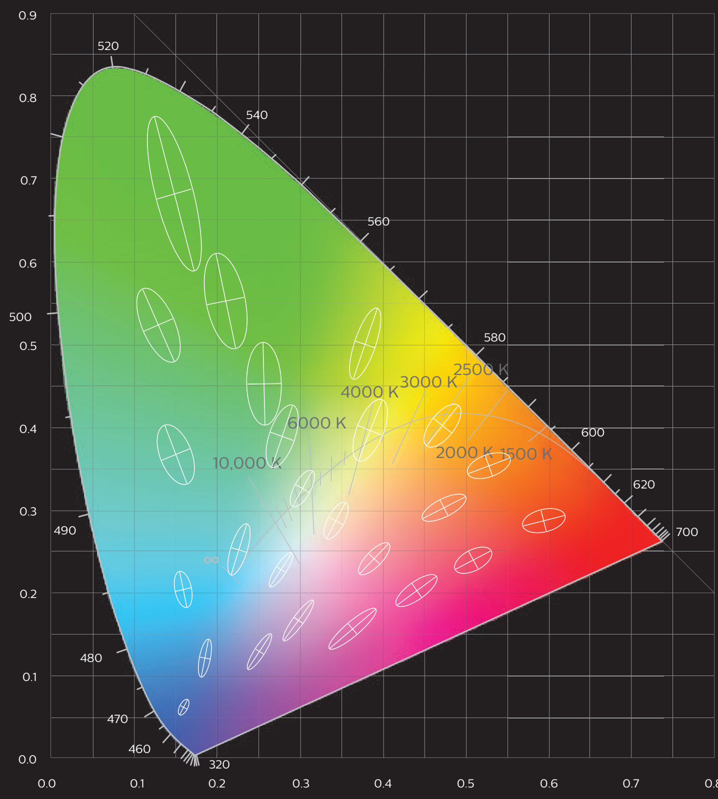
The axes of the CIE 1976 color space are u′ and v′, instead of x and y. Duv measures the distance from the black-body curve, and therefore the degree of color change (its delta). Positive Duv values are above the curve, while negative Duv values are below the curve.

The size of each quadrangle is determined by the CCT and Duv ranges for each color temperature, as specified in the ANSI standard. For example, the quadrangle for nominal CCT of 2700 K is centered on 2725 K, with a tolerance of plus or minus 145 K. The 2700 K quadrangle, therefore, covers from 2580 K to 2870 K along the black-body curve. In the other dimension, the quadrangle extends 0.006 Duv above and below the curve.

How much can the color of nominal CCT vary?

The threshold at which a color difference becomes perceptible is defined by a MacAdam ellipse.

A MacAdam ellipse is drawn over the color space in such a way that the color at its center point deviates by a certain amount from colors at any point along its edge.



Note that, for clarity, the MacAdam ellipses shown in this diagram are 10 times larger than actual size.

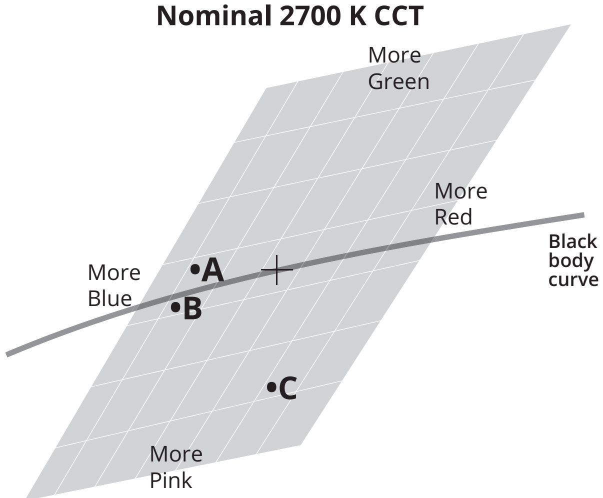
The scale of a MacAdam ellipse is determined by the standard deviation of color matching (SDCM). A color difference of 2 SDCM “steps” is barely visible by the trained eye, while a 4-step deviation is visible by the trained eye. The size and orientation of MacAdam ellipses differ depending on their position within the CIE 1931 color space, even when each ellipse defines the same degree of deviation between the color at its center and any color along its edge.

The quadrangles that define the color ranges of the ten nominal CCTs described in the ANSI C78.377A standard are roughly equivalent in size to 7-step MacAdam ellipses. Any LED light source whose measured color point falls within one of these quadrangles is considered to have that nominal CCT. But since color differences of 7 SDCM steps are readily visible, light sources with the same nominal CCT can display fairly large — and noticeable — differences in hue.

For example, the chart to the right shows three hypothetical LED light sources, A, B, and C. Even though A and B are on either side of the black-body curve, the color difference between them is negligible. The color variation between A and C, on the other hand, is four times as great as the color variation between A and B. Nevertheless, all three light sources conform to the ANSI specification for nominal CCT of 2700 K.

One important goal for luminaire manufacturers is to ensure that color differences between luminaires are small, if not imperceptible. Since nominal CCT does not ensure this degree of color uniformity, LED luminaire manufacturers devise various binning schemes to tightly manage color variations in the LED sources that they purchase and use in their luminaires.

Nominal 2700 K CCT



Achieving consistent color with Optibin

During production, LEDs vary in color, luminous flux, and forward voltage. Since the differences are significant, LEDs are measured and delivered to the market in subclasses, or bins. Binning makes it possible to select LEDs that conform to stated specifications — for instance, to select LEDs for traffic signals with the specific color required to meet the European standard.

Photography: © Ammar Keylani

What is binning?

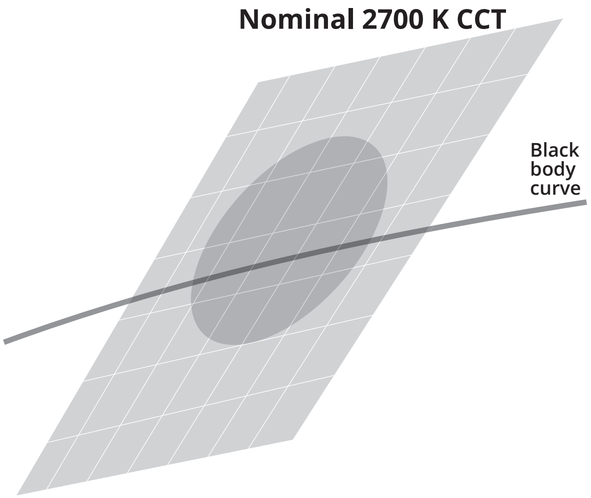
Lighting luminaire manufacturers devise methods of selecting bins of LEDs in such a way as to minimize differences in color that might be visible from luminaire to luminaire or from production run to production run. While these methods vary, the overall goal of binning is the same — to select LEDs that are readily available in high volume, which helps guarantee color uniformity across luminaires and production runs. In short, binning takes a first, important step toward assuring color consistency.

For example, Color Kinetics has developed Optibin, which begins the color consistency process by grouping (or binning) LEDs by flux as well as color point. This proprietary binning optimization process uses an advanced bin selection formula that exceeds industry standards for chromaticity to guarantee uniformity and consistency of hue and color temperature.

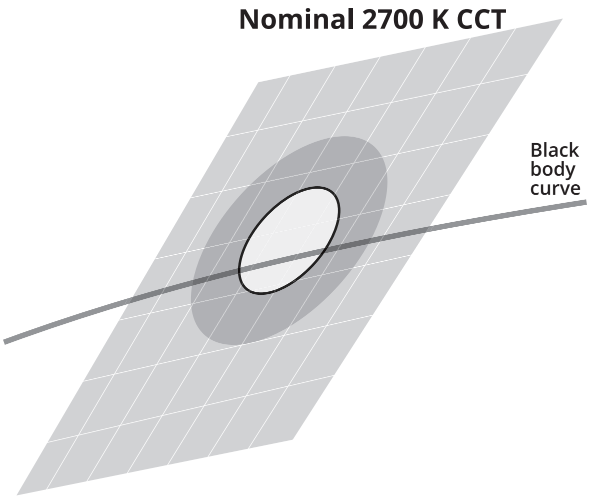
How Optibin works

Optibin uses proprietary algorithms to ensure color consistency from luminaire to luminaire, as well as from manufacturing run to manufacturing run. The Optibin process is applied each time Color Kinetics selects bins of LED sources for purchase from its suppliers. The Optibin process is also applied each time manufacturing builds a run of luminaires, to determine the placement of LED sources within those luminaires to maintain optimal color consistency.

By purchasing and intelligently combining tightly specified LED sources from a range of manufacturing bins, Optibin guarantees the availability of LED sources with the correct color attributes, as well as their proper deployment, throughout the lifecycle of the lighting luminaires that use them. All Color Kinetics luminaires ship with Optibin.



For white-light LED products, Optibin dictates the use of LEDs from bins which lie as close as possible to the black-body curve within a 4-step ellipse.



Optibin's CCT and hue tolerance for LED luminaires fall within a 2-step MacAdam ellipse to ensure that any variations in color will be barely visible, even to the trained eye.

The balance of warm and cool light creates an inviting and eye-catching effect at Baron Palace in Cairo, Egypt.

About Color LED Binning

When bringing consistency to color LED products, Optibin bins LEDs by flux and center wavelength.

Color Kinetics chooses a combination of these two key measurements to achieve the highest consistency possible. In large installations, Optibin ensures color consistency, no matter what the date or bin codes of the LED luminaires. And with Optibin, customers do not need to track manufacturing or binning codes for their job.

Ensuring reliable color consistency over time is especially important for phased installations where luminaires are purchased and installed at different times, for expansion and multi-site installations, and for color-matching replacement luminaires in case of luminaire failure.

Bringing consistency to dynamic color-changing luminaires

Beyond Optibin, Color Kinetics also developed Chromasync, an advanced algorithm that delivers improved color consistency within luminaires (node to node), as well as from luminaire to luminaire, by adjusting the node's color point. With Chromasync enabled, colors are more consistent, regardless of the specific LEDs used, date of manufacture, and other variables. Chromasync allows Color Kinetics luminaires to achieve high color precision – for example, those within the IntelliHue family – with a color variation of less than 2 MacAdam ellipses (2 SDCM) across multiple luminaires.

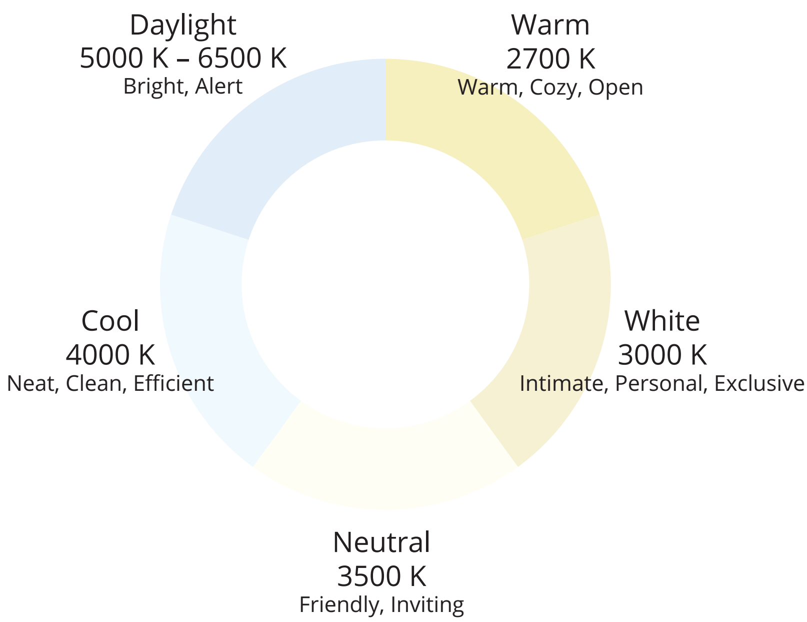
Photography: Istavrit Agency

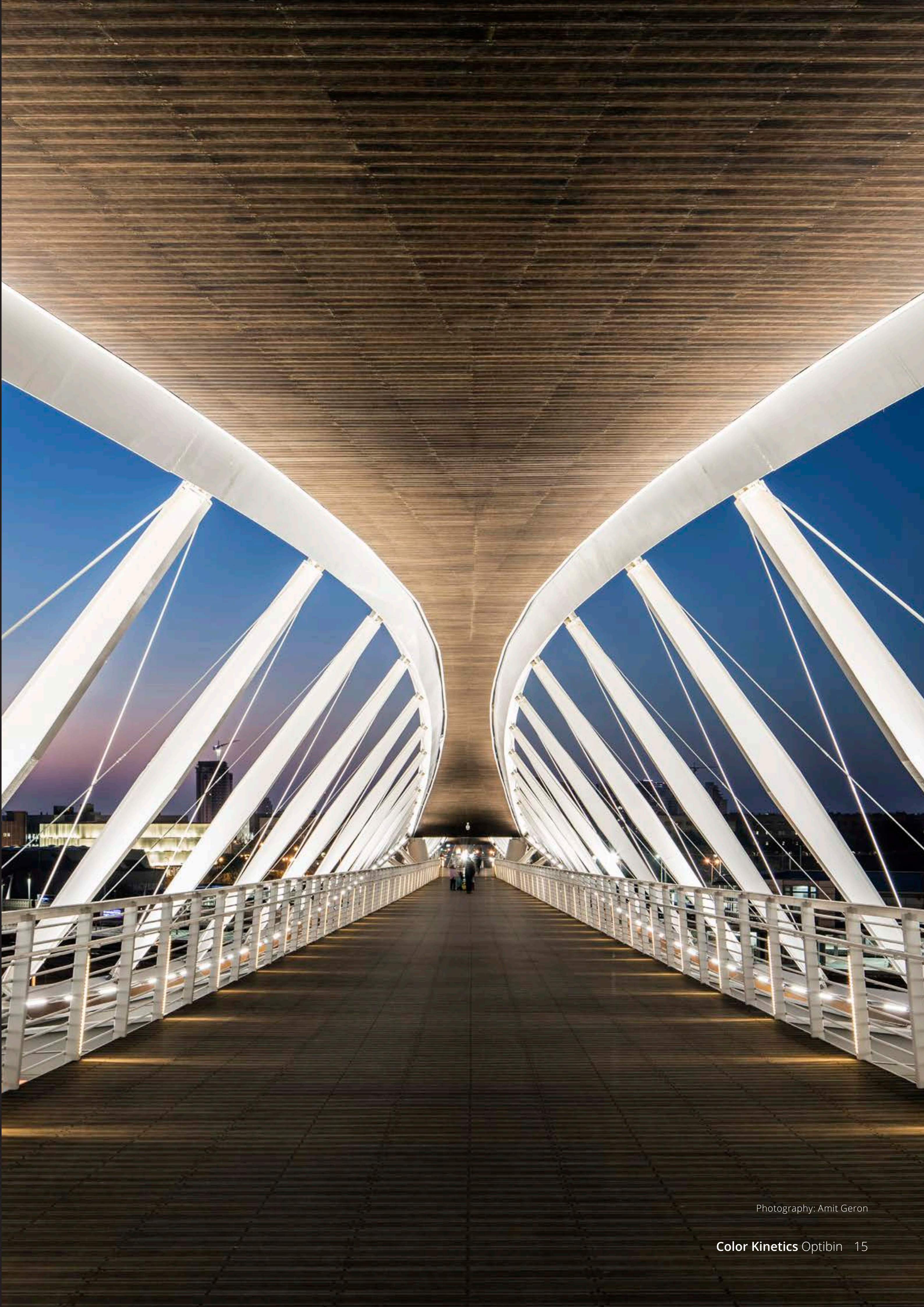
Choosing the Right White

LEDs cover a wide range of color temperatures that approximate the color temperatures of many non-LED lighting sources including daylight.

Particular color temperatures, from warm to neutral to cool, are associated with certain light sources and environments. Color temperature also alters the emotional effect of a space, and can dramatically affect the appearance of objects on display in stores, galleries, and museums.

Tunable white-light LED luminaires offer a range of color temperatures that can be varied on the fly with lighting controllers. Tunable white light is ideal for illuminating changing retail displays, for altering the mood of a public space (with different morning, evening, and overnight lighting schemes, for example), and for theatrical or studio applications that call for varying levels and shades of white light.





Photography: Amit Geron

Color Kinetics technology portfolio

We continually explore your challenges, invest in research and development, and make the significant commitment required to develop and perfect breakthrough technologies. The result of decades of work, our unequaled portfolio of proprietary, quality-enhancing technologies helps you achieve the best possible results. These technologies increase quality by ensuring sustainability, consistency, raising uniformity, providing precision control, and more.

Optibin

Where consistency begins.

Our LED optimization technology begins the color consistency process by grouping (or binning) LEDs by flux as well as center wavelength. This proprietary binning optimization process uses an advanced bin selection formula that exceeds industry standards for chromaticity. The result? Higher uniformity and consistency of hue and color temperature for all our luminaires.

Chromasync

Optimize output & color consistency.

Our advanced output optimization technology controls and boosts output while ensuring color consistency. When enabled, Chromasync ensures excellent color consistency between luminaires, without manually adjusting color points on each luminaire.

IntelliHue

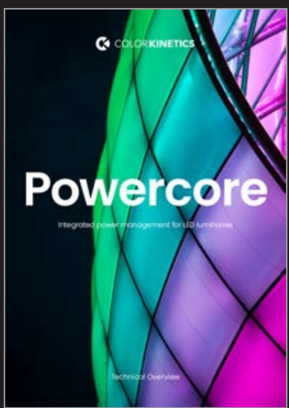
The smart way to deliver white & color light.

Our advanced approach to color mixing produces high-quality white light, subtle pastels, and fully saturated colors in the same precisely controllable luminaire. All with unrivaled color accuracy across the entire range of color temperatures.

OptiField

Uniformity never looked this good.

OptiField's freeform optic creates a breakthrough rectangular beam that covers large surfaces with full, bright, even light. And OptiField can cover more surface area with fewer luminaires — simplifying installation while lowering energy use.



Powercore

Power made simple.

Our patented approach to power output proves that simple is better. As well as faster, more efficient, and accurate. Powercore® controls power output to luminaires directly from line voltage. It merges line voltage with control data and delivers both over a single standard cable—dramatically simplifying installation and lowering total system cost.

IntelliPower

Retrofit made easier.

IntelliPower is a groundbreaking implementation of proven power line carrier technology (PLC), a system for carrying data on the same conductors used for transmitting electrical power. By applying the principles of PLC, IntelliPower lets you install and digitally control intelligent Powercore luminaires using existing electrical branches, 2 + ground wiring, and luminaire mounting points.

What matters in professional lighting?

Our series of guides explores key topics in professional lighting—Color Science, Light Matters, Quality Matters, Optics Matter, and more. It's part of our commitment to passing on our deep technical knowledge and decades of expertise to help you achieve your vision.

Color Science

Color science serves as an underlying technical foundation for the entire lighting industry. It establishes a consistent way of thinking about light—how it is created, controlled, and delivered in real-world implementations. A core understanding of the science of color is critical to lighting professionals, who must be able to specify the right light—color, technology, luminaire, and more—clearly and accurately.

Light Matters

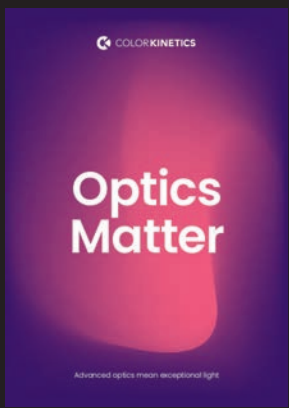
Traditional methods of evaluating light focused on lumen output, which was defined by the output capabilities of a light source, such as an incandescent lamp. The advent of LED lighting changed all that, since lumens were no longer the best measurement of a luminaire's capabilities. We explore some of the new ways lighting can be evaluated in the age of LED.

Quality Matters

What does quality mean to you?

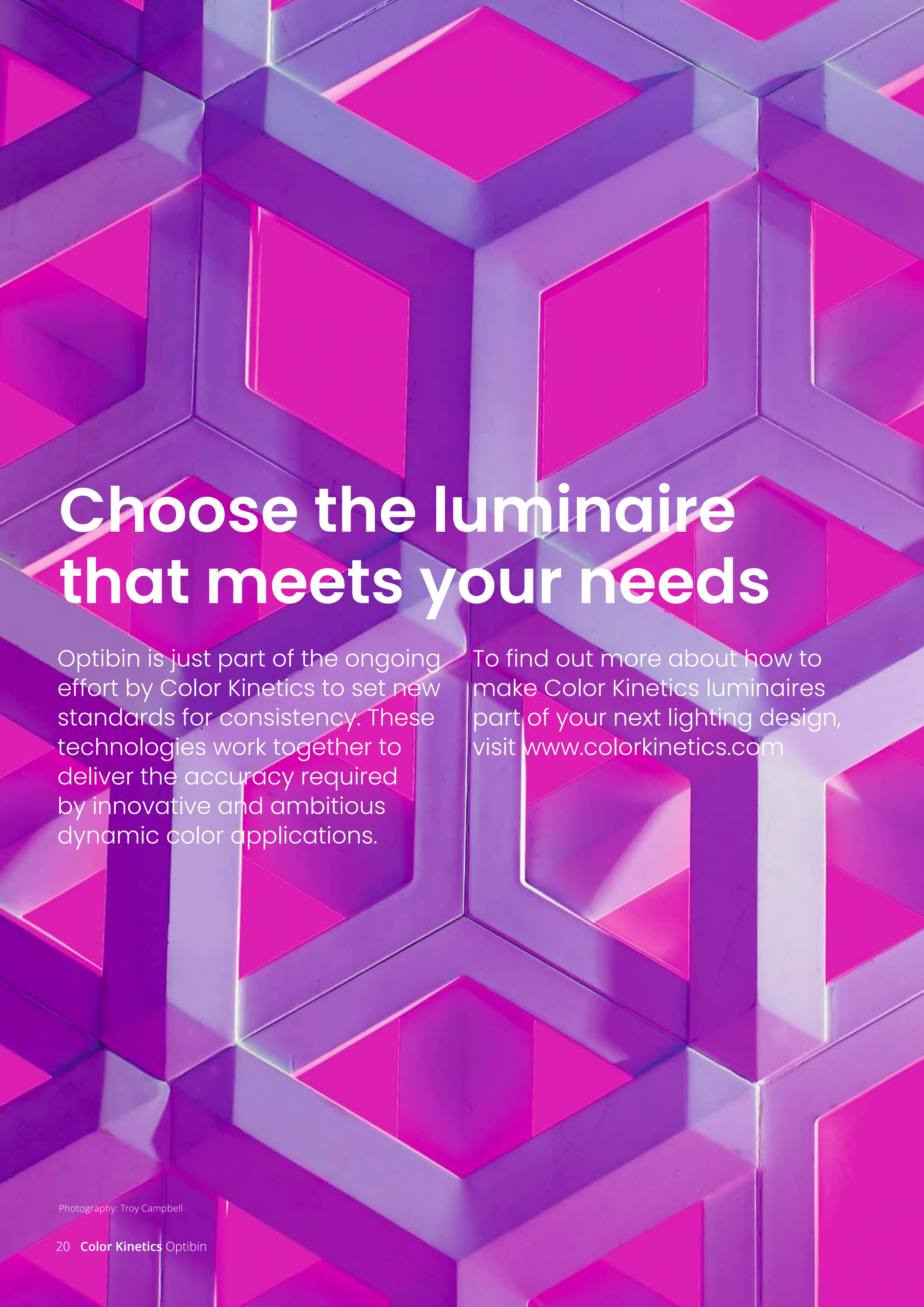
The answer depends on what you do within the lighting industry. Quality has different meanings for building and site owners/managers, lighting designers, and installers.

We delve into the needs of each of these groups as we take a holistic approach to quality, one that begins and ends with the customer.



Optics Matter

It's safe to say that few lighting designers, building owners/managers, or other lighting professionals have ever seen the optical system housed inside an LED luminaire. But the optical system, or optics, play a vital, but often hidden role in performance, efficiency, and more. The right optics within a luminaire make a big difference in the final results—for both interior and exterior applications.

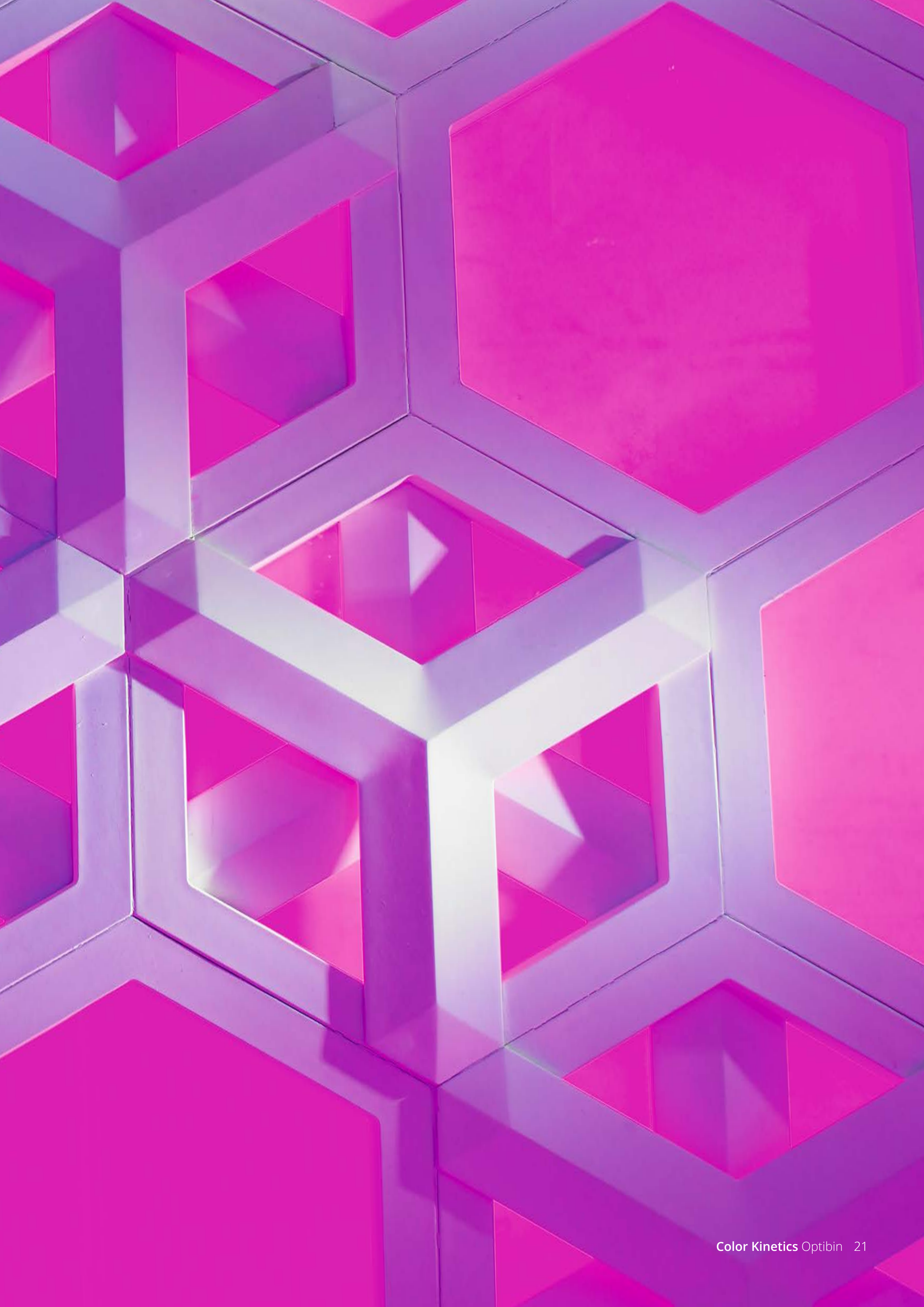


Choose the luminaire that meets your needs

Optibin is just part of the ongoing effort by Color Kinetics to set new standards for consistency. These technologies work together to deliver the accuracy required by innovative and ambitious dynamic color applications.

To find out more about how to make Color Kinetics luminaires part of your next lighting design, visit www.colorkinetics.com

Photography: Troy Campbell



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www.colorkinetics.com