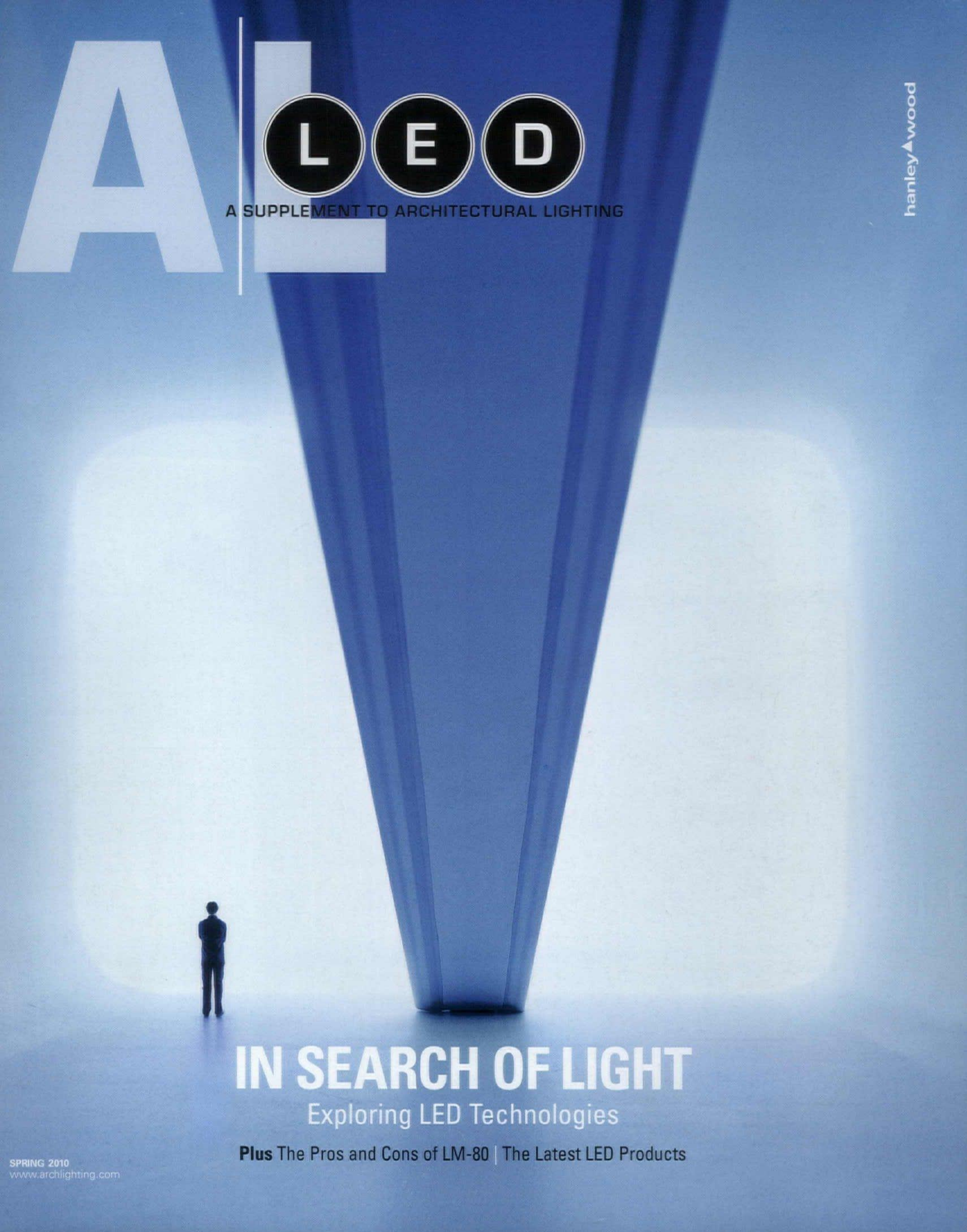

AL LED

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Exploring LED Technologies

Plus The Pros and Cons of LM-80 | The Latest LED Products

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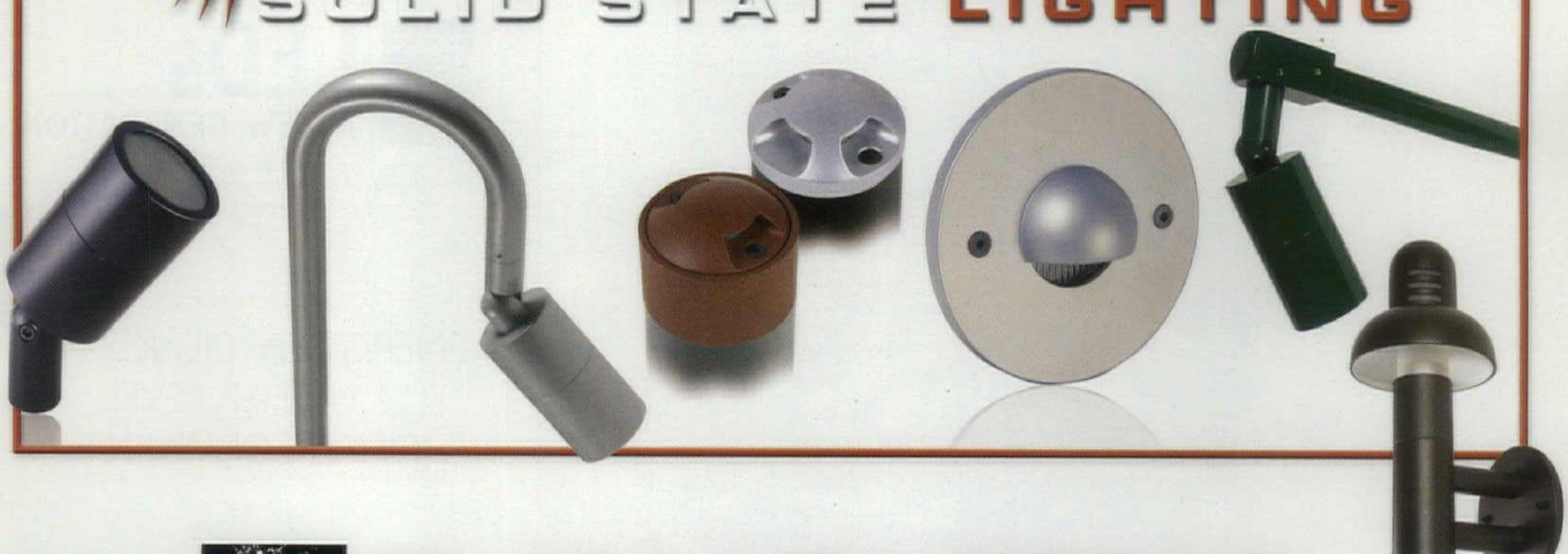

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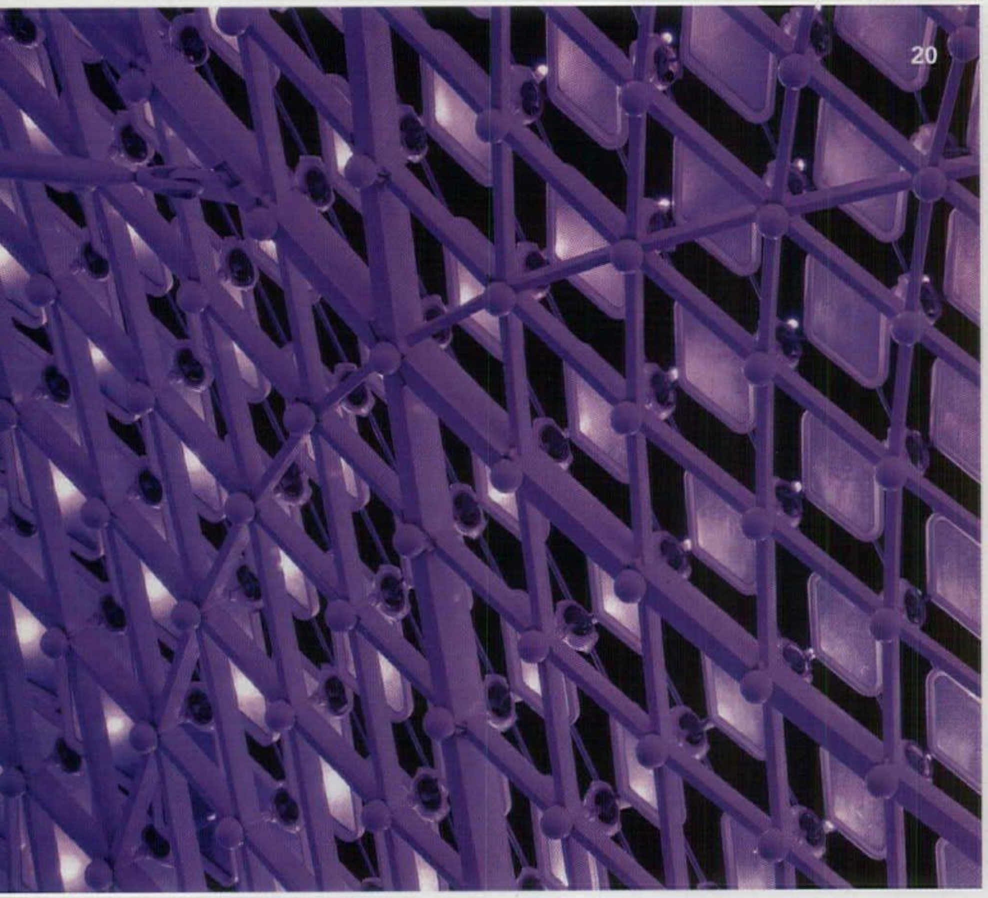
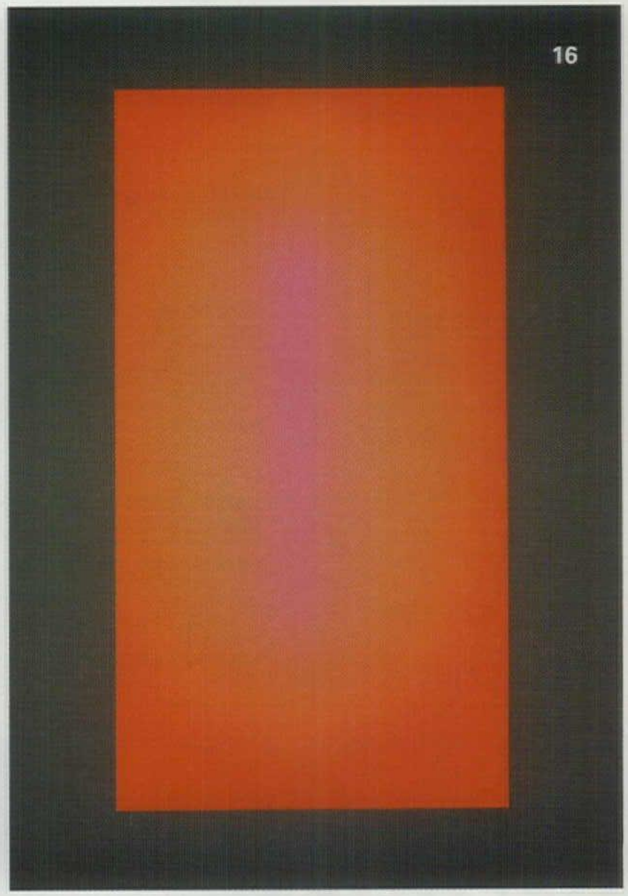
LED
A SUPPLEMENT TO ARCHITECTURAL LIGHTING





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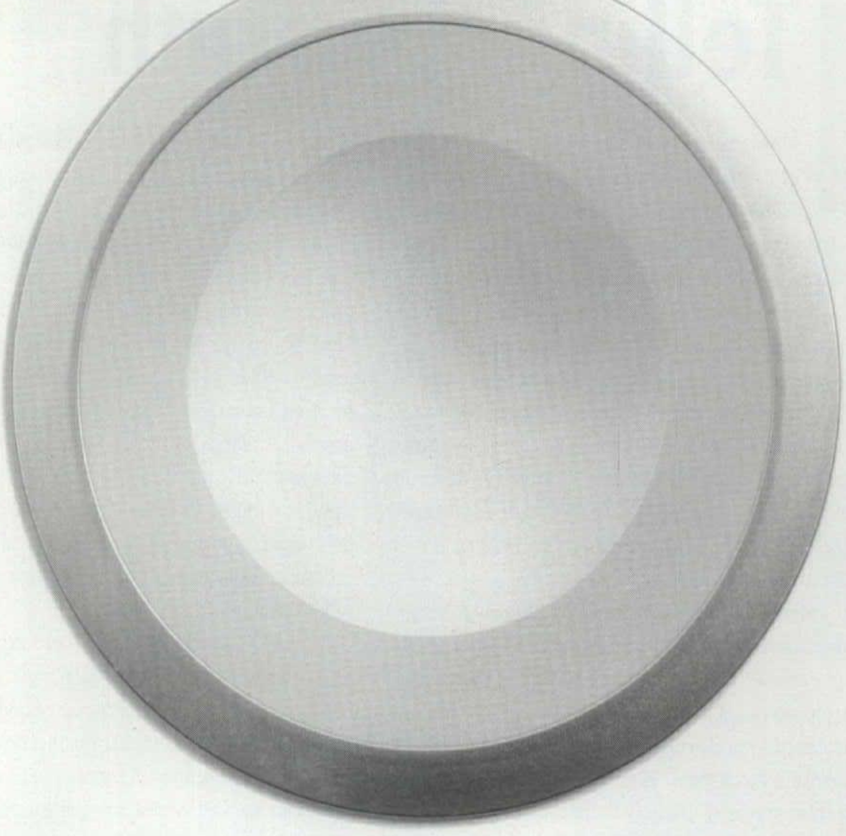
Cover: The Wolfsburg Project, a ganzfeld installation by James Turrell at the Wolfsburg Museum, Wolfsburg, Germany.
COURTESY WOLFSBURG ART MUSEUM

This page: The grid shell façade of the Yas Hotel, Abu Dhabi; "Tall Glass" by James Turrell at the Wolfsburg Museum.
PHOTO: BJORN MOERMAN, COURTESY ARUP LIGHTING; COURTESY ZUMTOBEL



Telling the Truth

The greatest challenge facing the solid-state lighting industry is not a technology issue, but a public relations one. Simply put, it's a matter of trust. And there is a significant lack of this coming from the design community these days when it comes to some manufacturers of LEDs, who are trying to rebound from the lingering impact that their false product claims and unreliable goods have made in the marketplace.

Certainly, strides have been made by the LED and lighting industry over the past several years to address these issues. Product testing programs, such as the Department of Energy's CALiPER program, are more robust than ever, and industry protocols, such as the Illuminating Engineering Society's technical guidelines LM-79 and LM-80, have been established to describe the photometry method for LED luminaires and define lumen maintenance issues specific to LED sources.

There also has been a steady increase in dialogue. Lighting designers are asking LED manufacturers some hard-hitting technical questions. Burned more than once by these LED products, lighting designers are no longer willing to play the guinea pig. Compounding the technical difficulties, the present economic conditions leave a slim margin for error.

So what can be done to rebuild this trust? First, a new level of transparency must be established in everything related to the creation and use of LEDs—from the manufacturing process to the creation of accurate specifications documents. A new degree of transparency might entail rethinking how to structure product warranties for LEDs and the various components that also go into the total luminaire package. In addition, manufacturers might be well served by inviting designers to see the production process as well as the binning selection process.

In fact, the binning process might be the very key to establishing new quality assurance levels. If there were a grading system for LEDs, designers could decide to use only the highest quality diodes for architectural luminaires. This grading system could be set up to correspond to the needs of both commercial and residential lighting applications.

But how the lighting industry will end up incorporating, managing, and progressing LED technology goes deeper than the problem of a matter of trust between the design community and manufacturers. It's really the influence of one industry (semiconductors) on another (lighting), and how the two can best find common ground. Companies that have, in the past, focused on lamps and luminaires are now figuring out ways to work with companies that specialize in electronics. This is a necessary next step, as lighting moves from an analog to a digital world.

Figuring out how to deal with the pressures of the marketplace is an always-present issue for any manufacturer. At the moment, the lighting community is feeling the heat, positioned as it is between the design community and the semiconductor industry. One cannot just throw another LED fixture into the pantheon of lighting offerings, especially if it is not going to deliver on the need for technical performance and reliability. Designers won't stand for it; manufacturers shouldn't either. The lighting industry needs to keep a vigilant watch on itself and its competitors to avert the danger of "LED washing," something akin to the "green washing" problems that have beset the green building industry. Building product manufacturers, eager to jump on the sustainability bandwagon, announce that their products have green characteristics or perform to sustainable standards when they don't.

Fortunately, several recent initiatives indicate that the LED industry is trying to steer clear of these pitfalls. One recent positive development is the formation of Zhaga, a group of companies that has assembled to create industry-wide cooperation for the development of standard specifications for LED light engines. The goal is to define standards for the physical parameters as well as the photometric, electric, and thermal characteristics of LED light engines. The companies who founded the group are Acuity Brands Lighting, Cooper, Osram, Panasonic, Philips, Schréder, Toshiba, Trilux, and Zumtobel. The plan is for the Zhaga consortium to expand and include companies from all sectors of the LED industry, including those who manufacture LED luminaires and suppliers of components such as heat sinks and optics. This is a very important step: Lighting designers should see this as a serious commitment on the part of manufacturers to re-establish their good intentions toward the design community and to build the foundation needed to move forward.

But actions speak louder than words. The most important step that the LED and lighting industry can take right now is to present honest, reliable products and information. With a trustworthy foundation, the rest will fall into place.

ELIZABETH DONOFF

EDITOR

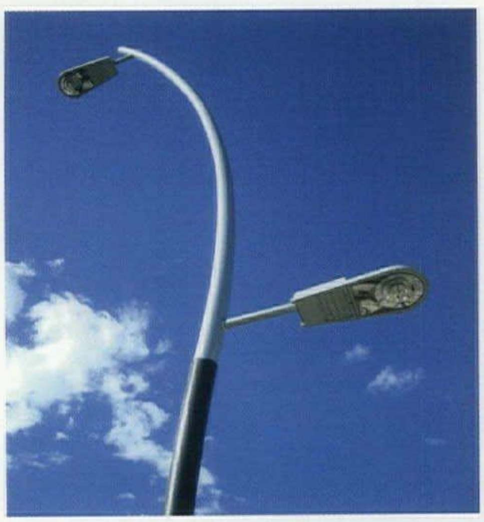

Curve
by Finelite™
Best in Class Winner
NGL2009
The Curve by Finelite was awarded Best in Class in the DOE 2009 Next Generation Luminaires™ (NGL) Design Competition. This LED desk lamp features classic styling, Quicktouch™ dimming, and a field-replaceable LED module. Visit www.finelite.com to get more information on this award-winning desk lamp.
FINELITE
Better Lighting

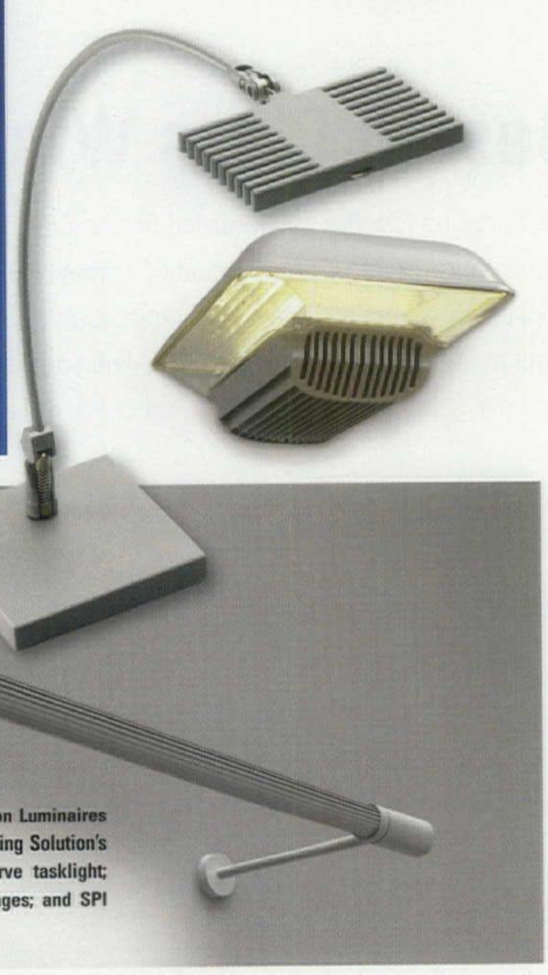
NGL Competition Winners

Winning products in the second annual Next Generation Luminaires (NGL) Design Competition were announced on Feb. 11 at the Strategies in Light Conference in Santa Clara, Calif. Launched in 2008, this program for commercial solid-state lighting fixtures is sponsored by the U.S. Department of Energy, the Illuminating Engineering Society, and the International Association of Lighting Designers. Its goal is to promote excellence in the design of energy-efficient LED luminaires for general illumination in commercial lighting applications.

Out of a total of 126 submissions, the 2009 competition recognized 47 products representing 60 different lighting manufacturers, and covering 11 indoor lighting categories as well as six outdoor lighting categories. Awards are made at two levels: "recognized" and "best in class." Only four luminaires received best in class, which is the competition's highest honor: Finelite's Curve tasklight, SPI Lighting's Stile Styk wallwasher, GE Lighting Solution's Evolve LED R150 Roadway luminaire, and Philips Wide-Lite's VizorLED fixture for parking garages.

The jury of 12 individuals, representing the different facets of the architectural lighting design community, evaluated the entries based on performance, appearance, constrictions, and submitted photometric data. This year's judges were: Robert Berger, Jeffrey L. Brown, David Brumbelow, Mary Matteson Bryan, Nancy E. Clanton, Lara Jacobson Cordell, Barbara Cianci Horton, Kevin Houser, Chip Israel, Jeff McCullough, Avraham Mendall Mor, and Melanie Taylor. For complete information about the competition and an overview of all the winning luminaires, including the 43 recognized winners, go to ngldc.org. ELIZABETH DONOFF





The 2009 best in class winners of the Next Generation Luminaires Design Competition. Clockwise from top left: GE Lighting Solution's Evolve LED R150 Roadway luminaire; Finelite's Curve tasklight; Philips Wide-Lite's VizorLED fixture for parking garages; and SPI Lighting's Stile Styk wallwasher.

REPORT CONFIRMS LEDS ARE ENERGY EFFICIENT

Solid-state lighting advocates have been quick to promote the energy-efficient performance of LEDs, but have done so based more on intuition than reported findings. However, with the release of Osram Opto Semiconductors' November 2009 report, "Life Cycle Assessment of Illuminants: A Comparison of Light Bulbs, Compact Fluorescent Lamps and LED Lamps," there is now data to confirm that hunch. "Life Cycle Assessment of Illuminants" finds that, from "cradle to grave," LED lamps do indeed deliver on energy efficiency.

The report studied the production and use of LED lamps and evaluates their environmental impact throughout all of the stages of lifecycle analysis—raw material production, manufacturing and assembly, transport, use, and end of life—and compares these results with those of an incandescent lamp and a compact fluorescent lamp (CFL). For the specific purposes of the study, an 8W Parathom LED lamp was tested against a 40W incandescent general service lamp and an 8W CFL Dulux Superstar. All three of these lamps are part of Osram's available lamp offerings.

The study arrived at three main conclusions:

- Expenditure of energy to produce an LED lamp is negligible—less than 2 percent. This dispels criticism that the manufacture of LED lamps expends more energy than is saved by the lamp's lower active light output.
- LED lamps are competitive with CFLs. Testing found that incandescent lamps consume approximately 3,302 kilowatt-hours, whereas CFLs and LED lamps each use less than 670 kilowatt-hours per hour over the course of their life. This translates to an energy savings of 80 percent.
- Future improvements of LED lamps will further reduce energy demand. As LED efficiency increases and higher lumens-per-watt levels are achieved, this savings will transfer to all aspects of the LED lamp and luminaire assembly.

To ensure that the evaluation of the three light sources was fair, the test looked at the manufacture, packaging, and shipping of the lamps in Asia and Europe and intended for sale in Germany. The researchers also took into consideration primary energy demand and global warming indexes. How the lighting industry utilizes this report is to be seen, as individuals will still make their own assessments when it comes to specifying LEDs. ED

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LEDs on the Scene

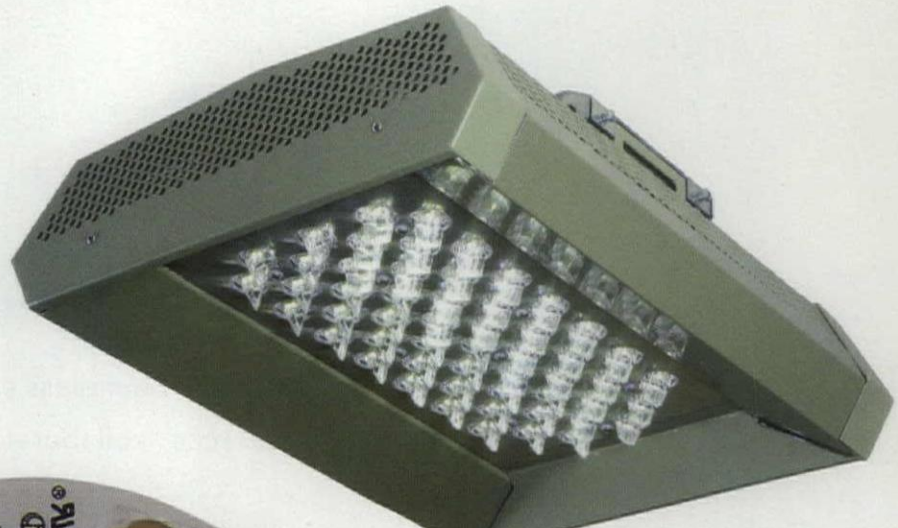
EDITED BY KIMBERLY R. GRIFFIN

PRESCOLITE LED DOWNLIGHTS

This is the next generation of the company's 4-inch and 6-inch specification-grade LED downlights: the D4LED3 and D6LED3 are now available in high-efficacy models, and the D4LED4 and D6LED4 in high-output versions. The D4LED3 also features four 5W LEDs with an output of 47 lumens per watt to meet energy code requirements. The D4LED4 is best suited for applications that require high output capabilities and incorporates four 10W LEDs. The D6LED3 model uses 10 14W LEDs, while the D6LED4 model utilizes 10 28W LEDs. All fixtures in this product family provide, according to the manufacturer, 50,000-hour life at a lumen maintenance of 70 percent. *prescolite.com* CIRCLE 102

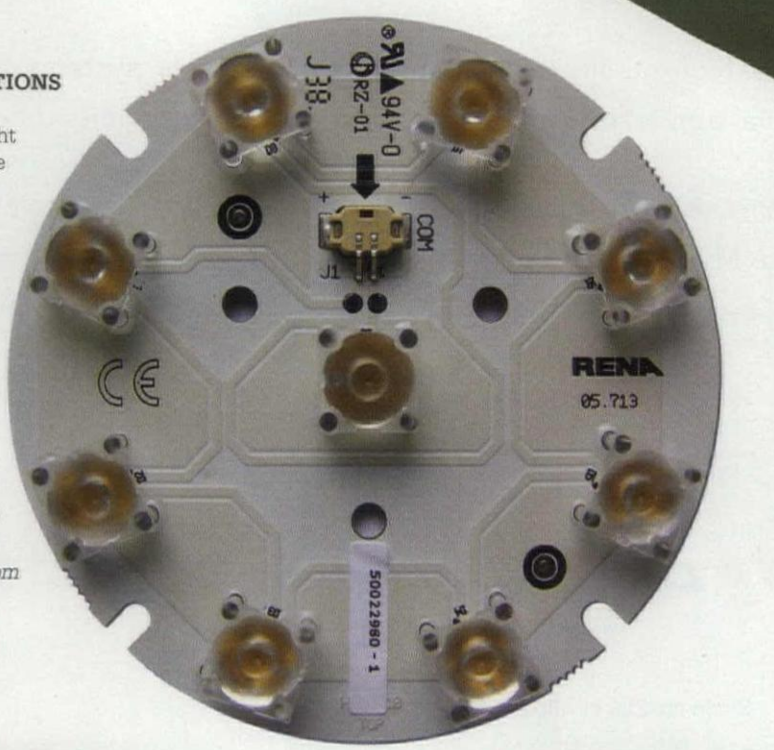
HUBBELL INDUSTRIAL KOOLBAY LED

The Koolbay LED luminaire is suitable for use in both a freezer or a cooler. The fixture uses only 150W and emits little heat and ultraviolet rays, minimizing food spoilage. A membrane bottom lens helps to reduce glare. Also, instant-on capabilities accommodate control systems, allowing the Koolbay to be turned on and off by occupancy sensors or timers to save more energy. Hubbell's patent-pending design dissipates heat generated by the LEDs, which helps the module last up to 60,000 hours. *hubbellindustrial.com* CIRCLE 100



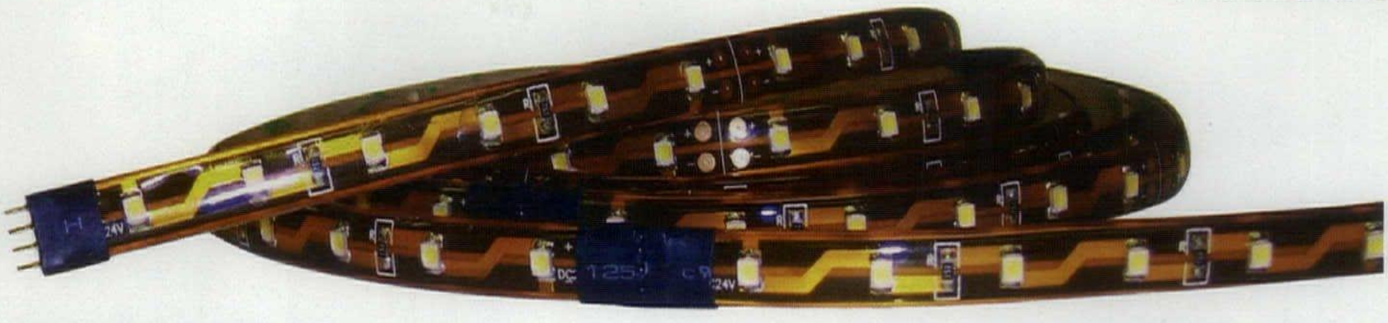
FUTURE LIGHTING SOLUTIONS
SIMPLELED

The simpleLED line of LED light engines, designed to aid in the development and prototyping of SSL luminaires, features more than 600 customizable options, all featuring ANSI-binned integrated Luxeon Rebel LEDs. The 12 configurations include linear, circular, and square array layouts with one, two, three, four, six, or nine white 3000K, 3500K, or 4000K LEDs. All simpleLEDs support drive currents up to 1,000 mA and have a minimum CRI of 80. *futurelightinsolutions.com* CIRCLE 101



PHILIPS EMCO LIGHTING
LED GARAGE LUMINAIRE

This new EMCO LED Garage luminaire (ELG) is designed for ceiling- or pendant-mounted installations in parking garages. The fixture housing incorporates extruded aluminum thermal radiation fins for better heat management. The design also helps to reduce debris build-up, helping to extend the life of the LEDs. The ELG also is available with an optional diffused acrylic lens, which limits perceived luminaire brightness, and contains individual LED arrays that are field replaceable for easier maintenance. *sitelighting.com* CIRCLE 103

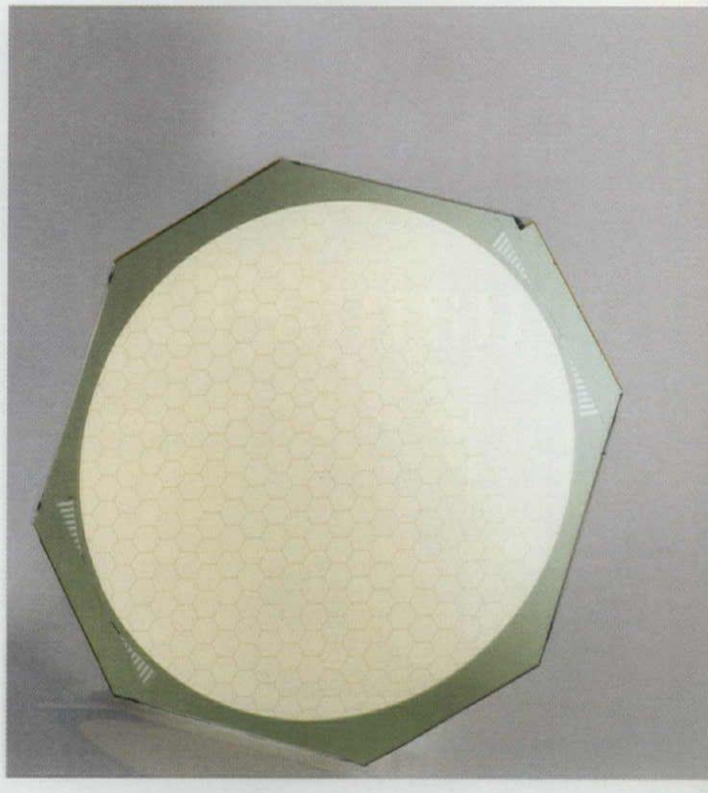


NORA LIGHTING LED TAPE LIGHT

Nora's LED Tape Light measures $^{7}/_{16}$-inch wide by $^{1}/_{8}$-inch thick, emits a color temperature of 3000K and 65 lumens per foot. The string format is designed to cast no shadows, with its seamless glow and low profile, suiting it for discreet locations. The strips come in 16.4-foot-long rolls separable every 20 inches; although, each strip can be cut every 4 inches. The tape offers 18 LEDs per foot at 1.5W per foot, and 24W per roll. The silicone encapsulated tape is IP65 rated for wet locations. *noralighting.com* CIRCLE 104

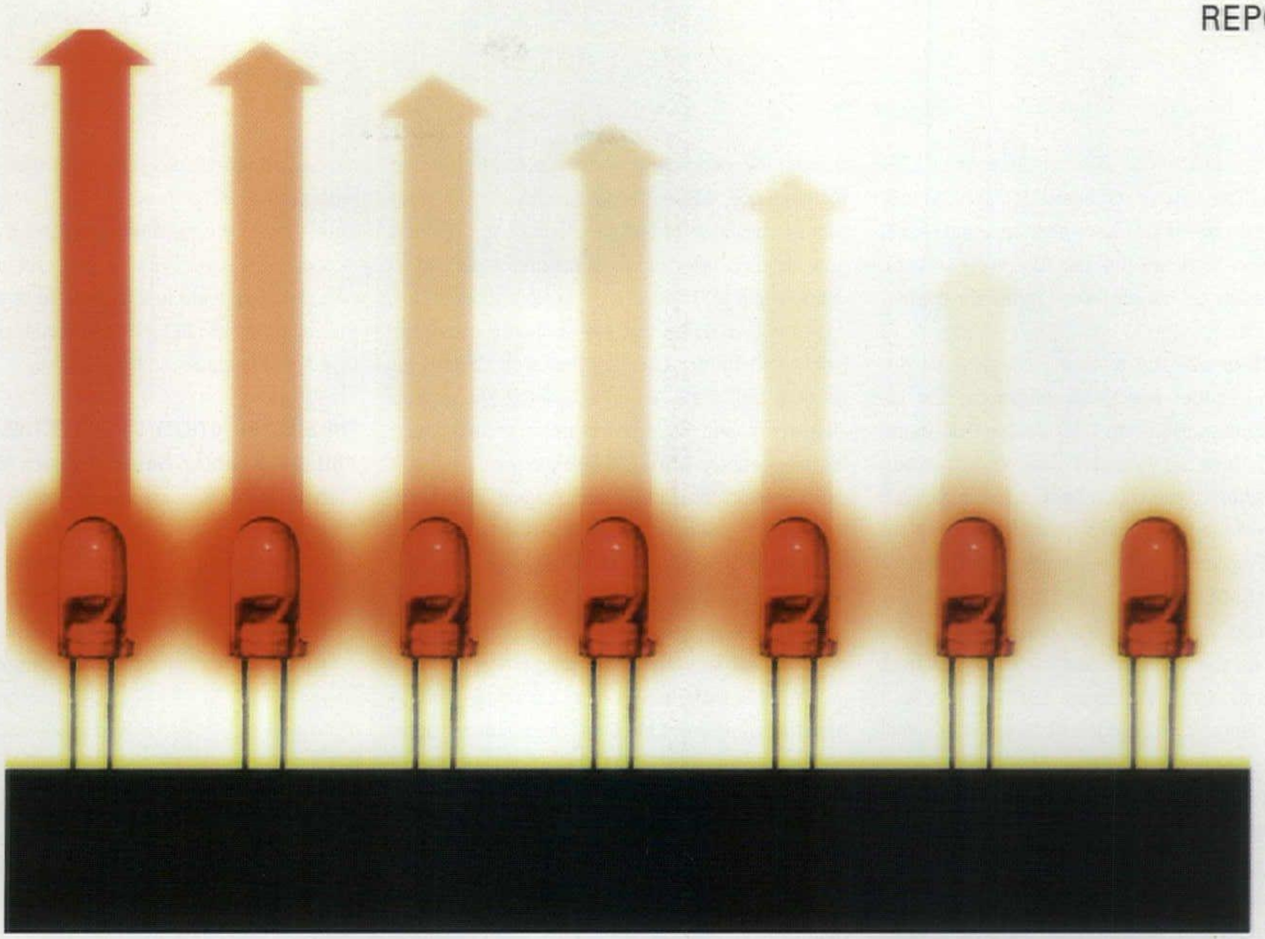
GE LED MODULE

The technology featured in the new LED module from GE Consumer and Industrial's LED business unit—Lumination—allows designers to easily upgrade LED directional lighting fixtures. The small, puck-shaped, dimmable module simply twists into place, says the manufacturer. Oftentimes, integrated LED luminaires are inflexible and require mechanical fasteners attaching an LED package to a heat sink and a plug to make the electrical connection. GE's new module makes the necessary thermal and electrical connections once twisted into its socket. Lumination purchased this next-generation LED module technology from Journée Lighting, a California-based LED fixture designer and manufacturer. The new fully dimmable GE brand LED module will debut in Journée Lighting's Azara and Pentas tracklight luminaires in early 2010. GE also is making the module available as a component for use by various LED luminaire manufacturers. *ge.com* CIRCLE 105



OSRAM OPTO SEMICONDUCTOR ORBEOS

Osram's Orbeos is an organic light-emitting diode (OLED) source that produces warm white functional light appropriate for myriad architectural lighting applications. Measuring just 2.1-millimeters deep and weighing only 24 grams, the panel has a lamp surface diameter of 80 millimeters. According to the manufacturer, the OLED has an efficiency of 25 lumens per watt, surpassing halogen lamps, and it emits a color temperature of 2800K and CRI of up to 80 to match the warmth of incandescent lamps. Orbeos contains no mercury, releases no UV or infrared radiation, and is continuously dimmable. *osram-os.com/oled* CIRCLE 106



ESTABLISHING LED TEST DATA PROTOCOLS

MEMBERS OF THE LIGHTING COMMUNITY WEIGH IN ON THE PROS AND CONS OF IES LM-80-08

Although LEDs and solid-state lighting (SSL) have made great strides in the lighting marketplace over the past several years, reliable testing of SSL products and data documentation have not kept up. It has taken the lighting industry some time to understand how to develop a set of metrics to properly represent the nuances of this light source in architectural lighting applications. Once it was realized that the procedures used to test traditional filament sources are not well suited for LEDs, organizations such as the Illuminating Engineering Society (IES) and the U.S. Department of Energy (DOE) began working on more appropriate standards.

There has been substantial progress on the documentation front. Through its CALiPER (Commercially Available LED Product Evaluation and Reporting) program, the DOE has documented a number of products, through several rounds of testing. The latest, Round 9, was released in December.

The IES, the recognized technical authority on illumination, recommends best practices for the industry and has issued new guidelines as lighting technology has advanced. In 2008, it released two documents to address SSL and LEDs. The first report, LM-79-08: "IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products," describes the photometry method for LED luminaires. The second report, LM-80-08: "Approved Method for Measuring Lumen Maintenance of LED Light Sources," outlines the measurement of lumen maintenance—the amount of light output sustained over time. A third report, TM-21: "Lumen Depreciation Lifetime Estimation Method for LED Light Sources," is in development.

LM-79 and LM-80 have been welcome additions to the discourse about LEDs and SSL. In fact, LM-80 was given the 2009 Lightfair Innovation Award for Best Research Publication.

The report has garnered a lot of attention, and to understand its impact on the industry, ARCHITECTURAL LIGHTING asked members of the lighting community to offer their thoughts on the pros and cons of LM-80. In order to get as complete a picture as possible, we asked practitioners who represent manufacturing, design, and electric utilities.

The consensus? LM-80 supplies an excellent foundation on which to continue the important work of establishing reliable SSL test data and procedures. ELIZABETH DONOFF

THE LIGHTING MANUFACTURER'S PERSPECTIVE

Kevin Dowling, Vice President Innovation

Philips Color Kinetics, Burlington, Mass.

In the LED and SSL industries today, lumen maintenance often is used as a proxy for the lifetime of LED-based systems. But lifetime is not the same as lumen maintenance. Period.

The standard LM-80-08 measures lumen maintenance of the LED devices and brings a note of consistency. It is the first major step toward a transparent and

ILLUSTRATION: MATT WOOD

honest appraisal of one aspect of lifetime for LED systems. The figures we see of 50,000 hours or 100,000 hours—or, as I have seen in some cases, even larger figures—are not lifetime numbers. They are lumen maintenance numbers applied to products.

LM-80 details the testing procedure for determining, under specified conditions, the lumen maintenance of an LED device—no more, no less. It does not yet provide for prediction and extrapolation of these numbers, nor is it a direct measure of the lumen maintenance of a complete fixture. Prediction method development is under way, but LM-80 does provide a directly measured assessment of photometric characteristics for as long as the units are tested. While the time required to test 6,000 hours, 10,000 hours, and more is lengthy, it is required to provide a real and tested number.

Predicting lumen depreciation is the next major step, and TM-21 "Lumen Depreciation Lifetime Estimation Method for LED Light Sources" is the ongoing SSL committee effort within the organization that was convened to address this issue. LM-80 and the many standards in process should provide comfort and real specifications for LED systems. A world of consistently applied specifications and testing methods is far better and far more comfortable than one without.

Note: LM-80 was prepared by the Subcommittee on Solid-State Lighting of the IESNA Testing Procedures Committee. Kevin Dowling served as the chairman of this subcommittee.

THE LIGHTING DESIGNER'S PERSPECTIVE

Michael Hennes, Senior Associate
Cline Bettridge Bernstein Lighting Design, New York

Most lighting designers can probably point to a number of installations they have been involved with where LEDs have failed much sooner than their rated life, leaving the designer to question the reliability of LEDs while dealing with unhappy clients. This reality underscores the need for accurate, consistent, and reliable testing of LED technology.

LM-80-08 was issued with these concerns in mind, and it takes a number of good first steps, starting by defining how to report LED lumen maintenance. LEDs do not die like other lamp sources, but instead become dimmer and dimmer until barely a glow remains, making it difficult to define when LED end-of-life actually occurs.

LM-80 provides two measurement standards (conceived by the Lighting Research Center) for defining LED life: L70 and L50 define the time to 70 percent and 50 percent lumen maintenance left, respectively. Next, LM-80 addresses the many variables that affect LED testing results (and eventual real-life performance), such as ambient temperature and humidity, airflow, case temperature, voltage and current regulation, and drivers. In turn, it establishes a clear methodology of how to standardize these factors in the testing process.

Another major issue is an LED's sensitivity to high temperatures. LM-80 calls for testing at three case temperatures: 50 C (122 F), 85 C (185 F), and a third temperature chosen by the manufacturer. While 85 C is a good high-temperature target, the third temperature, which is selected by a manufacturer based on its expectations of customer applications, provides an opportunity for testing at an even higher temperature.

Yet LM-80 leaves many questions unanswered. The standard is based on testing LED packages and modules, so it is not taking into account the impact of the luminaire. This would seem to be a big gap, since luminaire design plays such a large role in LED performance. Testing also must be carried out for 6,000 hours, but it is not clear whether this is sufficient for accurate prediction of full life. The problem is further complicated by LEDs' atypical curve of light degradation, which can have an early bump upward in output, making extrapolation of a full life estimate curve from the test results difficult. Also, LM-80 strongly recommends chromaticity testing to measure color temperature shift over life, because excessive color shift is another measure of end-of-life. Yet it is not clear how this information can be integrated into the lumen maintenance reporting data or what amount of color shift over life is acceptable. Lastly, the testing only addresses lumen maintenance, or light loss over time. While LM-80 requires that catastrophic failures be reported in the test results, it is not clear how that information would be factored into the final reported life data, and it does not take into account the potential for system component failure at the luminaire level.

Clearly, additional research and standards are needed to reach the goal—data that accurately reflects the LED consistency and reliability over time—that lighting designers and their clients expect to receive. Without this type of information, lighting designers will continue to question the reliability of LED luminaires and their ability to assuredly specify these products.

THE ELECTRIC UTILITY'S PERSPECTIVE

Philip F. Keebler, Senior Project Manager
Electric Power Research Institute, Knoxville, Tenn.

LM-80-08 defines a most important test procedure for determining the lumen maintenance for LED packages, arrays, and modules. The standard establishes clear definitions needed to guide users of the test procedures. Regarding test procedures, LM-80 nicely addresses elapsed operating time and uncertainty, and it requires use of video and current monitoring of LED samples during the test period. The standard also properly specifies photometric operating conditions and measurements.

The use of LM-80 will identify the drive current to the LED samples and the lumen output they produce within the test duration of 10,000 hours. However, as utilities become more involved in advanced light sources and begin to include more of them in rebate and incentive programs, further documentation of energy and power performance—especially as LEDs reach their expected lifetimes—will help ensure that LED systems save energy as they age.

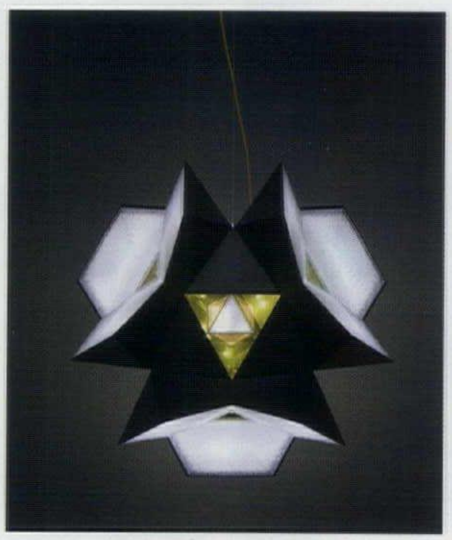
Adding a requirement to measure the input power to the LED samples in the next revision of LM-80 will enhance data collection and provide a means for further documenting power performance of sample operation during the test duration. The next revision also should consider addressing photometric performance beyond the 10,000-hour duration, provide additional guidance on specifying operating cycle times, and guide users on documenting driver characteristics and operating methods. These considerations for the next revision will help manufacturers and users better understand LED performance beyond typical operating periods to determine any drifts in photometric and energy performance as LED systems age beyond the 10,000-hour point.

Experiments In Light

ARTISTS OLAFUR ELIASSON AND JAMES TURRELL EXPLORE LIGHT'S POTENTIAL WITH THE AID OF LED TECHNOLOGY

Light can assume many different personalities. Its mercurial properties enable it to be simultaneously utilitarian and abstract. And, on occasion, when artistic explorations lead to practical applications, we are reminded of design's capacity to solve problems and re-imagine basic principles.

Collaborations between artists and manufacturers have been some of the most fruitful enterprises in creating a setting for artistic creativity and technological experimentation. Recently, Zumtobel has provided artists Olafur Eliasson and James Turrell the freedom to explore the potential of their ideas using new solid-state lighting technologies. The result is work that takes the explorations of surface, color, and form to new levels—one artist uses an object and the other uses space itself.



Starbrick, an octahedron-shaped LED light module, explores the relationship between light and architecture. It can be used as a stand-alone luminaire (above) or grouped together for dynamic sculptural and architectural configurations (facing page).

STARBRICK

Starbrick is the most recently completed collaboration between Berlin-based artist Olafur Eliasson and lighting manufacturer Zumtobel (they also are at work on a façade in Reykjavik). Eliasson's work is rooted in the phenomenological exploration of space and nature, and Starbrick is the result of his investigations into "the spatial challenges involved in the shaping of a complex geometric brick." The form of each Starbrick module starts with "a cube on whose six surfaces additional cubes have been placed at a 45-degree angle." These additional cubes function as connectors, allowing the Starbrick module to be assembled into configurations of any size and shape.

First introduced as a prototype at Euroluce in 2009, the octahedron-shaped module is fabricated from injection-molded polycarbonate components with a matte black finish and a semitransparent yellow core of reflective surfaces backlit by LEDs. Measuring approximately 21 inches wide by 22 inches long by 18 inches deep, each module's light from its outward-facing LED boards is evenly distributed via the polycarbonate refractors. The LEDs are arranged to emit white light and to create a luminous yellow kaleidoscopic effect in the center of the module. Because the LED technology is dimmable, Starbrick provides both directional and ambient light while expressing different qualities and hues of light produced by the LEDs. When multiple Starbricks are stacked, the number of opaque surfaces is limited so that the prominent feature between the bricks is the actual light.

"I have attempted to develop a module that, while functioning as an object in itself, can also be assembled to form multiple basic architectural elements such as walls, whether freestanding or integrated into an overall structure, suspended ceilings, columns of all shapes, sizes, and volumes," Eliasson explains. And yet, Starbrick is much more than a singular object; it is a repeatable unit that merges light and volume. The sculpture/fixture/module allows Eliasson to ask larger questions, such as "How does light define space?" and "What politics of light infuse our immediate surroundings?"

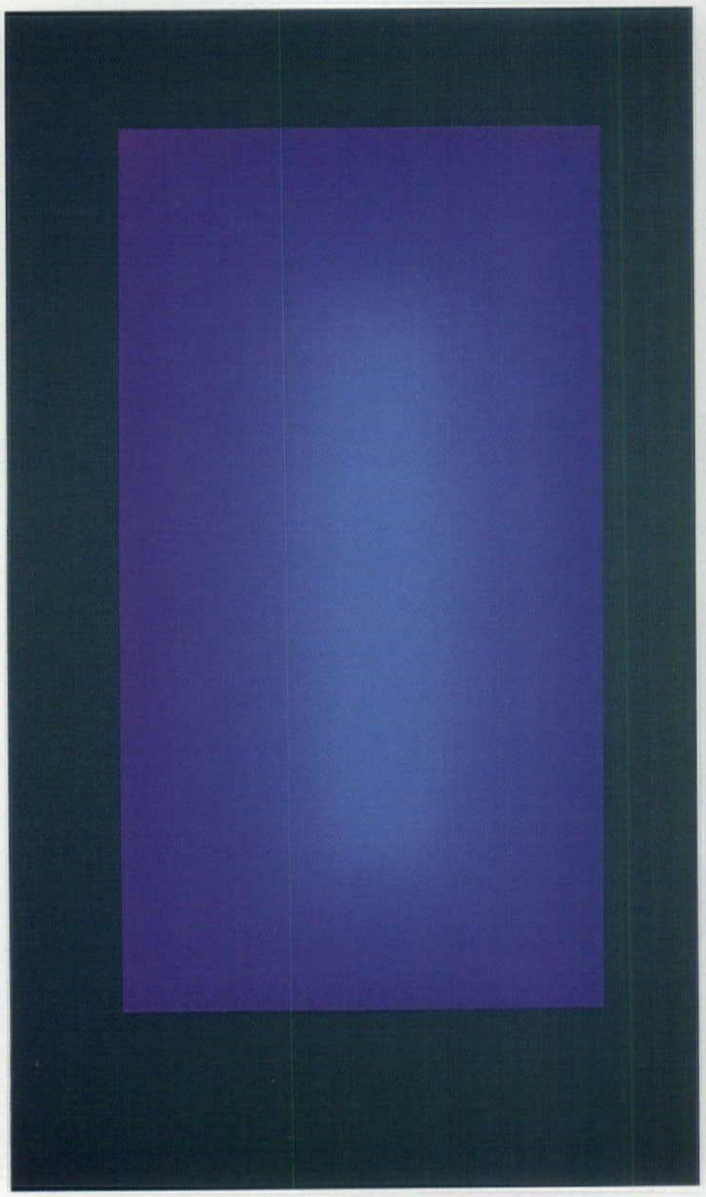
THE WOLFSBURG PROJECT

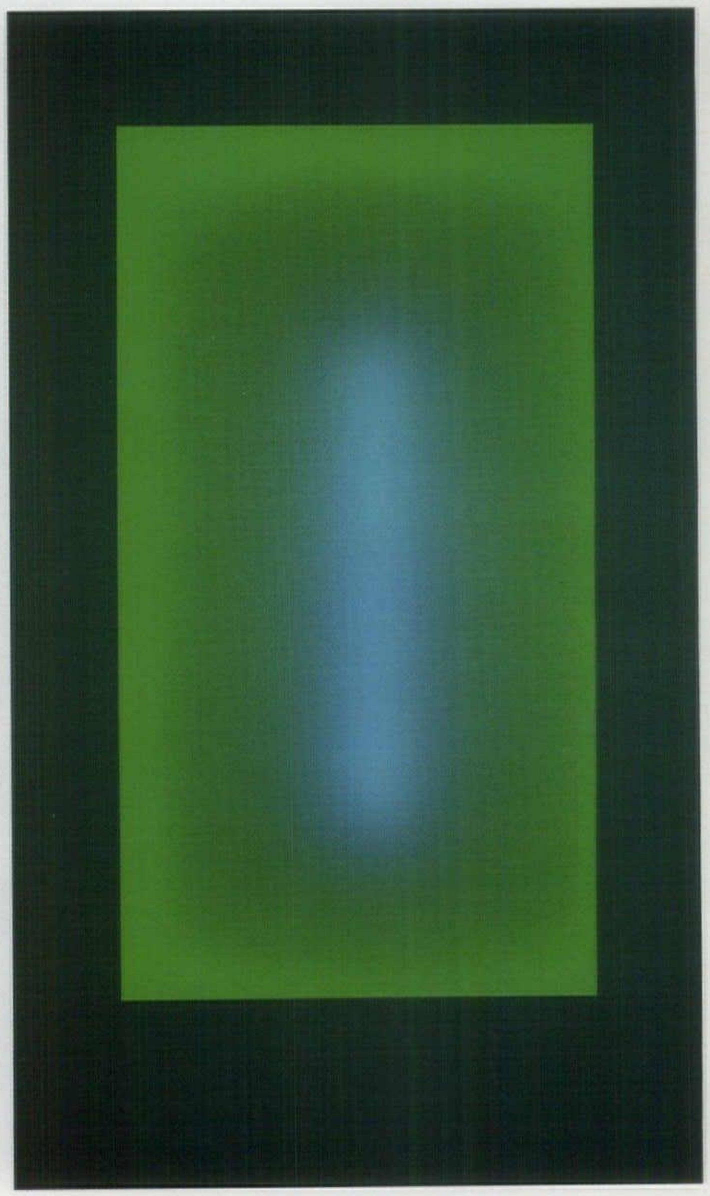
How light defines space and informs our surroundings are issues that have been at the core of artist James Turrell's work for the past 30 years. Known for his large-scale installations that challenge how we perceive light, color, and space, his most recent work is the Wolfsburg Project, also a collaboration with lighting manufacturer Zumtobel. On display at the Wolfsburg Art Museum in Wolfsburg, Germany, through Oct. 3, the exhibit showcases the largest ganzfeld piece Turrell has ever installed in a museum.

And Turrell is known for employing the ganzfeld effect—a phenomenon of visual perception caused by staring at an undifferentiated and uniform field of color that when viewed for even the shortest amount of time causes the eye to loose its ability to differentiate depth perception and color—in a number of his installations. The piece in Wolfsburg measures nearly 40 feet tall in an area of approximately 7,530 square feet. It's set up in two connecting rooms, named "Viewing Space" and "Sensing Space," both of which are bare except for the flood of slowly changing colored light. Museumgoers are submersed in this aura of pure light for a complete sensory experience, a situation that requires a sensation that Turrell describes as "feeling with one's eyes."

While similar in quality and effects of light that his other work is known for, what sets this Turrell installation apart from his other works is its very large scale. Once again, technology steps in to play a role in the form of source, luminaire, and controls. Linear fixtures and spotlights equipped with 30,000 LEDs and controlled using DMX protocol were used to create millions of different colors and more than 65,000 different levels of brightness.

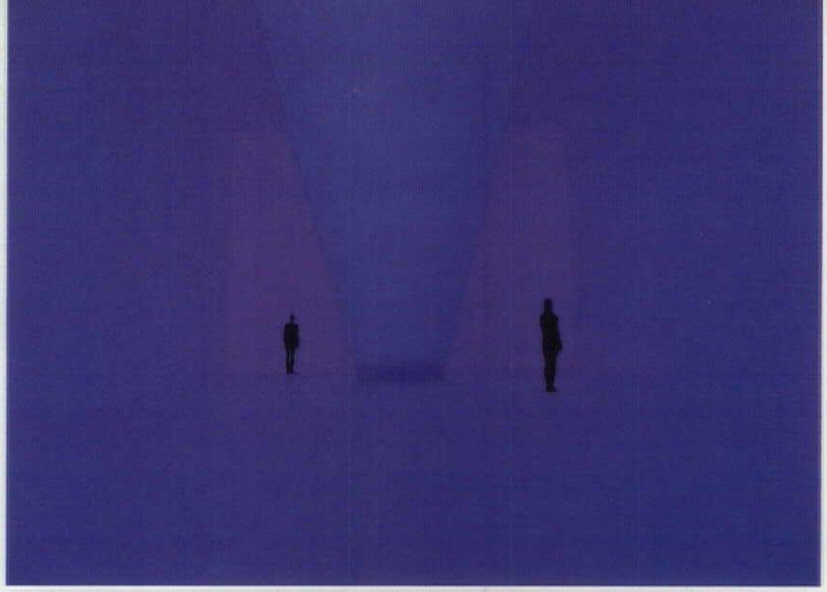
Accompanying the ganzfeld installation is the exhibition's second Turrell piece, "Tall Glass," a frosted white glass panel backlit with 15,000 LEDs

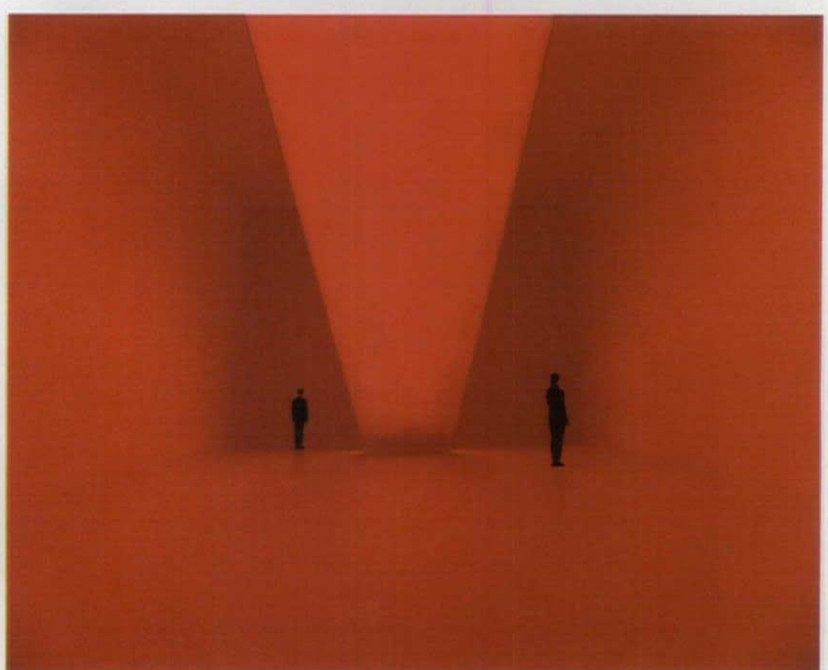


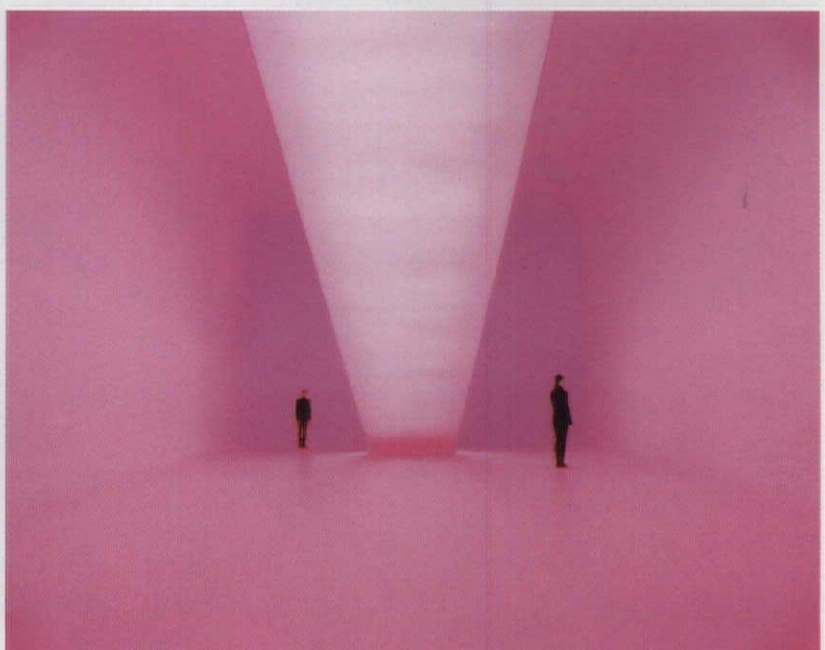


that cycle through millions of colors in a program that runs for 200 minutes. Different colors of LEDs—red, green, blue, yellow, white, and bright white—are used for the individual light points and they create a dynamic yet fluid change of color. Custom-selected LEDs (with particular focus on the binning process) were chosen to withstand the required color intensity and saturation for the color sequences along with a five-channel control system also specially developed for this artwork.

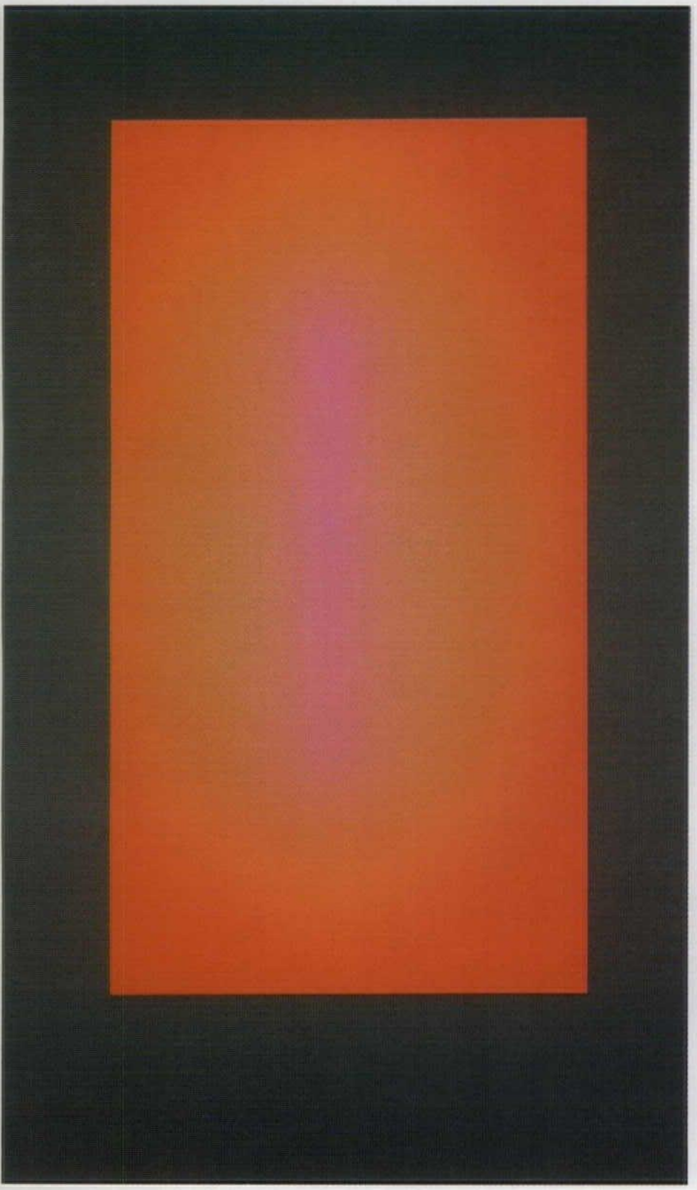
From the experiential to the art of the everyday, Turrell and Eliasson not only push the boundaries of light's artistic potential but the technology to make it happen. In doing so, they defy conventional expectation and enable us to experience light in a whole new dimension. ELIZABETH DONOFF

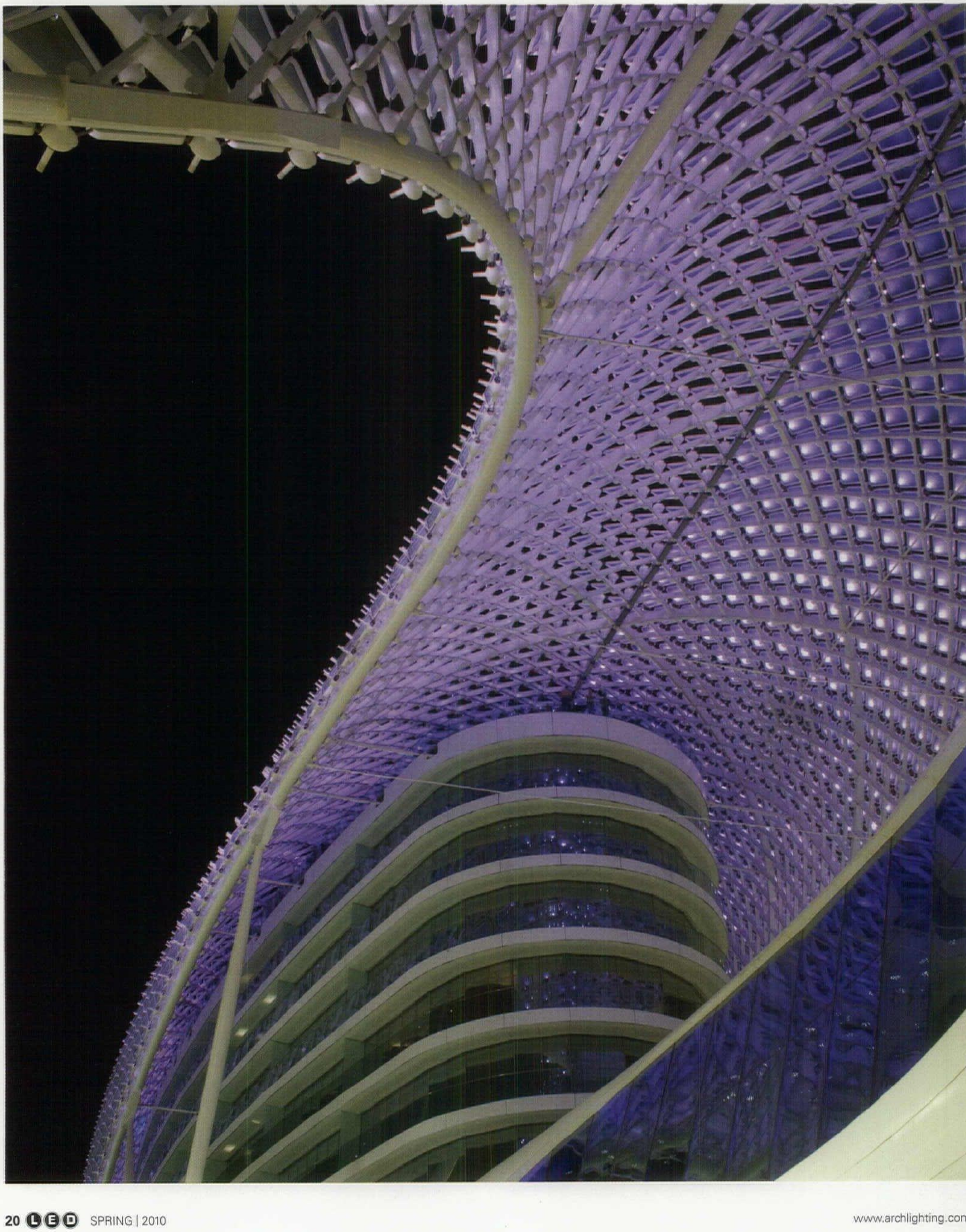






Artist James Turrell's installations at the Wolfsburg Art Museum, a ganzfeld piece (right) and "Tall Glass" (below), explore the dynamics of space, color, and surface through the use of light. LED technology helps achieve the color saturation and control capability.





SHIMMERING VEIL

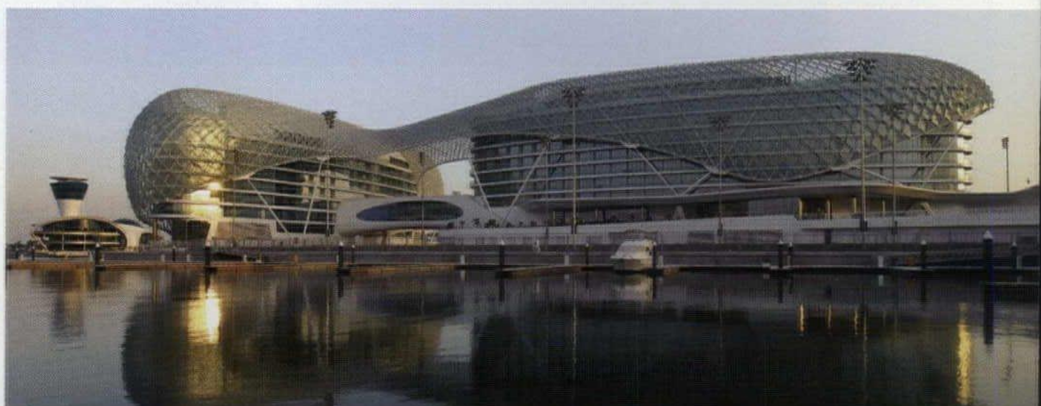
A SOPHISTICATED LED SYSTEM BRINGS THE EXCITEMENT OF FORMULA 1 RACING TO ASYMPTOTE'S YAS HOTEL

Project Yas Hotel, Abu Dhabi, United Arab Emirates **Design Team** Asymptote Architecture, New York (lead architect); Arup Lighting, New York (lighting designer); Dewan Architects & Engineers, Abu Dhabi, and Tilke & Partners, Dubai (local architects); Dewan Architects & Engineers, Abu Dhabi, and Arup, New York (structural engineers); Schlaich Bergermann und Partner, Stuttgart, Germany, and Waagner-Biro, Vienna (grid-shell engineers); Front Inc., New York, and Taw & Partner, Hamburg (façade consultants); Gehry Technologies, Los Angeles and New York (grid shell BIM consultant) **Project Size** 850,000 square feet (overall); 183,000 square feet (grid shell) **Project Cost** $608 million **Manufacturers** Cooper Lighting and Safety, e:cue Lighting Controls, Enfis

Since its formation 20 years ago, New York–based architecture practice Asymptote has had a love affair with technology and light. In a number of conceptual projects and installations, co-founders Lise Anne Couture and Hani Rashid have played with these two elements to discover different ways to transform a building's skin into a living, breathing surface capable of mapping phenomena and projecting emotion. But they had been waiting for a project whose program and budget would allow them to undertake such a technological exploration. A recent commission to design a hotel at the Yas Marina Circuit—a Formula 1 (F1) racetrack on an exclusive island development in Abu Dhabi, United Arab Emirates—offered the perfect opportunity to develop these ideas on a grand scale. "We salivated at the prospect of being able to build something that would have a relationship to the cars, but also a framework based in the atmosphere of the desert and the way the light is by the sea," Rashid explains.

To harness the energy and excitement of F1 racing, the architects arranged the 499 rooms of the 850,000-square-foot hotel into two towers that straddle the racetrack. A two-story bridge housing a hotel bar connects the towers and provides a perfect perch from which to watch the races. Then Asymptote looked to the ways people in the Middle East traditionally have fended off the heat: tent structures, veils, and kaftans. "These beautiful, poetic forms culminated in a sensual and technologically advanced skin that we could drape over the building, sheltering the rooms from the light and producing some amazing events that would tie back to the race," Rashid says. Collaborating with a team of lighting designers, engineers, modelers, and fabricators that included Arup Lighting, Schlaich Bergermann, Gehry Technologies, and Waagner-Biro, the architects realized this vision in a fluidly formed 183,000-square-foot grid shell structure of steel and glass. During the day, the shroud hovers protectively above and around the hotel guestroom buildings, creating a stack effect that draws hot air away from the building envelope. At night, the structure becomes a screen set in motion by thousands of custom LED fixtures.

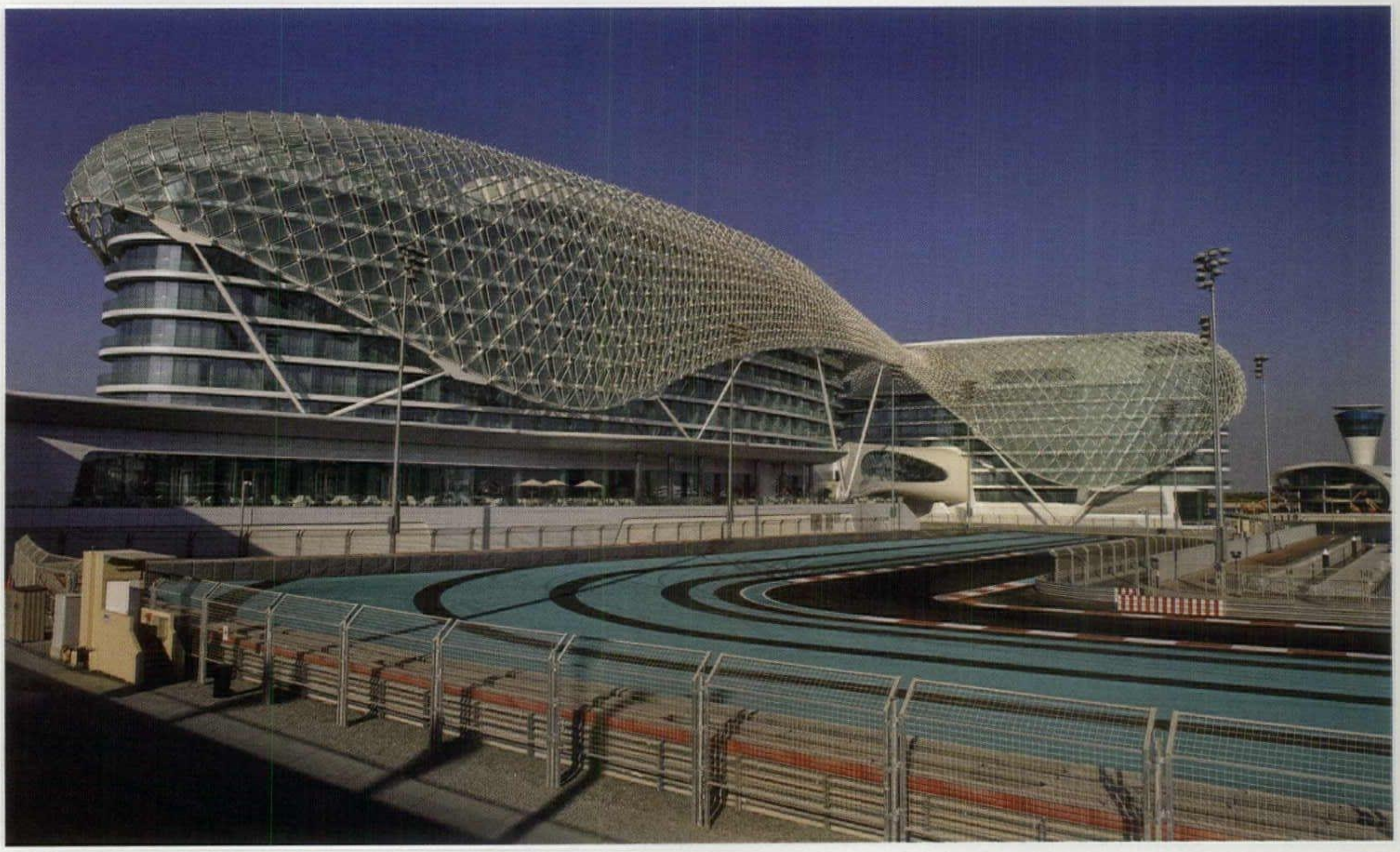
Even with a relatively high budget (construction costs ran to $608 million), Asymptote's design threatened to break the bank. The fluid form that



Not your typical lodging, the Yas Hotel in Abu Dhabi is part of a larger complex, which includes a marina and a Formula 1 racetrack. The building's signature feature is a 183,000-square-foot grid shell structure of steel and glass that by day shields the hotel from the sun (above), and at night becomes a canvas for animated light displays (facing page).

it originally envisioned for the grid shell required the construction of thousands of uniquely shaped panels. The most economical solution—a pair of domes joined in the middle—would have compromised the design. However, through parametric modeling, the team was able to arrive at a compromise that not only maintained the flowing geometry but organized the 5,800 panels into 180 standard shapes while meeting the budget requirements.

Another feature of the grid shell that needed to be re-evaluated because of its cost was the use of moving parts. "The original idea was that the motion of the cars would trigger movement in the panels, so the skin would seem to shiver and the whole thing would flicker," Rashid says. Fortunately, a close semblance of this effect occurs without manipulating the panels. Instead, each lozenge-shaped panel of laminated low-E glass is positioned

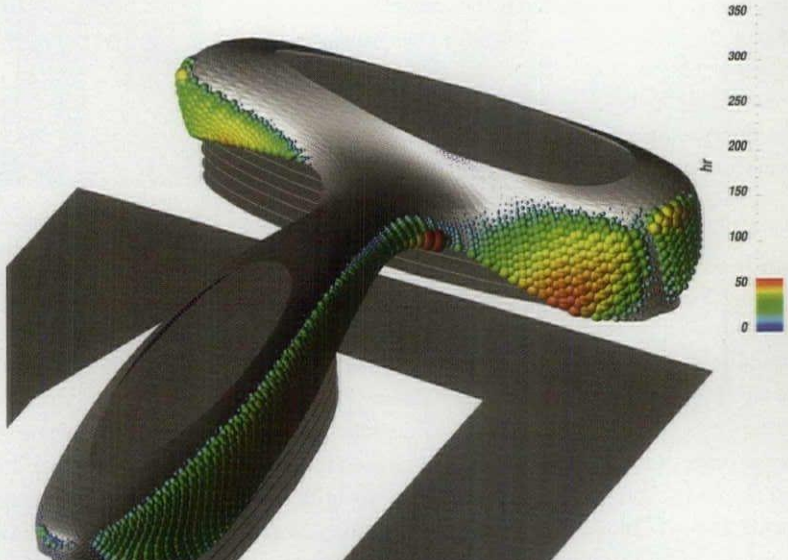


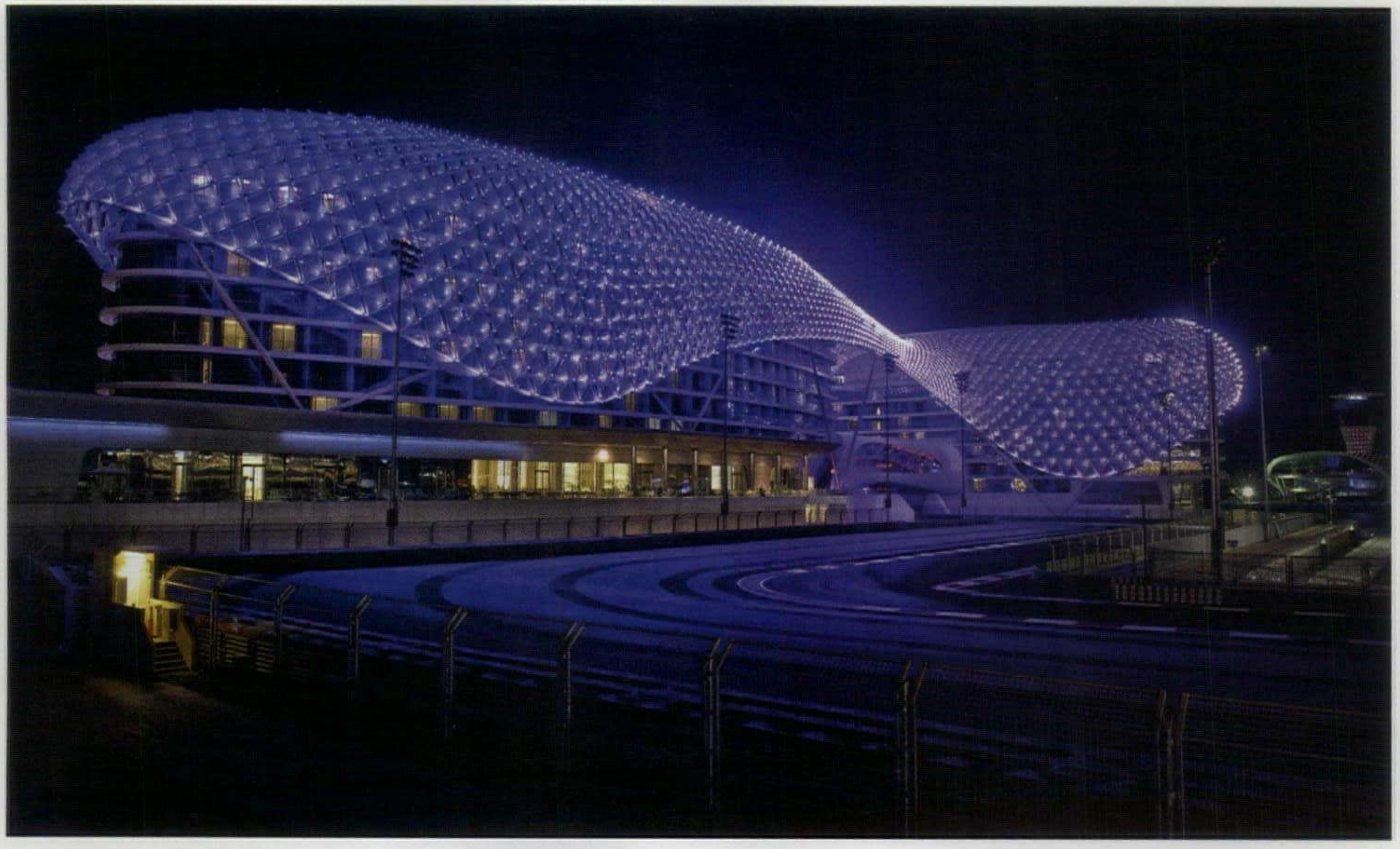
Asymptote Architects and Arup Lighting devised a frit pattern on the grid shell's glass panels to diffuse light and reduce glare, and integrated a custom-designed LED fixture atop each structural node (facing page bottom). The grid shell is designed so that light does not interfere with the hotel rooms or the racetrack, either by day (above) or by night (facing page top). Arup Lighting conducted extensive solar studies (below) so it could precisely position the grid shell panels for maximum solar control.

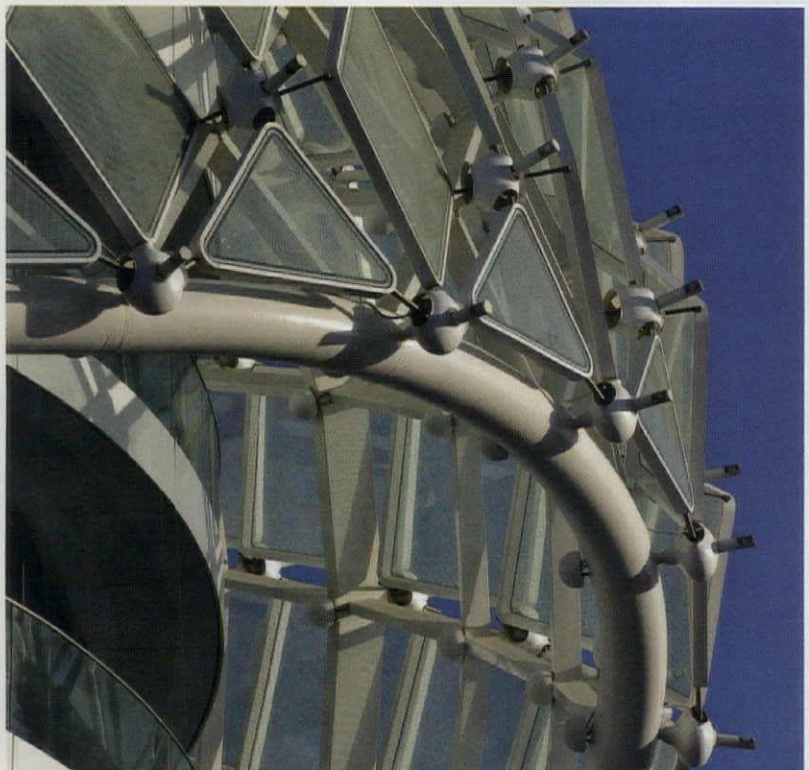
in its frame to produce a varied reflection, so that the light—natural and electric—glimmers across the surface as a viewer's perspective changes. Asymptote and Arup Lighting were careful to position the panels so as not to shine light into the eyes of the drivers below or into those of pilots passing overhead—a serious concern. A frit pattern in the glass helps to diffuse the light and reduce the glare, keeping the natural lighting comfortable in the hotel rooms while maintaining a shimmering aspect on the hotel's façade, much like a snake's skin or the scales of a fish.

The grid shell comes most to life, of course, at night, when 5,800 fixtures with RGBW LEDs, each targeted at a dedicated panel, fire up to transform the structure into a giant animated display. The choice of LEDs seemed an obvious one, but it did present a unique challenge. "Day one was: We're going to have this media façade; great LEDs!" says Brian Stacy, project director at Arup Lighting. "Day two was: Wait, what did we agree to? A desert is the antithesis of an ideal environment for LEDs."

To a great extent, the performance of LEDs depends on the ambient temperature of the operating environment, and overdriving them in high temperatures—such as those found along the Persian Gulf—can result in the LEDs failing. Arup Lighting worked with a number of manufacturers to find a way over this hurdle, most of which involved designing custom fixtures with large heat sinks. The most elegant solution used a standard fixture







outfitted with remote device management (RDM) DMX control. This system allows bi-directional communication between the fixtures and a central computer, which monitors their temperature and dims the entire display before overheating can occur.

The luminaires are positioned at a distance from the grid shell on posts atop the structural nodes, and they cast their light down onto the glass panels. "Because the panels come in different shapes and sizes, we had to come up with a design solution that provided variable beam adjustments and variable intensities," Stacy says. "So when you have 100 percent on one panel it looks similar to 100 percent on another panel." Arup Lighting developed software that adjusts levels to create a consistent look. They also based the frit pattern on an algorithm that varies the density of the ceramic dots to encourage an even diffusion of light across the glass surface. The fixtures are woven throughout the grid, terminating at the shell's structural nodes in steel globes that contain the electronics for the control system.

Asymptote and Arup Lighting then worked together to come up with a framework for the animated sequences. "We wanted the video feed to create these conceptual effects of breathing and undulating," Rashid says. "But what it came down to were lighting effects that were suitable to the race." Indeed, while watching the waves of color race across the surface of the grid shell the first sensation that comes to mind is speed—not just the speed of F1 cars, but also the speed of LED development, which each year extends the possibilities for designers to expand their means of expression. **AARON SEWARD**

Peter Ngai

AN ENGINEER AND RESEARCHER WITH AN EYE ON INNOVATION AND DESIGN

An electrical engineer by training, Peter Ngai didn't plan on a career in lighting. Instead, lighting found him during an elective course needed to complete his undergraduate degree at the University of California, Berkeley. Ngai, a nationally recognized authority on lighting technology and luminaire design, has spent all but two of his 30-plus-year career at Peerless Lighting (now part of Acuity Brands Lighting). His research in fluorescent lighting pushed the technology from T12 to T8 lamps in the '80s and then from T8 to T5 lamps in the '90s. Interested in how lighting technology can achieve energy efficiency while maintaining design integrity, Ngai has turned his attention to solid-state lighting, which he believes will become the mainstay of the industry. But no matter the technology, at the root of Ngai's passion is lighting's ability to express human experiences. As Ngai says, "Good lighting is the soul of what we do." ELIZABETH DONOFF

What have been the "game-changers" in the industry?
Energy efficiency, codes and regulations, understanding the basic science of lighting, and the creation of a generation of lighting professionals.

If solid-state lighting is the future, can the lighting industry comfortably meet the pace being set by the semiconductor industry?
The lighting industry has been a slumbering giant. Now we have a very strong companion industry—semiconductors. They have trained their eye on lighting. They can help propel us to the next level.

Where do you see solid-state lighting heading?
We've already experienced some of the pitfalls of early LED luminaire designs. Now we have a better understanding of what LEDs can provide so [that] they can make a real impact on the design of lighting.

Can technology ever get in the way of design?
[New technology] can be intoxicating, but we have to remember that it is simply a foundation—so that lighting remains our focus.

What goes into a great design for a light fixture?
A great luminaire is one that can celebrate lighting with light.