Leading lighting manufacturers and designers recognize that the widespread adoption of energy efficient solid-state lighting (SSL) sources will not occur based solely on energy costs. Lighting accounted for a modest 12% of total U.S. electrical consumption in 2011[1], with the split between residential and commercial sectors being approximately 40% and 60%, respectively, of all electricity used for lighting. Ultimately, the combination of energy efficiency, design, quality, performance and price point will determine how much market share LEDs claim against incumbent technologies in commercial and residential applications.

Incandescent bulbs are woefully inefficient, with only 5-10% of the electricity consumed converted into useable light and the rest wasted as heat. Compact fluorescent lights (CFLs) are more efficient, but have fallen short in terms of performance and longevity. Conventional thinking has been that SSL definitely produces energy savings, but the quality of the lighting might be less than optimal. In fact, SSL has made enormous strides since starting out as a novelty product. LEDs are now a viable option in a wide range of applications.

Several years ago Molex joined with a group of companies and government agencies to prove that SSL could be used to dramatically reduce energy usage, while providing excellent quality lighting. Results of the ZEBRAlliance demonstration conducted by the Oak Ridge National Laboratories (ORNL) showed how energy savings and LED lighting quality and aesthetics can be achieved by leveraging the right design and technologies.

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Kevin Willmorth, owner of Lumenique, LLC, designed the LED lighting in home #4 to demonstrate the capacity of LEDs to enhance design, deliver proper illumination levels and reduce energy use simultaneously. The goal was to make the lighting designs functional and aesthetically attractive. Home #3 featured CFL and linear fluorescent lighting selected from conventional luminaire showroom sources. The completed design resulted in 2.1 watts per square foot total lighting for home #3. Home #4 featured Molex’s custom GU24 120VAC LED light sources throughout. This first generation of Transcend lighting envisioned a direct AC line voltage LED product built into an assembly that easily snapped into a fixture using a standard GU24 socket. With Transcend, Molex wanted to deliver on the promise of bringing LED back to the nature of the plug-in socket of traditional light bulbs but with an LED source. No commercial fixture products were available at the time of construction so Lumenique custom designed the fixtures for this application.

Lumenique designed luminaires to integrate Molex Transcend light sources, each of which contained a single AC LED produced by Seoul Semiconductor and provided roughly 150 lumens of warm (3000K) light and consumed 4W of power. The light level was not nearly as high as today’s 1,000+ lumen LED light sources, but with a proper lighting design, the team achieved excellent results. Lumenique’s design approach focused lighting where it was needed to avoid waste and glare. They calculated optimum light levels in different living areas, utilizing illuminance renderings and numeric calculations to visualize light patterning. The completed design resulted in less than 0.3 watts per square foot total lighting.
The homes were unoccupied between 2010 and 2012. Occupancy was simulated through automation and robotic control, minimizing the potential for differences due to occupancy habits. All aspects of energy use within the homes were measured and data was collected for two years. Home #3 and #4 were identical in style and size. Both homes were controlled to the same duty cycle, and the two homes had the same wired light circuits for making a fair comparison between SSL and CFL light sources.

The four homes were monitored continuously for two consecutive years. After two years of field data collection, the lighting energy load in home #4 using the LED lighting system was shown to be 55% less than the CFL lights used in home #3. The results prove energy savings are possible and also demonstrated the aesthetic value of a total lighting design approach rather than focusing exclusively on lumens per watt.

In final visual comparisons, the LED-equipped home provided more task lighting with less glare, and improved appearance and color in a number of areas over the CFL-equipped home. According to the Home Energy Rating System, the ZEBRAAlliance homes had a rating of about 45, which indicates a 55% energy savings compared to conventional code-built homes. LEDs resulted in significant energy reduction throughout the house (e.g., 42% reduction in main entry, 65% den, 60% dining room, 70% living room, 73% kitchen).

**TRANSFORMATIONAL DESIGN PLATFORM**

Beyond energy savings, it’s important to look at how LEDs can add value to lighting designs. CFL has long been a mainstay recommendation for efficient lighting. However, CFLs can offer neither the energy savings nor design flexibility of directional LEDs. Early attempts to retrofit LEDs into existing lighting fixtures and shades produced less than desirable illumination and shadows. The high cost and low quality of LED illumination turned off some consumers accustomed to economical incandescent bulbs. Longevity and energy savings appealed to early adopters, many of whom ended up feeling shortchanged as they were paying more for products that delivered inferior lighting effects.

Despite a slow start, estimates show market growth with LED technologies is projected to meet an estimated 50% of all lighting by 2020. Industry focus has shifted from well-documented energy savings to how best make aesthetically appealing, more functional LED products that consumers want. Capable of emitting a higher quality and quantity of light without sacrificing energy efficiency, today’s LED technologies can provide more than replacement value. The right blend of technologies can offer a transformational platform to create entirely new and unique lighting designs.

Compared to today’s technologies, the LED modules used in the ZEBRAAlliance demonstrations were of low luminance but provided sufficient illuminance with proper placement. Many newer LED products are more modular, thinner and provide equivalent or better light quality and aesthetics to CFL and incandescent bulbs. The quality of light provided by next-generation LED chips has dramatically improved and LED lights now come standard to 1,000 lumens. Molex Transcend light sources have also evolved and feature a magnetic low voltage interface so users can effortlessly configure, adjust, upgrade or replace light sources on-site as simply as changing light bulbs of the past. The power rail and power sockets eliminate the need for additional power attachments. The integrated light source package includes optics, thermal management and electronics to reduce time to market on new lighting designs.

Transcend low voltage light sources are safe, easier to install and magnetically transferable anywhere throughout a home or commercial space. Powered by a 24V DC Class 2 power supply, the latest Transcend portfolio offers a range of lumen outputs, color temperatures and beam angles, which all work with the same track and power supply for adaptability to a variety of fixtures, including under cabinets, linear pendants, down light cans in addition to decorative and flush mount fixtures in residential, retail, hospitality and commercial applications. Lighting manufacturers can choose from a range of lumen output and CRI (color rendering index) options, including CRI greater than 95 and with a range of beam angles to achieve illumination levels that more closely resemble traditional 60-100W incandescent bulbs.
NEXT-GEN LED SYSTEMS: INTEGRATION AND INNOVATION

Pairing LED technology with a self-contained, modular design has the potential to dramatically change the way users interact with lighting. Continuous power rails or single power sockets and magnetic light modules allow users to create lighting effects and change brightness or ambiance themes. The user simply places a module anywhere along the top or bottom of an installed magnetic rail or into a single magnetic socket to produce instant illumination. More light simply requires adding higher intensity modules or using additional modules. By repositioning modules one can quickly set up a task staging area or create a dramatic effect. The bold, modern and smart approach allows users to determine the right individualized level of brightness for their commercial or residential space.

Design innovation, quality, ease of use and aesthetics will remain critical challenges to LED development. Being a lower power light source, LEDs offer an ideal blend of energy savings and design flexibility. The LED price factor needs to be addressed through greater integration of the heat sink and power supply. Optics can be optimized with the LED to improve quality and drive down cost. Heat-generating silicon chips can be managed by integrating low voltage magnetic rails that transfer heat away from the LED and into the fixture surface where it disperses the heat.

Newer designs go well beyond traditional bulb delivery systems, with newer LED designs featuring easy, fun, and changeable colors, brightness and color temperature. Using magnetically coupled LEDs with 12 or 24V DC, rather than traditional 120VAC power, lowers the voltage to enable maximum portability within a space without high installation costs or risk of electrical shock to the user. Low voltage lighting also reduces the capacitor burnout risk associated with the power supplied in LED bulbs.

12V or 24V power for LED lighting can be delivered in a number of ways. Technologies such as solar and wind allow the storage and use of renewable energy without having to convert it through a separate “power brick.” A further benefit of direct voltage power conversion is being able to simultaneously power multiple devices. In more traditional homes, conversion of line voltage to low voltage offers opportunities to enhance control while reducing individual fixture unit costs by eliminating redundant power supplies.

Longer term options for providing power for lighting in commercial applications include Power over Ethernet (PoE). With many existing buildings already wired for PoE to bring power and data to computers, phones, access points and security cameras, etc., it is an easy transition to add low voltage lighting and controls to the list. Standard CAT5e/CAT6 cables along with standard RJ45 connectors could provide both power and controls such as dimming, emergency lighting and notification, energy harvesting and security.

LEVERAGE LED DESIGN & TECHNOLOGICAL CHARACTERISTICS

The ZEBRAAlliance project provided a valuable glimpse at how technology and science can make dramatic changes in the cost of heating, cooling and lighting energy use. Choosing the right technologies and exploiting the advantages of SSL-LED light sources can improve lighting design of residential homes and commercial buildings and reduce energy consumption by as much as 55% when compared with CFL or 80% compared with traditional incandescent bulbs. In review of the completed project in terms of the current state of technology, Willmorth estimates an additional 45% energy savings could be realized while retaining all gains in lighting quality, plus additional savings and performance from being able to apply more refined control using distributed low voltage technology.

As production ramps up on reliable and attractive SSL designs, LEDs become a more attractive option for manufacturers and a better value in the eyes of consumers. Industry can expect continued technological and design improvements. New and better approaches to power and control low voltage LED lighting can add significant intelligence to lighting systems and accelerate customer return on investment through energy savings, reduced energy costs, elimination of separate copper wires and can revolutionize how lights, and buildings, are powered, controlled and optimized. Costs will decrease as LED products become mainstream, providing opportunities to make strides into the residential market in ways that CFL failed and is incapable of addressing. Solid state LED lighting is rapidly becoming the best option for high quality, dimmable and low energy lighting. In time, as has been demonstrated here, it is inevitable this will have a significant impact in the residential lighting market, a market that to date has been resistant to change based solely on energy efficiency.

REFERENCES:

A leading manufacturer of some of the most innovative and reliable interconnect products in the world, Molex’s extensive product range includes sealed and unsealed interconnect solutions, wire and cable assemblies and thermal management expertise for a complete range of lighting segments. By combining best-in-class electrical, thermal and optical expertise with innovative ‘in-house’ design and manufacturing capabilities, Molex has created new ranges of LED light modules specifically designed to overcome LED lighting challenges. For more information please visit www.molex.com.

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