



LED

The 'most disruptive technology' to affect the lighting industry since Edison?

$$R = (V_S - V_L) / I$$

A White Paper examining the channel impacts of LED technology
by
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Disruptive Technology

A convergence of the semi-conductor and electro-mechanical industries.

LED is everywhere these days. The 2009 LightFair exhibit had more LED displays than all other lamp sources combined. If you were a casual observer walking the Javits Center, you could easily surmise that lighting IS LED any more. In this white paper we explore: the strategic impacts of LED, what the downstream implications for wide-spread LED usage may be, the impending channel implications and finally, can anyone really make money selling LED?

LED Impacts.

LED technology has exploded, with efficacies and color control expanding in a near-parallel rate as Moore's Law of technology growth. (Specifically, Haitz's Law predicts the rise in efficacy of LED technology). The lowly 'indicator light', first discovered in 1907, has now emerged as a viable source for commercial lighting applications. At the current cost versus benefit ratio, the investment community sees this as a huge growth industry and is pouring \$100M's of dollars into emerging companies. LED is truly an emerging technology, fraught with a host of problems to reconcile over the next decade, but bestowed with enormous potential to impact our definition of 'lighting' and building technology for decades to come.

LED sources are now approaching a 'lamp' efficacy of 100 lpw. Overall fixture efficacy is confounded throughout the lighting industry by the incorporation of the entire luminaire system; ballast losses, lens media, reflector efficiency, and ambient temperatures (for fluorescent primarily). The standard methodology of assessing lumens/watt is as a pure lamp function; lamp watts, operated under ideal lab conditions without including any wattage losses of ballastry or control devices. As such, with a diode performance approaching 100 lumens/watt, it would be competitive to most fluorescent applications with the added feature that it is environmentally 'green'; while fluorescent still has the stigma of mercury pollution and attendant disposal issues.

LED re-opens a dialog throughout the electrical construction industry. Functionally a DC system, LED technology, if broadly applied could lead to an emergence of dual power distribution systems within commercial spaces. AC power for all analog applications; space heaters, coffee makers, cleaning/vacuum systems, circulating fans, electrified window treatments, door openers, etc. DC power for all digital equipment: computers, LED lighting, phone systems, alarm systems, sensors and controls, chargers, TV's, etc.

Functionally, the discussion of DC versus AC power distribution is outside the scope of this paper. However, the merits of a DC system versus an AC system have been argued since Edison v Westinghouse; with a mini-resurgence of the debate due to the emergence of LED technology for commercial lighting.¹ Lighting accounts for roughly 43% of a building's energy consumption.² Current technology development of LED is moving rapidly to AC LED systems. Since the electrical industry is nearly exclusive AC, it is

logical to assume that LED will move more towards AC than trying to move construction trends into adopting a dual DC power distribution system. It is conceivable that the lighting circuits could be established in 12VAC, although newer trends in LED are accommodating voltage inputs up to 277V.³ Once LED is commercially viable in mass application, that energy load will diminish with a cumulative savings in reduced HVAC loads. Whether there are enough potential savings in moving to a DC distribution system is arguable, however the debate for DC vs. AC has been going on within the Data Center market for some time due to the high density of DC devices (computers). I'd recommend reading Neil Rasmussen's white paper on the advantages of high voltage DC systems for Data Centers.⁴

LED issues.

LED comes with a litany of problems. At the recent Strategies in Light conference in February, 2009, there were over 300 LED companies listed as capable of providing LED fixtures. Those companies are ADDITIVE to the over 800 commercial lighting fixture manufacturers in the US currently. With this large of a rush of new entrants into 'lighting', there are myriad issues to be resolved:

- **Confusion.** LED technology changes monthly. The claims of the LED companies that are producing LED dies, power supplies and boards are all over the map. Basic definitions of lumens per watt are confounded by whether the power supply is included or not. Life spans range from 35,000 hours to over 100,000 hours. Life span is generally regarded as the point of 70% lumen depreciation of the diode, but there is little press given to the life of the other board components and drivers.
- **Standards.** There are very few standards for LED technology, although NEMA and other organizations are working towards that purpose. Currently, most of those 300 manufacturers of LED equipment are not UL listed. Some are CSA, some are EU certified, but caveat emptor is strongly advised before you buy.
- **Lumens.** "lighting guys" understand that lumens are the equivalent of 'distance golf balls'; more is better only if the control is there. Fixture efficacy is critical. The beauty of LED is it's a pure point source, generated within a narrower range of direction than FL sources and for many applications that is a very efficient lamp structure. Although LED's are being strung together in bands to produce broader arrays of 'point sources' to simulate a FL application for large area illumination, FL may still be the optimized solution. Not all optical packages are specific for all applications. E.g. one of my client companies prefers HID arc tube construction as an optimal source for generating the roadway distributions for their outdoor lighting applications.
- **Quality.** It can't be emphasized strongly enough that with little oversight and standards, there are numerous entrants into LED that have little to no quality control in their products. The worst case for LED as a nascent 'industry' is to install a large base of LED equipment and have it fail in one or two years (or months). If the manufacturer is touting 50,000 hours, ask about their 50,000 hour guarantee. (or more accurately, a 70% lumen output guarantee period)

- System issues. LED is functionally an integrated fixture/emitter 'system'. It's not considered advisable to simply retrofit an LED 'bulb' into an incandescent fixture, for example, because LED is temperature sensitive. Over-cook an LED and its life span could be measured in weeks or months, not years. As LED is applied as a system and lighting manufacturers design LED into their new equipment, the mindset of the manufacturer changes. Currently, lamps and ballasts are sold at an arm's length transaction. Ironically, lighting fixture manufacturers don't actually sell 'lighting'; they sell an electro-mechanical device that contains a third-party control device (ballast) that is energized by a licensed contractor and illuminated with a device bought from lamp manufacturers, sold through an electrical distributor. The warranty model for commercial lighting has remained unchanged for years. If your fixtures fail, don't call the fixture guy, he'll send you to the lamp guy, who will likely send you to the ballast guy. LED changes the game. You will now buy 'lighting' from a lighting fixture manufacturer. The ramifications are very broad: the fixture manufacturer will be directly and solely responsible for delivering foot-candles to task for a specified guarantee period. Warranty claims, quality control systems and product liability will all change. So, when the lighting manufacturer touts an anticipated 50,000 hour life span, the terms and conditions of sale will detail the actual liability of those claims. But product liability laws will soon follow suit. Manufacturers will become liable as a single point of responsibility and trade practice laws will curtail those claims of extended life, if unfounded.
- Replacement/upgrade impacts. Current lamp technology allows for commercial and residential lighting fixtures to easily last 20-30 years or more. In fact, fixture manufacturers have had the same fixture designs in their product lines for decades; with only modest changes for cost reduction or code changes. With LED sold as a complete system, how will the replacement or upgrade business function? Will manufacturers adopt a semi-conductor approach to their fixtures to mirror cell phones or desktop computers, i.e. throw them away every three years and buy the next generation with even more LED efficiency plus 5 new options you rarely need and would have never thought of?

Intellectual Property (IP) battle of the century.

LED companies universally tout their IP; how many patents they have and their level of sophistication in technology development. LED is as simple (and as complex) as 4 components: the LED (diode, or die), the power supply/driver, the pc board and optics. Within those components you get into die design, phosphors for color control and heat sink technology. I understand the leading LED companies are designing devices without power supplies and that the technology exists to eliminate the pc board with chip on heat sink technologies. As such, the discreet components are becoming fewer in quantity. I'm not an IC guy, but how many patents can you realistically develop into a system of only a few discreet pieces? (My industry network of experts advise it's a lot)

It is well known that Philips bought Color Kinetics for their IP value; based upon the multiple paid for CK, Philips has highly valued that IP asset. The number of patents and the assumed viability of that IP are considered by Philips to be a game changer in control of the new industry. Whether the CK technology is robust will ultimately be decided by the legal system. Philips is the largest lighting manufacturer in the world and presumably has more patent attorneys than all of those 300 new LED companies combined and the money and will to aggressively defend any inferred IP intrusion.

Many of the entrants into LED technology are off-shore (mostly Asian) companies who have spent decades in the development of semi-conductor technologies. Those companies have their own inventory of IP and patents, most of those registered off-shore. The looming IP battle will have global reach and will become particularly messy over the next few years. The domestic commercial lighting manufacturers are unaccustomed to the speed of technological development in semi-conductors and may be at a disadvantage from the patent and IP protection aspects for awhile.

“Lighting” will become a strategic initiative of the semi-conductor industry. Watch for LG, Mitsubishi, Sony, etc entering the lighting industry in a big way. Armed with their semi-conductor technology and aggressive marketing budgets, we can envision an entire new field of ‘big boys’ in the market in the near future.

Channel convergence.

LED is electronic. It is born in the semi-conductor industry. The newer entrants into ‘lighting’ are mostly LED/semi-conductor people. Semi-conductor people don’t regularly talk to electrical contractors who buy their materials from electrical distributors. The channel implications are already apparent. LED companies are struggling to define their channel strategy; do they only build LED components and settle on an OEM strategy, servicing the large and small fixture manufacturers? OR, do they build their own fixtures, since they already understand how to package a collection of electronic gear into a consumer-pleasing enclosure (they call them TV’s, or DVD players or iPods, etc). OR, since LED’s have an unlimited versatility to their applications, do they develop new channels; solar powered signage, medical devices, warning lights, ‘light walls’, etc?

If you’re the size of an LG or Philips, why not do all of them?

It is very telling that the OEM leader in LED componentry, Cree, has embarked on a channel diversity strategy to introduce their own LED fixtures. The Big 4⁵ will eventually forego buying from their direct competitors. Philips is already experiencing the backlash of buying Genlyte-Thomas on their OEM divisions of Philips lamps and Advance ballasts. Cree will eventually resolve their market strategy or be bought by one of the Big 4. (or acquire one of the Big 4 themselves)

The current challenge centers on the fact that semi-conductor people don't generally understand how to get to the end-user of products that are professionally installed. Hence, sales channels, contractor-friendly features and VAR/distributor relationships are foreign to them. Most semi-conductor companies go through a couple of national electronic distributors (Arrow, Future) and rely on them to become their defacto sales organization. Fixture manufacturers have layers of indirect and direct sales organizations to take their products into multiple markets (residential, commercial, utility, industrial, DOT, governmental, consumer, etc). Those multiple markets are also defined by the specification influences over product selection; lighting designers, architects, professional engineers, design/build contractors, utility standards engineers, etc.

Those layers have to be fed and trained and managed with layers of internal and external customer service support teams. Electronics companies will take some time understanding how to ramp up a sales/marketing organization to displace, integrate into or expand upon the current channels to market.

The integration of LEDs –properly—into the commercial, traditional lighting industry is quite a challenge. The hand holding and involvement of the LED array/module suppliers is significant. It is no longer a matter of taking the lamp source and the ballast where required and “fitting” it to a fixture design. Much more knowledge is required on the fixture designer's part to effectively build a good fixture. This “learning” will take some time. Similarly, the lighting specifiers must learn to work with a new set of people and learn a new technology and the proper applications for that technology. These same specifiers don't naturally trust the non-lighting LED fixture suppliers. The rush of new LED companies, some of which who are contacting the specification community adds to the confusion of information (as discussed above). LED fixture suppliers will inherently need the traditional lighting channel to get their product to market and may need a conventional lighting company to align with. The alternate approach would be to ally with traditional lighting sales rep organizations and enable them to ‘package’ them into the specification channel.

I have had meetings with many LED companies, and most are well aware of the limitations of their sales strategy into a market they find confusing. They will learn. They are actively recruiting the core commercial sales and marketing talent that has recently been shed by the larger commercial fixture companies. For every one of those downsized, older, highly-paid sales and marketing managers who were considered too costly to keep during this economic crash, they will re-emerge as the new talent to teach the semi-conductor companies the nuances of the commercial fixture sales channels. It was always assumed by the larger fixture companies that the barrier to entry into this market was the sales channel; that barrier is coming down quickly.

Price. Who can afford this stuff?

LED technology currently is largely price prohibitive for large commercial ambient lighting applications. At a premium over fluorescent, it is 3-5 times the installed cost, with virtually no return on energy savings. LED is currently being applied in large test applications where the money is there: government/municipal. It also is finding its way into areas where it provides specific attributes in higher-end construction projects; for its color-mixing capabilities in a restaurant or hospitality setting for example. The important thing right now isn't the current cost benefit ratio. Haitz's Law will bring it into practical application, fairly soon. There are plenty of niche applications where it's being accepted; cold room applications, signage, landscape lighting and some security applications. But the prize is to bring it into commercial office spaces for general illumination applications. Is it there yet? No.

But stay tuned.

I have a client company who has exhibited a full product portfolio at the past two Lightfairs which was highly praised and well regarded as innovative and exciting. They have not received a single order of LED equipment. But lots of people really like them.

LED isn't quite to the 'show me the money' stage. But the speed is picking up.

Disruptive or Eruptive?

I've been involved with lighting directly and indirectly since I was in high school. I've bent troffers on a press, by hand. I've watched this industry consolidate only to have 10 new companies spring up after each acquisition. There are about 1600 'lighting fixture' manufacturers in the US; which includes commercial and residential. The industry is 'consolidated' into the Big 4⁵, but in revenues, the Big 4 comprise only about 60% of the lighting revenues generated in the US. That means it's a big sandbox out there for new companies who have a new message, a new idea or a new technology. With the price realization of LED added into current lighting revenues, the lighting market could conceivably be 50% larger, solely due to the price impacts of selling LED equipment versus FL. The race is on to see who can garner the growth market. And as with all new technologies, the ability to deploy LED technology into applications no one has thought of yet will blossom and grow over the next several years.

Questions for the future.

How will the legacy costs embedded in capital equipment required to form fluorescent and HID equipment have a mitigating effect on the Big 4's ability to invest heavily in LED technology? Assembly plants designed to run 1000's of FL fixtures every day will need to be reconfigured to accommodate the physical differences of building a lighting 'system'. How will the remaining Big 3 (Philips has already made the move) react to investing in LED technology?

Vendor relationships will change.

- Will the Edison socket become obsolete?
- Will ballast manufacturers have a place at the table? If so, will they be building FL lamp ballasts or power supplies for LED's?
- And the lamp manufacturers?
 - Philips is already positioned heavily in LED and traditional lamp technology.
 - Osram-Sylvania appears to be well-positioned.
 - And then there's GE. Will they finally just exit the business entirely rather than invest in a technology that they would likely not be able to dominate?

Will the current formula of selling through an independent agent still apply if the newest entrants are primarily semi-conductor companies who may have an alternate viewpoint on getting products to market? The lighting rep business model is anachronistic in many ways wanting for a technological infusion to become more efficient than faxes, manual cut sheets and paper catalogs.

LED is erupting. Where the industry will go and how it will look 10 years from now should be an exciting ride.

Bibliography:

¹ *DC power distribution favors LED lighting*, Patterson and Ziegenbein, LEDs Magazine, Feb 09.

² Department of Energy

³ Lynk Labs and Seoul Semiconductor have patented AC-only devices currently available in the market. It is presumable that other manufacturers will follow their lead.

⁴ *AC vs DC Power Distribution for Data Centers*, Neil Rasmussen, 2006. American Power Conversion.

⁵ Big 4: Philips Lighting, Acuity Brands Lighting, Cooper Lighting, Hubbell Lighting

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