Arbor Capital Markets

Market Update

January 2018

Human Centric Lighting Contradicts Circadian Rhythm

In previous Newsletters Arbor Capital Markets announced its new focus on the LED lighting industry commensurate with its new partnership with industry expert Keith T.S. Ward and ACM's engagement of Arborlight, Inc., an Ann Arbor, Michigan company focused on developing and selling patented, proprietary Daylight Emulation® LED luminaires as its latest client.

In our November Newsletter we addressed the transition from conventional lighting to LED's and reviewed the consolidation of lighting and fixture companies; noting recent transaction metrics. In December we focused on the LED industry and its focus on IoT. In this issue we focus on the next generation of lighting; the transformation from Human Centric Lighting to Daylight Emulation consistent with Circadian Rhythm.

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The advent of smart tunable (color changing) ***LED lighting systems*** is changing the nature of lighting itself as well as the economics of lighting. Whereas, previously a commercial lighting decision was based on the illumination quality and cost efficiencies from reducing energy budgets, the advent of IoT and human centric lighting means lighting can not only improve efficiency metrics throughout a building and beyond, but can have a ***significant impact on customer and employee mood, human wellness, and productivity.*** Given that human resources can drive a material percentage of business budgets the economic impact of intelligent light is growing exponentially.

The primary leap forward comes with the advent of tunable lighting, providing the industry an opportunity to provide lighting solutions focused on biological stimuli known as Human Centric Lighting ("HCL") and with IoT lighting that allows remote and variable settings, connectivity, and analytical feedback. ***Arbor Capital Markets believes lighting is entering an even newer generation, that of daylight emulation supported by IoT, providing exciting new opportunities; the delivery of sustained health-promoting lighting through an IoT LED platform.***

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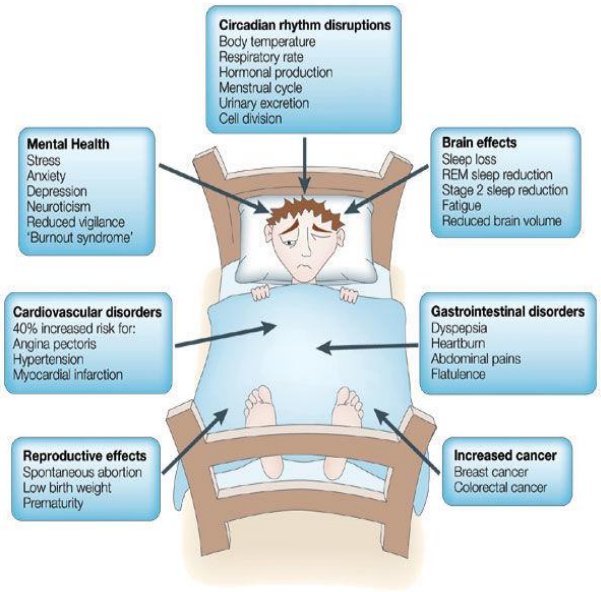
HCL enormously widens the applications of light from simply visual tasks to the support of healing processes and prevention of chronic diseases. The first generation of HCL employs application-based lighting metrics in a static environment to stimulate certain biological responses. For instance, if the application is in a traditional office then lighting systems might provide a CCT of 3000-4100 to promote employee productivity. On the other hand, a restaurant may want to set a mood by providing light with a CCT of 2400-2700 and a hospital patient room may be most effective with a CCT range of 5000-6500.

HCL can provide induced short-term benefits, but the long-term effect on health could be adverse. When used to provide static lighting, a differentiated but unchanging color, HCL is actually application-based, not human centric. It can positively affect moods and alertness or encourage sleep; achieve short-term stimuli, but unless the light is changing dynamically, over the course of the day, consistent with the seasons and geo-location, ***HCL does not emulate daylight and may actually contradict human circadian rhythm.***



Nature Reviews | Neuroscience

Circadian rhythm is influenced by the duration, color and intensity of light throughout the cycle. The major mechanism by which this is accomplished is through exposure to the appropriate intensities and wavelengths of of light at the appropriate times, which is a light intensity that increases gradually (sunrise), then displays a powerful, sustained intensity (daylight) followed by a gradual decrease (sunset) and then a prolonged period of profound darkness (night).

Interior artificial lighting is generally static in both intensity and Color Correlated Temperature ("CCT"), removing information about time of day that might otherwise affect occupant circadian rhythms.

Industry expert, Dr. Mariana Figueiro, (*Rensselaer Polytechnic Institute and Lighting Research Group*) notes "timing" is of utmost importance and static human centric lighting could disrupt circadian rhythm. In other words, ***if light is to truly promote long-term productivity and wellness, it should emulate the daylight cycle in concert with human circadian rhythm*** and advance beyond the first generation static applications of HCL.

Moreover, the speed of cultural/technological change far outstrips most evolutionary processes. This means that humans are only partially adapted to the current environment in which they live. This mismatch between biology and culture is likely to get worse as the rate of technological change increases; leading to increased chronic diseases.

Artificial light spectra have long been implicated in affecting mood, alertness, and sleep quality. The 2017 Nobel Prize in Physiology or Medicine, awarded to three Americans for their discoveries of molecular mechanisms controlling the circadian rhythm, has added credibility to recent research increasingly demonstrating that ***artificial lighting has become a public health issue***. In June 2003 researchers in JAMA cited $33B lost productivity due to depression which may be a product of lack of natural light and Seasonal Affective Disorder (SAD).

Numerous studies have demonstrated that disruptions in circadian rhythm have adverse health affects and that lighting emulating daylight increases wellness and productivity. Research undertaken by the **University of Michigan Department of Public Health: *"Light Innovations in the Workplace to Promote Physical and Mental Health" & "The Effects of LED-based Daylight Emulation Sensors v Traditional Fluorescent Lights on Health Behavior's in Office Workers"*** specifically compared Arborlight's Daylight Emulation® lighting to fluorescent lighting and found significant increases in in positive mood factors and reduction in negative mood factors and improved sleep patterns.

The solution to unhealthy light lies in the next generation of lighting, advancing from HCL to Daylight Emulation®, taking tunable lighting from static and application-based output (and thus short term

and unhealthy) to a healthy dynamic ***continuously changing light*** over the course of the day consistent with outdoor natural light and human circadian rhythm. True Daylight Emulation® can materially decrease the incidence of SAD and promote more productive and healthier living/work environments.

The foundational requirements of Daylight Emulation® are a lighting system controlled by algorithms and IoT-controls to provide continuous lighting change synched to:

- Time of Day
- Season and
- Geo-location.

Overview of Market Participants

Hundreds of LED companies produce products using varied CCT and/or blue light spectrums to provide Human Centric Lighting (application centered, discrete CCT/metric choices, limited controls).

Dozens of LED companies produce products claiming to reinforce circadian rhythms in some fashion. However, only a select few companies heavily promote controllable luminaires with the ability to replicate the cycle of natural sunlight with smart IoT compatibility and even fewer have the ability to provide IoT-supported continuous daylight emulation.

Ketra, a privately held LED company with over $11 million in revenue and over $50 million of invested capital promotes circadian rhythm lighting among its products and is rumored to be for sale, an indication of the growing acceptance that the industry is recognizing the new generation in IoT and healthy lighting.

Company	Company Metrics	Relevance of Patents	Controller/ IoT	Geolocation/ Seasonality Programming	CCT Range (applicable product)	Continuity (Color/Control)	Manufacturing / Distribution Capacity
Arborlight	**Private Small**	**√ √ √**	**√**	**√**	**2,000 to 10,000**	**√ √ √**	**√**
Ketra	Private $11m revenue 60 employees	√ √ √	√	√	1,400 to 10,000	√ √ √	√√
USAI Lighting	Private Small-medium	√	√	No	2,200 to 6,000	√√	√√
Walla Lighting	Private Small	√ √ √	√	No	2,200 to 6,500	√ √ √	√

Four companies heavily promote circadian rhythm and produce lights that allow for continuous light change over the day, but do not automate light controls to seasonality

Source: ACM assessments based on public information

Select Group of Companies Produce Products w/ Circadian Emphasis

Bios, C3 Lighting, Circadian Light, Glamox, LEDvance, Lighting Science, Soraa, and Trilux are examples of companies with promotional focus on Circadian Rhythm, some focus on blue light and/or offer only limited lighting dynamics and most generally do not allow for programmable, geo-centric, and/or continuous light change in synch with daylight.

Large Lighting Players

Some of the most established and larger LED Lighting companies, such as Acuity, Eaton/Cooper, GE, Hubbell, and Philips, offer products that address the concepts of Circadian Rhythm or Daylight Emulation®, but these products do so only in a very limited fashion. GE, for instance, offers separate residential bulbs (Align) with CCT specific for day and night, Philips offers the residential Hue product and Acuity offers commercial luminaires (Entera) with **very limited** CCT range (not capable of addressing the full daytime spectrum).

Arborlight's healthy IoT-Daylight Emulation® lighting is ushering in a new generation of healthful lighting with unforeseen and to-be-developed opportunities. In addition to providing high quality healthy lighting Arborlight's IoT control platform can be leveraged as cloud applications to independent hardware or the basis for expanding the application of light therapy by offering health professional directed lighting metrics to patients over the internet.

Arborlight's patents and commercialized products achieve the technological transformation into next generation lighting employing patented control drivers that allow for connectivity between various user interfaces (phone, tablet, computer), provide analytical feedback, and can be integrated with other building systems such that its lighting systems provide the same dawn, mid-day, afternoon and evening light that you would if you were outside in a natural sunlight environment. Arborlight is the only company with an exclusive focus on and offering true patented and trademarked Daylight Emulation®

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A Note to our Readers,

This concludes our three part report on the LED industry. Please visit *arborcapitalmarkets.com/news-publications* to review the series.

In conclusion this report addresses an industry concern....do the short term physiological stimuli from Human Centric Lighting rationalize the adverse longer term impact on health and productivity from the disruption of human circadian rhythm? We believe that the positive claims of many of today's HCL products will be challenged as research on circadian rhythm leads lighting into the next generation of Daylight Emulation®.

. We encourage you share your thoughts with us as we assist Arborlight and other LED technology companies address this growing and dynamic market.

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M&A advisory options for companies valued between $2 to $20MM is limited and often times serviced with unlicensed "finders" and national firms selling "fill in the blank" offering memorandum's.

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- Create the business-specific plan to achieve those goals;
- Develop individualized marketing documents and plans that highlight the distinct advantages of your business and;
- Market your business to a focused prospective list.

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About Us

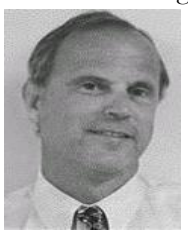
Keith Ward has nearly 40 years of lighting industry experience, including two decades of senior business leadership at Future Electronics, Luminus Devices, Inc., GE and Iwasaki Electric driving profitable growth companies, transforming traditional lighting companies while driving adaption of LED and the eco-system of supporting technologies. He was responsible for the successful restructuring of Luminus Devices and is currently serving advisory/board director roles in for MLS, LEDvance, Forest Lighting, Alternative Lighting Technology, Global Value Lighting, Arborlight, Inc. and Standard Products. Keith has a BSBA from Clarion University of Pennsylvania and an MBA from John Carroll University..

Keith T.S. Ward
Affiliate

Greg Buck has over 30 years of finance and investment banking experience as a senior executive and investor in early and mid-stage growth companies. He has served as a Partner in the Ernst & Young Corporate Finance Consulting Group as Managing Director of Alternative Investments for Telemus Capital Partners and as Credit Officer for Citibank. He co-founded Leonard Capital Markets and prior to that served as a partner of M Group, Inc, an investment firm based in Birmingham, MI, where he focused on technology investments and diversified manufacturing and service company acquisitions. He graduated from the University of Michigan with a BA and holds a MBA from Western Michigan University.

Greg Buck
Managing Director

John Palffy has over 30 years experience as an investment banker and business consultant. He was a lead investor and served on the Board of Relume, Inc (an LED pioneer). He began his private sector career as an investment banker , specializing in public offering and consolidation in the financial sector; first with Johnston Lemon & co. and then First of Michigan Corporation. In 1991 he formed JMP Financial, Inc. He began his professional career in Economic Policy with The Heritage Foundation, as Chief Economist to Dan Quayle and senior political appointee of President Reagan. He has an MBA from the University of Michigan and post graduate economics studies at George Mason University.



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