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Smart Lights | Smart Buildings

Enhancing Building Performance

Executive Summary: Enhancing Building Performance

Everyone understands what a high performance car means or a high-performance computing system. But what is a high performance building? Like a fast car or a powerful computer, a high-performance building is a finely tuned built environment that is constantly collecting data about current and changing conditions, automatically adapting to that data and providing a sophisticated degree of control to the operator.

The reason why "*high performance building*" has not entered the vernacular is because there simply aren't that many of them. While computers and cars have entered the fully digital age with thousands of parameters for command and control, buildings have remained trapped in a more analog age. Buildings lack a central nervous system and a centralized control mechanism that can provide real-time and historical data and use automation and intelligence to make smart decisions about energy usage, HVAC capacity, space allocation, and work patterns.

With a breakthrough combination of affordable distributed sensor networks and controls, a super-efficient low voltage DC power system, and a powerful software "brain" to manage building data and performance, we now have the technology base that can serve as a "central nervous system" required for true high performance buildings. This white paper will examine how these systems drive ongoing energy savings, optimize facility resources by keeping building operators fully aware about how their spaces are being utilized and operated, and ultimately maximize occupant productivity.

Introduction: What is a High-Performance Building?

There are three key aspects to high performing buildings:

1. First, operating costs are minimized. This means a high degree of energy efficiency from top consuming areas like lighting and HVAC. Maintenance issues are pro-actively brought to management's attention. And in general costs are correlated to presence (e.g. lighting goes off and HVAC is reduced when people are not around, kitchen, janitorial revolves around people being there or not.)

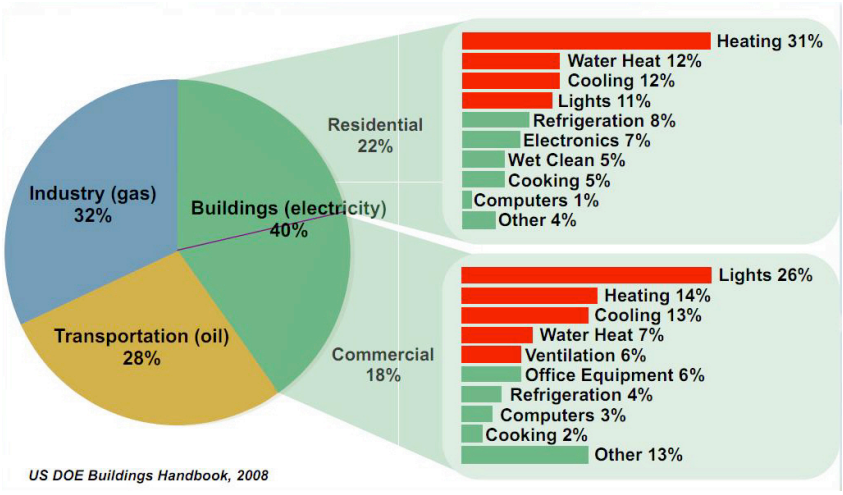
2. Second, facility resources are fully optimized. Using data from occupancy sensors, building managers and facilities teams can understand and optimize if there are the right number and type of conference rooms, how offices and common spaces are utilized, and how spaces are trafficked. This real-time and historical data can also supplement safety and security system to locate occupants in an emergency or determine where and when there is unauthorized occupancy.

3. Third, provide individualized control to maximize people productivity. Workers are most productivity when they can discretely monitor and control their own environments. For high performance buildings, this means having the right amount of light for what they are working on, individualized control of temperatures for individual workspaces, and ensuring that there is proper ventilation for air quality (CO2, CO, particulates).

Why Building Performance Matters

Since high performing buildings are lower cost to operate, facility managers have the opportunity to save real money for their organizations. Buildings in the U.S. today consume 72 percent of all electricity produced, and account for about 40 percent of total U.S. energy consumption (costing $350 billion per year), according to research performed in 2009 by the Lawrence Berkeley National Laboratory (LBNL)[1].

The U.S. Energy Information Administration (EIA) has forecasted that electricity prices will likely increase by an average of about 10 cents per kilowatt hour through 2035. This represents a steady drain on corporate coffers.



[1] Research by Lawrence Berkeley National Laboratory

While most buildings now are thoroughly wired with both Internet and power, the challenge has been to provide a low-cost sensor network that is easy to install and commission and reports information centrally both in real-time an historically across a number of different variables such as electricity levels, occupancy, temperature and air quality.

This leads to the second and perhaps more important reason that building performance matters. The cost of maintaining an office space for a full time employee varies widely by geography due to real estate cost differentials but estimates range from a low of $10,000 per year to a high of over $50,000 per year in expensive urban centers and high priced suburbs. Simply put, office space is the second-largest cost category for corporate managers behind payroll. Adding new facility space is often an option of last resort due to costs. So added intelligence about how spaces are used that can minimize unnecessary or inefficient space usage and reduce the need for new construction can result in millions in annual savings even for mid-sized companies with less than 1,000 employees.

High performing buildings automatically keep facility management fully aware about how their space is being utilized and operated. Because high performance buildings constantly collect fine-grained data about occupancy, temperature, and air quality, the facility management function now has the data and insights to better utilize space and positively impact employee productivity.

A New Paradigm: Enhancing Building-Performance Through Lighting

In the built environment, lighting is ubiquitous in all interior spaces, wired for power delivery, and often deployed in a pervasive, grid-like pattern. It is the most logical platform and cost-effective place to integrate a pervasive sensor network. The goal of such a network is to implement “Building-Performance Lighting” — using the lighting system to intelligently control lighting at all levels from building wide to intra-zone or intra-room. What’s more, this system can be extended to sense, report, and optimize many other environmental management parameters including HVAC usage, space utilization and planning, and air quality.

Using the lighting system as a way of enhancing building performance opens up a whole host of applications.

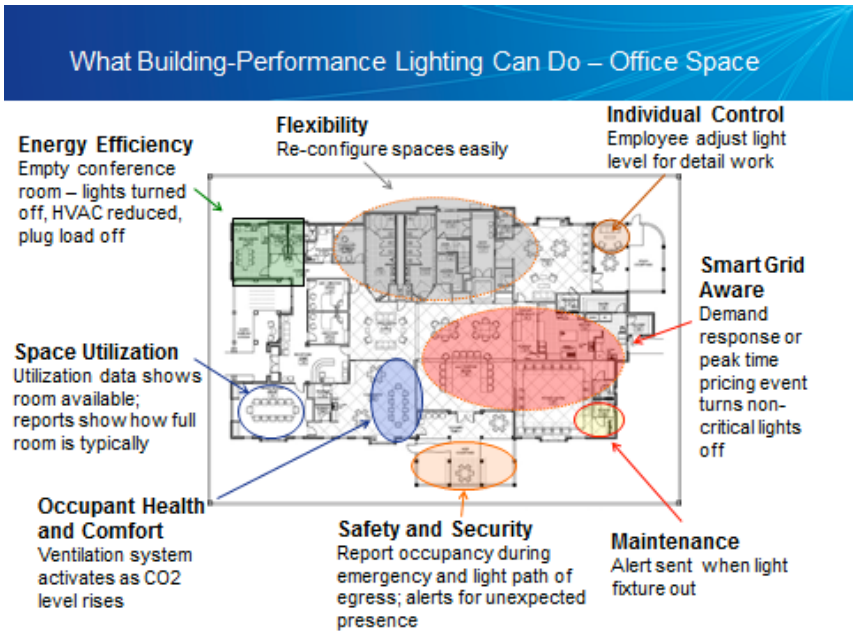


Figure 2: What Building-Performance Lighting Can Do

Energy Efficiency. There are many sophisticated energy saving capabilities related directly to reduction of lighting usage. Standard use cases include: automated dimming based on time of day or occupancy, one-click daylight harvesting based on networked sensor readings of outside light, utility mandated or requested demand response, and peak power reduction programs to reduce consumption during high cost periods. A networked-based LED lighting system can also enable significant HVAC savings. Not only do LED fixtures burn cooler than other forms of lighting, but granular control capabilities also allow building operators to dramatically reduce the heat output of lighting. This in turn diminishes the need for air conditioning and provides cost savings on HVAC systems as large as 35% to 40%.

Space Utilization. With high-density occupancy sensors, building owners can determine how much time a particular area, such as a conference room, is used per day and how full they are when in use. A conference room that is only used by smaller groups, for example, could be re-provisioned as two smaller conference rooms. The real-time occupancy data can be averaged over time to improve how spaces are allocated, including mobile work areas and “hotelling” spaces, workbench and open collaborative spaces, and for future space planning or space re-design projects.

Occupant health and comfort: To better manage heating, venting and air conditioning, a building-performance lighting system can generate alerts for zones or rooms that are out-of-compliance with

temperature ranges. This active monitoring of thermal comfort is recognized in LEED as a technique to both improve HVAC performance and individual worker comfort/productivity. [2]

Safety and Security: For life safety and security systems, the dense network of occupancy sensors can serve as an extremely pervasive intruder detection system with programmable zones, timed surveillance and monitoring windows. If entry is detected into a zone during the wrong time of day, then this could sound an alert. Or in the case of an emergency, the occupancy detection sensors can immediately identify the location of every employee in the building and notify first responders with this information for evacuation planning. In addition to "positive" assertions that motion sensors can provide, the system can use intelligence and analytics to report "negative" assertions. For instance, if a scheduled security or maintenance walk-through is supposed to occur every evening at 2:00 am, the system can report on evenings when these events do not occur, or in the case of cleaning crews, inform on spaces that did not see motion during these periods.

Maintenance: A building-performance lighting system can greatly reduce lighting maintenance costs by actively monitoring the performance of all fixtures powered by the system, and with per-fixture light sensors, provide real-time light output performance monitoring. With web-based fixture status, administrators can remotely troubleshoot wiring, sensor, or fixture issues without necessarily sending onsite maintenance staff to determine what's wrong.

Smart Grid Aware. These systems can also play a vital role in smart grid and demand response programs for optimizing building energy loads and peak load charges. Lighting is one of the critical building functions, yet it is also an application well suited to smart grid intelligent management. No other electric load has all of these key properties for the smart grid — sizeable load, instantaneously measureable and reducible, with exact control over how to shape and manage energy load reductions. With building-performance systems the lighting load can respond dynamically to a demand response event or peak time pricing by shutting off pre-defined non-critical lighting and reducing other areas through dimming.

Individualized control of light spaces. Network-based lighting allows building owners and facility teams to extend control from the "group" level of zones down to the individual fixture, and provide these controls to individual users through a myriad of access methods — web-based, smart phone, tablet, wall controller, or through VOIP phone systems. In addition, with full-range dimming automatically built-in, users can cater and customize lighting levels to their specific needs, improving comfort and worker productivity. A recent Gensler survey showed that workers could increase the amount of work they perform by an average of 21% if they had a better-designed working environment. [3]

Flexibility: Due to the flexible, low-voltage nature of the wiring in the system, building operators can easily relocate parts of a network without requiring an electrician or skilled technician. If a space needs

[2] See USGBC's LEED Indoor Environmental Quality Credit 7.2, Thermal Comfort Verification (http://www.usgbc.org/ShowFile.aspx?DocumentID=1095)

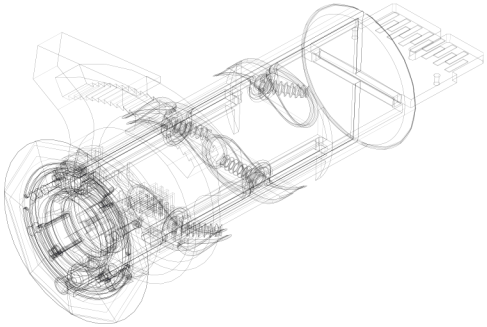
[3] See The Gensler Design + Performance Index, The U.S. Workplace Survey, 2008. (Source: http://www.gensler.com/uploads/documents/2008_Gensler_Workplace_Survey_US_09_30_2009.pdf)

to be reconfigured, re-adjusting motion policies or lighting groups can be facilitated over the web by simply re-arranging virtual fixture groups.

Pervasive Sensing In Building-Performance Lighting

One of the key architectural underpinnings of business-performance lighting is the deployment of high densities of sensors in a building. The keys to achieving pervasive sensing include:

Sensor density: Due to the decreasing costs of sensors and embedded microprocessors, it is now possible to combine multiple sensors for motion, lighting, energy metering, and temperature in a single device. This super-sensor can be deployed at each and every light, creating a dense grid with coverage for every 50-100 square feet of building space. This density provides an infrastructure capable of truly comprehensive sensing, reporting and environmental monitoring. Beyond lighting controls, this density of coverage can provide substantially deeper insights into temperature flows and thermal comfort, energy and lighting performance of the fixture, space utilization, space trafficking and fixture performance monitoring.



Multi-way Sensor for measuring light, motion, energy, temperature in buildings

Sensor setup and confirmation: Building-performance lighting solves and removes sensor installation and configuration complexities by quite literally "blanketing" a space with sensors. Since coverage is so comprehensive (at a per-fixture density), design and setup of these sensor networks is far easier. With automatic centralized commissioning of sensors, the process is literally drag-and-drop on a Web browser. The simplicity allows the building operator to make system modifications themselves, quickly and without disruption to the built environment and without incurring significant cost.

Power Management: Historically, most standalone sensors are not themselves energy optimized and can consume non-trivial amounts of power (3-5 watts / hour each). With a single sensor controlling an open area of 4,000 sq ft., that wattage expenditure is acceptable. But to achieve deep visibility with high density sensing, a building operator would need to deploy 40-80 legacy sensors that would collectively consume 240-480 watts. By reducing requisite power draw for sensors, by combining multiple sensors

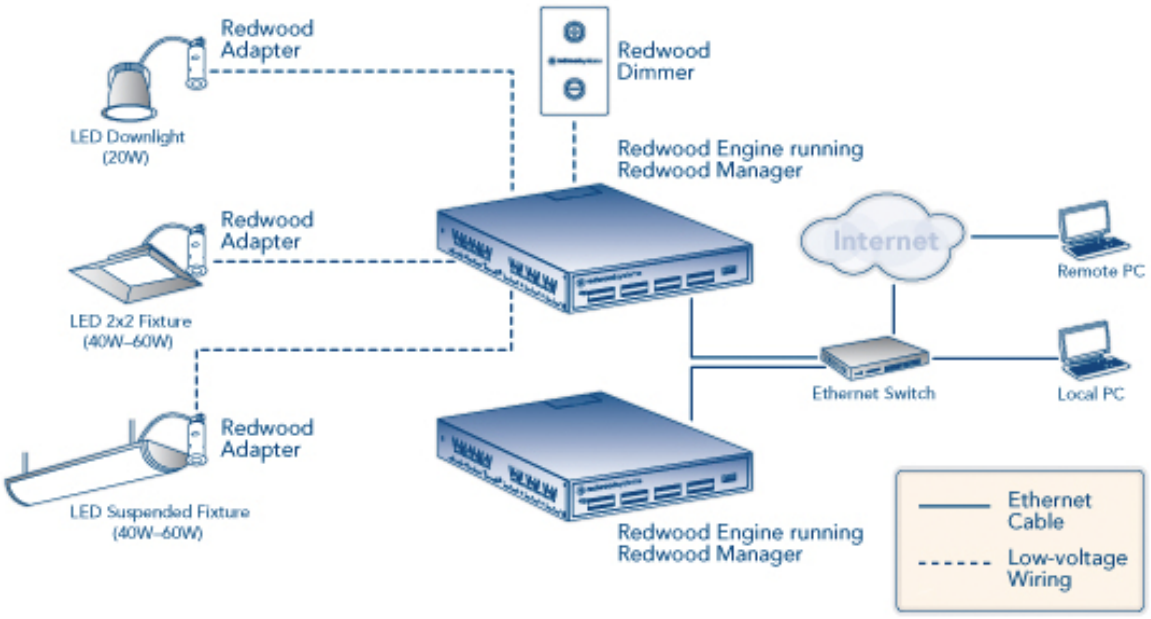
in a single device, by focusing on a highly efficient sensor design, and enabling those sensors to run off low voltage DC power that eliminates costly conversion stages, building-performance lighting systems deploying cutting edge sensors that reduce sensor power consumption to < 1/3 watt per sensor, a 10x to 30x improvement over legacy technologies.

Redwood Systems: The First Building-Performance Lighting System

Redwood Systems powers enhanced building performance through lighting. It has developed the world's only commercial lighting control network with an integrated building intelligence platform. Redwood's solution provides proven, best-in-class energy savings and cost-effective space utilization, temperature and power monitoring that enables customers to intelligently operate their facilities and enhance employee productivity.

Redwood's innovative approach combines power, control, and communication technologies over a single low-voltage network-based architecture, creating both distributed sensing, centralized management and building policy control. Redwood's building-performance lighting system consists of the Redwood Engine, Adapter, Manager, and optional Dimmer switch.

Redwood Systems lighting platform



The Redwood Engine, which serves as the “brains” of the Redwood platform, performs the sophisticated controls that significantly reduce energy consumption for LED lighting, and runs the software policies and applications required to deliver building-performance applications.

The engine powers and communicates with the Redwood Adapter, which accepts low voltage DC power from the Redwood Engine via Class 2 cabling and transfers this power to the LED fixture. The adapter also contains a set of environmental sensors to enable the Redwood platform to gather fine-grain data on all environmental and trafficking conditions throughout the interior of the building.

The Redwood Manager is Web-based software embedded in the Redwood Engine that is used to control lights and display power usage, occupancy data, and environmental temperatures. The manager also includes reporting applications that can provide visibility and insights into how spaces are being lit, heated, and occupied.

Redwood Systems’ patented technology turns lighting control into a digital application on a corporate network. Building operators can manage lighting in their environment with a simple drag-and-drop interface accessible from a PC or a smart phone. Through a standards-based BACnet API framework, the Redwood Systems architecture can also communicate sensor data to HVAC systems and other building resource management systems to create a unified dashboard of multiple systems beyond lighting control.

Summary: Going Digital in High Performance Buildings

Over time, practically every device and application in our lives adds advanced “digital” technologies to improve their performance, reduce costs, or deliver new features. Remember the dial phone, the mercury thermometer, or the days when you could open the hood of a car without computer diagnostics? Yet in the built environment, some of the most important, critical systems in commercial buildings — power delivery and lighting — have remained utterly analog in nature. Power deliver is “analog” because power either flows or doesn’t, and the lights are either on or off.

There is now the opportunity to fundamentally re-think and potentially redesign the lighting system to take advantage of these digital capabilities. In fact, by replacing the traditional electrical AC wiring to low-voltage networking cables for DC applications, these power cables can do double-duty, delivering both DC power and, two-way communications for digital applications. Combine this power and communication system with pervasive sensing to literally “see” comprehensively what’s happening inside a building, and we arrive at building-performance lighting.

Taken all together, these capabilities raise building control and management to an entirely new level. This empowers building operators not only to manage their buildings for better electrical usage and energy cost savings, but also for overall better employee and company productivity in multiple areas. Like a fine automobile or a high performance computer, a building equipped with Redwood Systems technology will become a responsive high performance built environment that is far more responsive to the needs of employees, municipalities, utilities and the organizations that lease or own the building.