A New Dawn in Efficient Lighting

THE FUTURE OF EFFICIENCY FOR BUSINESSES

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Lighting has played a central role in energy efficiency programs for decades. Often dubbed low-hanging fruit, lighting has presented savings opportunities for nearly every customer and has offered efficiency programs the ability to obtain a magnitude of energy savings unmatched by any other single technology. In Vermont, after years of successful efficient fluorescent lighting promotion, the capture of available lighting savings may seem nearly complete. This high level of fluorescent adoption, however, comes at a time of tremendous advancement for light emitting diode (LED) technology. By some estimates, as much as half of Vermont's lighting savings on the commercial side are yet to be realized, due to the savings potential of LEDs, when combined with the use of lighting controls and design. The obstacles that once stood in the way of widespread LED adoption are rapidly disappearing, and we can look forward to a new era of unprecedented lighting savings.

Key Insights

- LED technology is advancing rapidly, and it is already more cost-effective than fluorescent lighting for some applications
- As much as half of Vermont's potential energy savings from commercial lighting upgrades have not yet been realized
- LED technology already accounts for a majority of lighting savings in Vermont's commercial and industrial sector—by 2018, the share of savings due to LEDs will be more than 80%
- Lighting design and controls can maximize the energy saving potential and overall lighting performance of LEDs

The Fluorescent Era

When Efficiency Vermont was formed, in 1999, T8 fluorescent fixtures and compact fluorescent lamps (CFLs) were heavily promoted to customers as efficient alternatives to older T12 fluorescent and/or incandescent lighting. The reasons were obvious: Most customers had opportunities for lighting upgrades; the resulting energy savings were cost effective; and—in most cases—the new technologies offered significant improvements in light quality. Due to incremental improvements to fluorescent technology over the years, today's high performance T8 (HPT8) and CFL products offer superior performance and energy efficiency.

Despite these improvements, fluorescent technology has a limited future in Vermont as a source of new energy demand reductions. The technology is already near its energy efficiency peak[1] and most customers have already upgraded to some form of efficient fluorescent lighting. Within Vermont, 83% of all commercial fluorescent equipment is now an efficient technology (T8, HPT8, or T5)[2] and 92% of homes statewide use some CFLs[3].

Enter LEDs

Historically, lighting has accounted for approximately 70% of energy saved through Efficiency Vermont's programs. As recently as 2009, LEDs represented a mere 1% of that total. In just the last three years, however, the LED contribution to overall Efficiency Vermont savings grew dramatically to nearly 25%. Within the commercial and industrial sector, LEDs now account for 55% of savings across all lighting technologies.

[1] According to the U.S. DOE Energy Savings Potential of Solid-State Lighting in General Illumination Applications (Navigant: 2012), efficacy performance improvement for fluorescent products is limited to 10% by 2030.

[2] Vermont Market Characterization and Assessment Study (Navigant: 2011).

[3] Vermont Single-Family Existing Homes Onsite Report (NMR Group, et al: 2012).

There are many reasons for the current trend toward rapid adoption of LEDs. First, they can match the light output, distribution, and color that customers demand while offering incredibly long lifetimes. Additionally, LEDs do not present many of the challenges that dogged earlier efficient lighting technology, such as mercury content, flickering, and limited dimming range. Most notably, LEDs deliver up to 80% energy savings, depending on the technology that is replaced.

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To date, Efficiency Vermont has promoted LEDs predominately for commercial exterior and select directional interior uses. In such commercial settings, where operating hours for lighting are much longer than in homes, the advantages of LEDs make them financially feasible, despite their higher upfront cost. Additionally, LEDs are better suited than fluorescents for exterior and many interior settings because they can be directionally controlled (to create a spotlight) and perform well in cold temperatures. These applications offer a significant opportunity for energy savings; however, the much larger opportunity of commercial interior general lighting remains mostly untouched.

Opportunities and Obstacles

At current prices, an LED retrofit comes at a steep cost. Prices are forecasted to decline rapidly[4], however, and when accounting for LED lifetime the total life cycle cost will also be lower. These anticipated LED cost reductions, plus incentives, are expected to bring LEDs within reach of the masses, while forthcoming performance improvements are expected to further increase their appeal. But is there enough of a savings "pool" available after years of fluorescent retrofits? The answer is most definitely yes.

The most prevalent commercial lighting application is a fluorescent 2'x4' recessed ceiling fixture, commonly referred to as a troffer. The U.S. Department of Energy (U.S. DOE) has identified commercial recessed troffers as the largest opportunity for potential energy savings from LEDs[5]. In Vermont, most linear fluorescent fixtures in use are standard T8[6], and as shown in Table 1, the energy savings potential when upgrading standard T8 to LED (39 watts) already exceeds the best that can be offered by a fluorescent HPT8 upgrade (23 watts). However, an LED upgrade comes at a considerably higher cost.

Over the next few years, anticipated LED performance improvements will increase the energy savings potential far beyond what is possible now with fluorescent technology. Meanwhile, cost reductions will make LED upgrades compelling for most

[4] LED "warm-white" package prices are predicted to fall 55% by 2015 and 86% by 2020, according to the U.S. DOE 2013 Solid-State Lighting Research and Development Multi-Year Program Plan.

[5] Yamada, Mary, et al, Adoption of Light-Emitting Diodes in Common Lighting Applications (Navigant: 2013).

[6] Standard T8s account for 51% of all linear fluorescent fixtures, according to the Vermont Market Characterization and Assessment Study (Navigant: 2011).

Lighting Technology	Typical System Watts	Estimated Upgrade Cost	Typical Watts Saved	Upgrade Cost per Watt Saved
3-lamp F32 "standard" T8	88	-	-	-
3-lamp F28 HPT8	65	$75	23 (vs. T8)	$3.26
2013 LED fixture (106 lpW)[7]	49	$250	39 (vs. T8)	$6.41
2015 LED fixture (145 lpW)[8]	36	$150	52 (vs. T8)	$2.88
2020 LED fixture (193 lpW)[9]	27	$100	61 (vs. T8)	$1.64

Table 1: Comparison of technology performance and cost

applications. Efficiency Vermont will have the opportunity to revisit every fluorescent lighting fixture addressed over the past 15 years and obtain an equal, if not greater, increment of energy savings. Customers with T8 and HPT8 fluorescent lighting have benefited from lower energy costs compared to T12 fluorescent lighting, and in many cases the savings have already exceeded the upgrade investment cost. These same customers will have the opportunity to upgrade to LED and cut their lighting energy use in half, or more.

Controls & Design

Fluorescent lighting retrofits of the past have delivered substantial energy and cost savings but, unfortunately, an opportunity to reap even more savings was missed. In many cases, the inaccurate assumption was made that an existing lighting level and layout was appropriate for a customer, and fixtures were upgraded to deliver the same light output without considering what light level was actually needed. Further, lighting controls were often excluded from lighting upgrades due to cost and complexity. When the principles of lighting design are applied to evaluate a project holistically, energy savings can be maximized by providing an optimum amount of light precisely when and where it is needed. Efficiency Vermont promotes this type of approach through its RELIGHT program—and the resulting savings have been impressive. Compared to standard commercial lighting retrofits, RELIGHT projects average twice the level of energy savings. Further, RELIGHT projects achieve a much higher installation rate of lighting controls: On average, 52% of lighting fixtures

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[7] As of June 2013, the highest performing 3-lamp T8 equivalent 2'x4' LED fixture (approx. 5200 lumens), according to the DesignLight Consortium® Qualified Products List.

[8] LED luminaire efficacy improvement by 2015, according to the U.S. DOE Energy Savings Potential of Solid-State Lighting in General Illumination Applications (Navigant: 2012).

[9] LED luminaire efficacy improvement by 2020 (ibid).

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incorporate controls with RELIGHT projects versus the 21% with standard lighting retrofits.

While LEDs get the technology revolution headlines, lighting controls have made similar advancements over the last several years. These two technologies are highly complementary, and together they represent the future of lighting. Fluorescent lighting is challenging and costly to control, but LEDs are a highly compatible partner with lighting controls. LEDs are instant-on devices, can be dimmed with little or no additional cost, and are not impacted by frequent on/off switches. Lighting controls are the key to unlocking LEDs true potential as "smart" lighting devices that can provide benefits far beyond energy savings. As Gary Meshberg of Encelium Technologies has stated, "The future may be LED, but lighting control will be right there with it, delivering dramatically expanded capabilities to make lighting systems not only the ultimate in efficiency, but also flexibility, feedback and performance."[10]

Putting it All Together

When considering the full potential of LED technology, a design-centric approach, and advanced lighting control integration, it is clear Efficiency Vermont lighting savings within the commercial market shows no sign of slowing. As shown in Figure 1, the share of Efficiency Vermont commercial lighting energy savings from fluorescents has fallen precipitously from nearly 90% in 2008 to just 35% in 2013. LEDs have filled this void, and their contributions are expected to increase over time. In particular, the interior LED fixture category is likely to become a major source of energy savings, largely driven by recessed LED troffers.

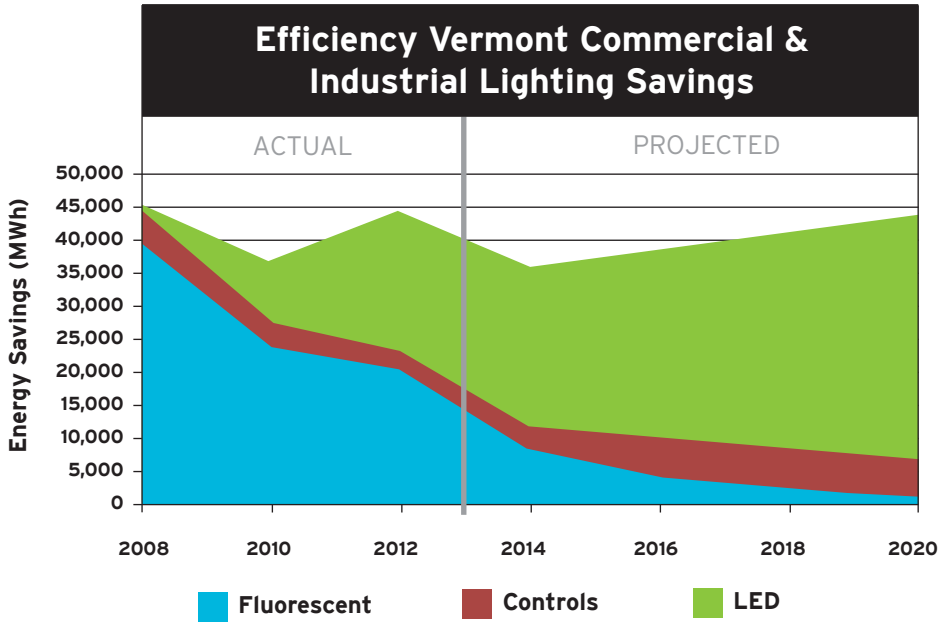

Figure 1: Commercial and industrial lighting history and projection

[10] Meshberg, Gary, "Control a Natural Partner for LEDs," LD+A, November 1, 2012

Conclusion

Lighting technology will continue to offer new and significant energy saving opportunities for the foreseeable future. The market has already seen a number of LED products used in niche applications, but the industry is now at a technological tipping point. With performance rapidly improving and costs continuing to fall, LED technology will soon be feasible and cost effective in just about every imaginable application. When this opportunity is coupled with advanced lighting control and thoughtful design, the remaining energy savings potential is immense, even in markets that are already mature with efficient fluorescent technology.

Dan Mellinger is the Lighting Strategy Manager at the Vermont Energy Investment Corporation. He is responsible for designing Efficiency Vermont lighting initiatives that serve Vermont businesses and lighting professionals. Dan has more than 14 years of professional and managerial experience in the lighting and semiconductor industries. He has delivered dozens of presentations and papers on efficient lighting topics through organizations including ACEEE, CEE, IESNA, and the U.S. Department of Energy. He received his degree in Electrical Engineering from Michigan State University and is a licensed Professional Engineer in Vermont. Dan is Lighting Certified, sits on the NCQLP Board of Directors, and is a member of IESNA.