

Getting to 50: How Vermont Plans to Reach 50% Market Adoption of Linear LED by 2025

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ABSTRACT

Linear LED products – fixtures, retrofit kits, and replacement lamps – offer the greatest reservoir of remaining energy savings potential of all lighting categories. These products, which replace ubiquitous linear T8 and T12 fluorescent technology, offer advantages in energy, lifetime, and controllability. Despite the significant opportunity and strong customer value proposition, early adoption was limited by price obstacles, scarce utility promotion, and a relatively efficient incumbent technology.

According to the U.S. Department of Energy, the linear LED product category represents 18% of the remaining lighting savings potential nationally. When paired with networked lighting controls, the savings potential jumps to 32%. In 2017, the installed penetration of linear LED products was estimated to be at just 6% nationally and 8% in Vermont. Vermont has developed plans, strategies, and forecasts to take the linear LED product category from single digit market adoption up to 50% by 2025. Along the way, networked lighting controls will be emphasized to maximize the opportunity. Doing so will take a well-coordinated effort combining multiple service delivery channels and will rely on deep partnerships with the supply chain. All strategies will be on the table, ranging from simple LED lamp replacements up to comprehensive lighting design incorporating linear LED fixtures with networked lighting controls.

In this paper, we review the current state of product adoption in Vermont. We discuss current and future trends in performance, price, and quality. And we take a deep dive into Vermont's research activities, strategies, and partnerships being developed to reach 50% linear LED market adoption by 2025.

Introduction

Efficiency Vermont has a long history of lighting program leadership within the commercial and industrial (C&I) sector. The energy efficiency utility was among the first in the nation to promote high performance T8 fluorescent fixtures (2004), midstream point-of-sale rebates (2008), DesignLights Consortium (DLC) qualified LED fixtures (2009), comprehensive lighting design (2010), and municipal LED street lighting (2012). It should come as no surprise that Efficiency Vermont is attempting to lead in another area of C&I lighting: widespread adoption of linear LED lamps and fixtures.

Linear fluorescent is by far the most common type of lighting used within C&I buildings. Linear fluorescent accounts for 79% of all C&I lamps installed nationally (Navigant Consulting 2017), and in Vermont approximately 74% of all C&I indoor lighting is linear fluorescent

(Cadmus Group 2017). After many years of promoting high performance T8 (HPT8) fixtures and lamps, Efficiency Vermont estimates that less than 10% of the linear fluorescent installations are older inefficient T12 as shown in Figure 1.

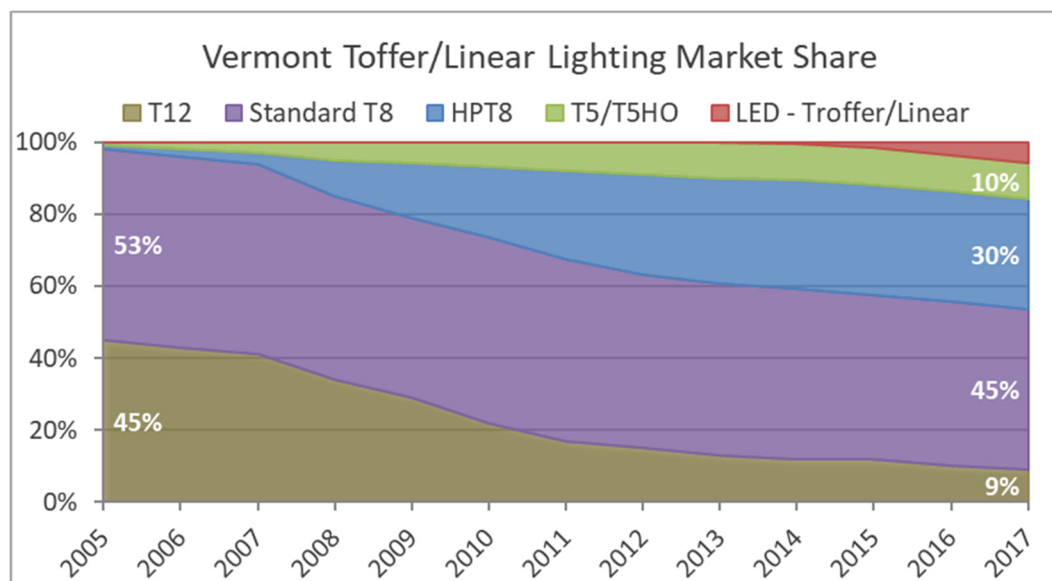


Figure 1: Vermont troffer/linear technology market share, 2005-2017.

With so little inefficient fluorescent technology remaining, it would appear as though this segment of the market is transformed. On the contrary, linear LED products – both lamps and fixtures – can replace standard T8 (and eventually HPT8) and deliver a greater increment of savings than was achieved through T12 to HPT8 upgrades. When paired with networked lighting controls, the savings opportunity is even more significant. Recognizing this potential, Efficiency Vermont has developed a comprehensive set of strategies to ensure that they and their customers reap the benefits.

Linear LED Savings Potential

Past upgrades from T12 to HPT8 resulted in savings of approximately 48 watts for a 3-lamp fluorescent fixture.¹ Based on current LED technology, a standard T8 fluorescent fixture can be upgrade to LED with a savings of roughly 45 watts.² As LED efficacy steadily improves, the savings potential will continue to grow. By 2025, the estimated savings per fixture will increase to as much as 70 watts if paired with networked lighting controls (NLC), as shown in Figure 2.³

¹ A 3-lamp F34T12 fixture with input power of 120 watts can be upgrade to 3-lamp HP F32T8 with input power of 72 watts, resulting in 40% savings.

² A 3-lamp standard F32T8 fixture with input power of 88 watts can be upgrade to an LED fixture with equivalent light output and input power of 43 watts, resulting in 49% savings. Based on 5,200 delivered lumens and 120 lumens per watt.

³ Based on 5,200 delivered lumens, 156 lumens per watt, and 47% savings for Networked Lighting Controls.

In addition to the higher per-unit savings potential, the target market for LED is larger than it was for HPT8. When Efficiency Vermont began promoting HPT8 in 2005, roughly 45% of linear fluorescent installations were T12. By contrast in 2017, approximately 54% of linear fluorescent installations are either T12 or standard T8 – both ideal candidates for LED upgrade. With future price and efficacy improvements, LED will eventually be a cost-effective option to replace the additional 30% of installations that are HPT8.

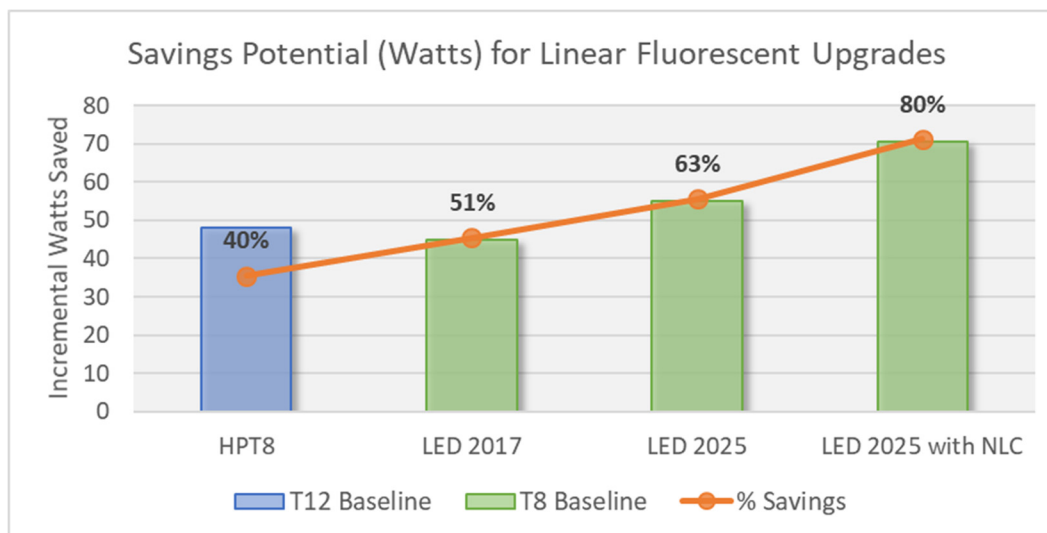


Figure 2: Incremental savings potential for linear LED.

By Efficiency Vermont's estimate, the installed stock penetration of linear LED products has reached approximately 8% in 2017. The combination of a low penetration rate, large target market, and growing savings per unit all contribute to linear LED products offering the most significant reservoir of remaining savings for C&I lighting, as shown below in Figure 3. Linear LED products have yielded the lowest savings to date compared to other LED categories, but the remaining Vermont savings potential of 166,500 MWh far exceeds other categories. Meanwhile screw base LED products, which have yielded the most savings to date, offer nearly the lowest future savings potential within C&I.

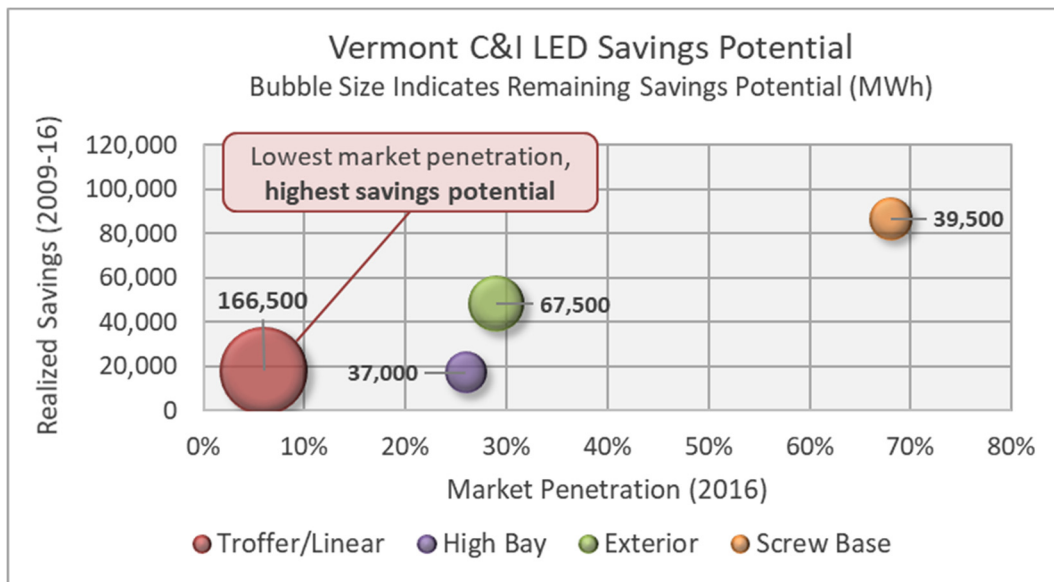


Figure 3: Remaining savings potential for various C&I LED lighting measures in Vermont.

LED Upgrade Options for Fluorescent Lighting

Linear fluorescent fixtures can be upgraded to LED through one of three possible solutions: (1) the entire fluorescent fixture can be replaced with a complete LED fixture; (2) the internal electrical and optical components of the fluorescent fixture can be upgraded to LED using an integrated retrofit kit; or (3) the fluorescent lamps can be replaced with LED lamps or linear retrofit kits. Each of these upgrade options are shown below in Figure 4.

Fluorescent light replacement options:

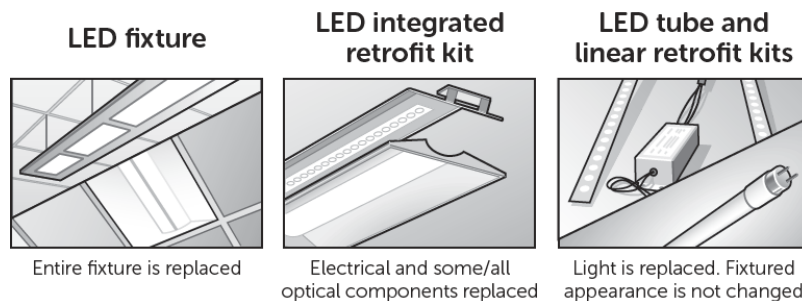


Figure 4: LED upgrade options for fluorescent lighting.

A full fixture replacement offers the most robust solution, and in most cases, delivers the highest levels of energy savings, lighting performance, and reliability. An LED lamp replacement (TLED) is the easiest and cheapest option to install, but customers may be leaving some savings on the table. Lamp replacements and retrofit kits are not always compatible with sensors or other controls, which can offer added savings and functionality to a space. Furthermore, existing fluorescent ballasts can fail or draw additional electricity, even if the fluorescent lamps were recently switched to LED.

The Efficiency Vermont rebates for these product categories are structured to encourage the adoption of high quality products. Prior to 2017, a single higher rebate was offered for the more robust solution of fixtures and retrofit kits, and a much lower midstream rebate was offered for TLED replacement lamps. The fixture and retrofit kit rebate amounts were bundled for simplicity. Instead of having two rebate categories (such as troffer fixtures at \$60 and troffer retrofit kits at \$40), all products received the same rebate regardless of its DLC qualification status as a fixture or retrofit kit. This approach proved to be ineffective with a wide spectrum of product form factors, qualities, and prices available in the market.

In mid-2017, strip-style retrofit kits began appearing in the Vermont market and were being sold in large quantities. These linear retrofit kits were comprised of linear strips of LEDs attached to tape or magnets and wired to an LED driver. The solution was popular with contractors since they could quickly install the strips in an existing fixture housing, where fluorescent lamps had been previously, in just about any application. The kits came without a lens or any other means to optically control the light. The lack of optical engineering and the use of inexpensive materials allowed them to be sold at a very competitive price point. In fact, many products were priced at or even below the Efficiency Vermont rebate amount and were advertised to customers as "labor only", "free" or "low cost" after the rebate was applied. Due to the way these products were qualified by DLC, they were eligible for the full fixture rebate amount from Efficiency Vermont.

While these kits may be appropriate in some applications, they are not a universal solution as they were being marketed and utilized. Customers may have been happy with cheap or free new lights but they were unaware of the lower light quality compared to other possible solutions. For example, in a non-lensed fixture, the glare from the strips can be quite objectionable and distracting. Within a few months Efficiency Vermont began receiving complaints about reliability, as the low-cost products suffered early failures.

In response to this unintended outcome, Efficiency Vermont redefined retrofit kits as a separate rebate category in July 2017 and established the rebate amount at half of the level for full LED fixtures. Along with the change in rebate, Efficiency Vermont began providing messaging and education to end users, such as the table shown in Figure 5, to assist them in selecting the best upgrade option for their space.

	LED fixture	LED integrated retrofit kit	LED tube / linear retrofit kit
Energy savings	★★★	★★	★
Light quality (uniformity, appearance, distribution) over life of lamp	★★★	★★	★
Materials + installation cost	\$75-250	\$50-200	\$15-40
Maintenance cost over life of product	\$0-25	\$0-50	\$25-100
Controls compatible (dimnable, occupancy sensing)	Yes	Yes	Sometimes
Condition of existing fixture	Any	Any	Less than 10yr old

Figure 5: Efficiency Vermont messaging regarding LED upgrade options.

Figure 6 demonstrates the impact on product adoption experienced during this timeframe due to low- or no-cost retrofit products. A large number of retrofit kits were installed in June and July of 2017. The interest in retrofit kits didn't appreciably change the overall product adoption, but rather shifted participation primarily from TLEDs to retrofit kits. After the rebate was reduced to half of the full fixture rebate, TLED quantities returned to normal and the adoption of retrofit kits fell significantly.

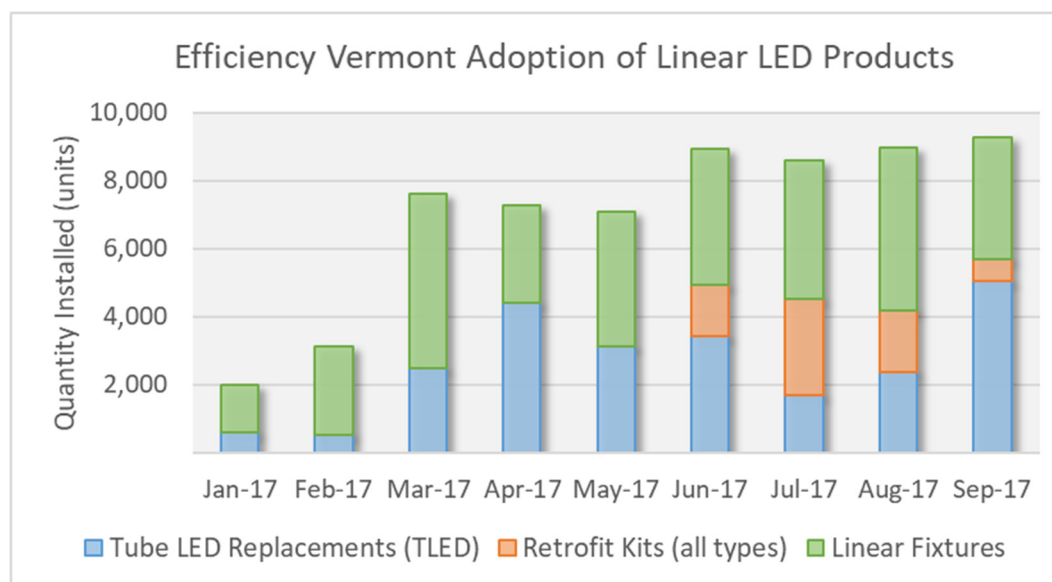


Figure 6: Efficiency Vermont adoption of Linear LED products in 2017.

This experience highlights the importance of maintaining an agile program design capable of adapting to unforeseen changes in the marketplace. Field staff intelligence is critical to gaining visibility to trends while they are developing, rather than after the fact. Efficiency Vermont Account Managers regularly visit distributor partners and meet with local contractors and manufacturer representatives. This allows the program managers, who work inside the office and see data on a lagging basis of a month or more, to get real-time information and feedback about programs. In this case, field staff provided the advanced knowledge that lower tier products were being sold at nearly no cost, and at unsustainable volumes. Programs must be conscious of rebate levels, knowing that contractors and customers will often pursue the least cost option if they are unaware of the consequences or drawbacks. Clearly, education plays an important role.

Lighting Controls

Lighting controls, such as occupancy sensors and daylight dimming, are encouraged by utilities as a strategy to further reduce lighting energy use. Despite decades of promotion, adoption has failed to reach significant levels due to many reasons such as poor operational performance, added cost with unclear customer benefits, and a lack of contractor support. According to the U.S. Department of Energy, only 18% of all commercial lighting employs

controls nationally (Navigant Consulting 2017). In Vermont, occupancy sensors are used in 31% of commercial spaces, but only 5% of linear fluorescent lighting is occupancy controlled (Cadmus Group 2017).

In 2017 Efficiency Vermont surveyed local lighting trade allies to better understand the barriers that have prevented greater adoption of lighting controls in the Vermont market. The trade allies surveyed were a mix of electrical contractors and designers who had been key users of integrated lighting controls on Vermont projects in 2016 or 2017. Integrated lighting controls (ILC), for the purpose of this survey, were defined as dual occupancy and daylight sensors that are fixture-mounted by the lighting manufacturer. Space types where ILCs were installed mainly consisted of office, classrooms, and hallways. Key findings of the research were:

- Lighting designers are champions of ILC technology. A lighting designer was identified as the driving source for the product choice 88% of the time.
- Customer awareness of ILCs is low, but customers generally enjoy the systems after they are installed.
- Commissioning the systems to ensure they are operating correctly required a lot of unforeseen time. Electricians do not want to be involved, and it may take a manufacturer representative several weeks to appear on-site.
- Steep learning curves exist for system installation and setup, but some stakeholders indicated that over time the ILC systems would reduce labor costs for wiring.
- Efficiency Vermont product-specific training helped with installation, start up, and commissioning. Comprehensive product-neutral trainings were less useful.
- More documentation and support for system set up and commissioning are needed.
- There were no significant issues with procurement of ILCs, but the products are not typically stocked locally and therefore can require additional lead time.

The research project made clear that education plays a critical role in adoption. There is a definite need to continue product-specific and hands-on training for all levels of the supply chain. Contractor certification programs, such as those offered through DLC or manufacturer partners, may be helpful. And, general awareness of integrated lighting controls must be increased among customers and trade allies.

Networked Lighting Controls are a more comprehensive solution that offer the potential to deliver deeper energy savings while also improving the operational performance and feature set. These systems enable communication among a group of lighting fixtures to optimize the implementation of multiple control strategies include occupancy sensing, daylight dimming, scheduling, personal control, and task tuning. According to the DesignLights Consortium, networked lighting control systems have the potential to reduce lighting energy consumption by 47% on average (Energy Solutions 2017).

Nearly all networked lighting control projects that were proposed on Efficiency Vermont projects in 2017 were done so through the Lighting Design program. Lighting designers are typically more aware of these control systems and are better qualified to manage the system complexity. Lighting designers are often able to persuade customers to try innovative solutions while relieving the burden on distributors and contractors to find compatible high-quality products.

Vermont Strategies

Efficiency Vermont is employing a multi-faceted strategic approach designed to accelerate the adoption of linear LED products, including controls. Recognizing that all customers have different needs, and that the goals of Efficiency Vermont do not always align with its customers, no single solution is being prioritized.

Multiple Service Delivery Channels. Efficiency Vermont is utilizing all service delivery options available to increase the adoption of linear LEDs and controls. In the custom program, large projects are processed as well as complicated lighting designs which often have networked lighting control systems associated. Rebates for more common and higher volume product categories are managed through the prescriptive program. In 2017, a record volume of lighting products were processed prescriptively. Operational efficiency will be essential to ensure that customer value is maintained while processing a high volume of rebate applications. Finally, midstream programs, discussed below, enable greater market reach and improved operational efficiency.

Midstream Programs. A midstream program allows for greater participation by applying rebate discounts at the point-of-purchase while prescribing certain savings assumptions. Transactions are batch processed monthly by program staff. As products evolve in the marketplace, Efficiency Vermont will continue to evaluate the product mix offered through the midstream program. Typically, products offered through the midstream program experience a higher sales volume due to local product stocking, ease of customer participation, and the capture of time-of-sale opportunities that would otherwise be missed. As an example, in 2017 Efficiency Vermont moved TLEDs from the downstream prescriptive rebate form to the midstream program and saw a 150% increase in product volume compared to 2016.

Emphasis on fixtures and quality. Aware of many inexpensive and low-quality products in the market, Efficiency Vermont continues to promote the use of fixtures over other technologies. While there are low quality fixtures in the market as well, they tend to be less problematic for customers than low-cost retrofit kits and TLEDs. Since fixtures are designed as a complete system, with optics and electronics optimized for LED, they typically deliver better overall savings and light quality than simply replacing lamps. As a result, customers receive quality lighting where they need it, and can occasionally even reduce the number of fixtures instead of purchasing the exact same amount of linear replacement lamps.

Controls. Prescriptively and on a custom basis, Efficiency Vermont offers attractive incentives for controls, knowing that customers are rarely going to select and install controls themselves. By greatly reducing the financial obstacle, adoption is finally starting to accelerate in Vermont. In addition to incentives, Efficiency Vermont is using education to emphasize the benefits of controls, highlighting both the energy savings opportunity and other potential benefits such as asset tracking and space utilization.

Design Professionals. Lighting designers play a key role in the adoption of new technologies. By turning what would be simple one-for-one retrofits into comprehensive lighting projects, guided by the expertise of design professionals, we not only improve the result for our customers, but achieve energy savings that would otherwise be left on the table. Lighting designers play the role as specifier on jobs big and small, including broad or product-specific LED fixture and control recommendations to meet customers' unique needs. Efficiency

Vermont's Lighting Design program has proven to be a successful tool in encouraging the installation of lighting controls. Historically the adoption of lighting controls across the other two service deliveries, prescriptive and custom retrofit, have been very low. In the prescriptive path, only 7% of projects contain controls. Within the custom program, even when Efficiency Vermont is providing direct customer support and recommendations, adoption only reaches 40% of projects. Meanwhile in the Lighting Design program, 100% of projects incorporated lighting controls in 2017. Due to the expertise and encouragement from local lighting designers, every single Lighting Design project has included controls since the program's redesign in 2016.

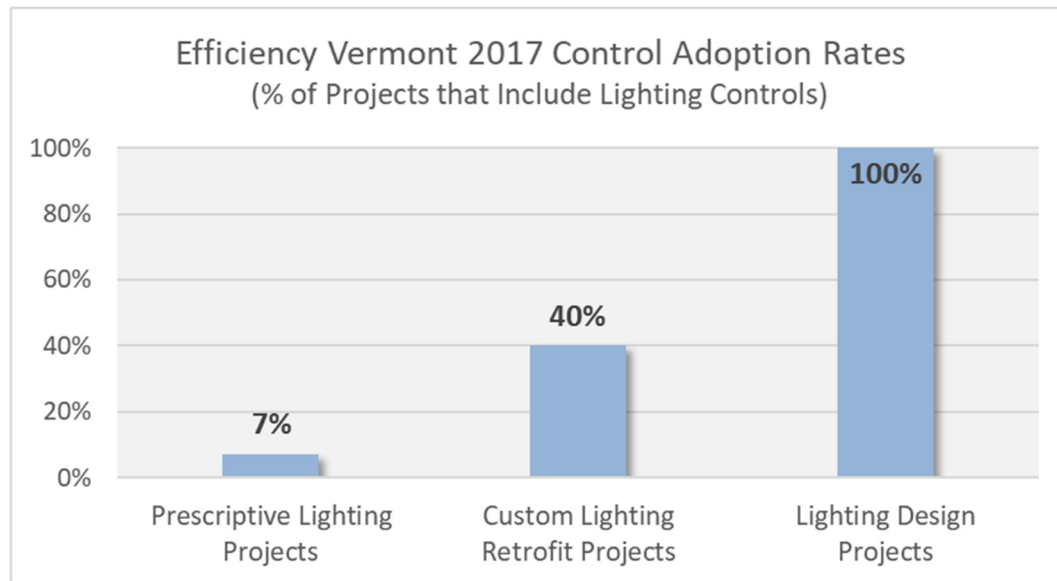


Figure 7: Efficiency Vermont 2017 Lighting Control Adoption Rates

Contractor Outreach. Efficiency Vermont's Efficiency Excellence Network (EEN) regularly provides contractors with information about emerging technology and program details through training and Account Management outreach. This group of contractors receive marketing materials, sales trainings, co-op advertising, and lead referrals for their enrollment in EEN. They also serve as a source of field intelligence for Efficiency Vermont and collaborate on program revisions or the prototyping of new concepts. Through our research, these contractors have identified that hands-on, product-specific trainings have been incredibly valuable to being prepared on jobs, especially when installing complicated integrated or networked lighting controls are involved.

Supply Chain Partnerships. By aligning sales and marketing strategies with manufacturers and distributors, a clear and consistent message reaches the market that will drive more product sales and energy savings. This goal will be accomplished through co-promotions, coordinated education & training, and sales incentives.

Local Product Stocking. Product availability plays a crucial role in the adoption of these lighting technologies. When efficient products are stocked locally, not only do customers benefit with quick and easy access, but promotion increases since distributors are motivated to sell their stock inventory first and foremost. Distributors need a reason to stock the products, especially new technologies that aren't widespread and may be more expensive. By providing them with a

value proposition to stock items through sales incentives, stocking promotions, and co-operative advertising, we can insure the products are readily available for customers.

Quantity limits. Quantity limits have been a long-standing program requirement in Efficiency Vermont prescriptive and midstream programs. In an effort to remove customer participation barriers, Efficiency Vermont will be increasing the midstream quantity limit for TLEDs from 250 units per project to 500 in 2018. Research showed that the limit of 250 created an administrative burden for these products since custom review was triggered for projects with as few as (125) 2-lamp or (63) 4-lamp fixtures on a project. Now, customers will be able to use the midstream channel for TLED projects of larger quantities, making adoption easier on our way to our 2025 goal.

Vermont Adoption Forecast

Through careful implementation of strategies included above, Efficiency Vermont anticipates achieving 50% market adoption of linear LED products by 2025, as shown below in Figure 8. These forecasted adoption rates are based on many factors including:

- Recent Vermont adoption trends
- Historical Efficiency Vermont adoption rates of HPT8
- Efficiency Vermont strategic plans
- Estimates of the Vermont installed base, based on DOE national inventory estimates (Navigant Consulting 2017)
- DOE national LED adoption forecasts (Navigant Consulting 2016)
- Anticipated improvements in LED product price and efficacy (Navigant Consulting 2016)

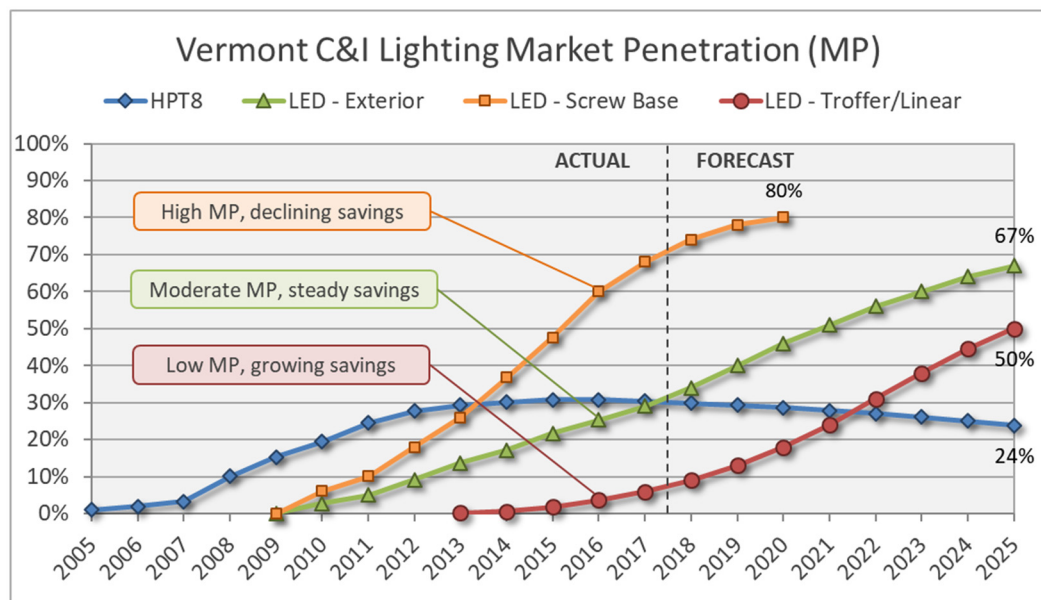


Figure 8: Vermont commercial & industrial installed penetration of LED products

Figure 9 illustrates that most of the gains in linear LED adoption will come from the replacement of standard T8 and any remaining T12 fluorescent. The installed penetration of T5 and HPT8 technologies will decline gradually, as equipment reaches end of life and is replaced with LED. Initially, very little HPT8 will be upgraded purely for energy reasons due to poor financial payback. Eventually the economics of replacing HPT8 and with LED will improve as linear LED product prices continue to fall and efficacy improves.

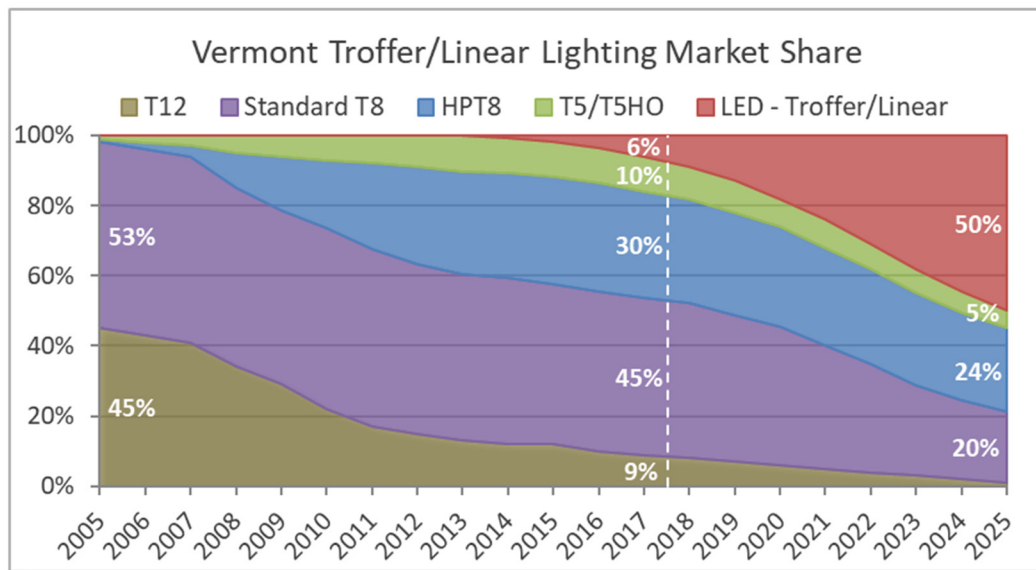


Figure 9: Vermont troffer/linear technology market share, 2005-2025.

Finally, based on the adoption forecast discussed above, Efficiency Vermont anticipates that commercial and industrial lighting savings will continue to increase for the next several years as depicted in Figure 10. This result is contrary to the common perception that utility lighting programs are at or near their end. While it is true that residential lighting programs – which primarily rely on screw-base LED products – have a limited future, commercial and industrial lighting programs have many more years of significant savings potential ahead. The Efficiency Vermont plans and strategies highlighted in this paper are being implemented to ensure that this potential is fully realized.

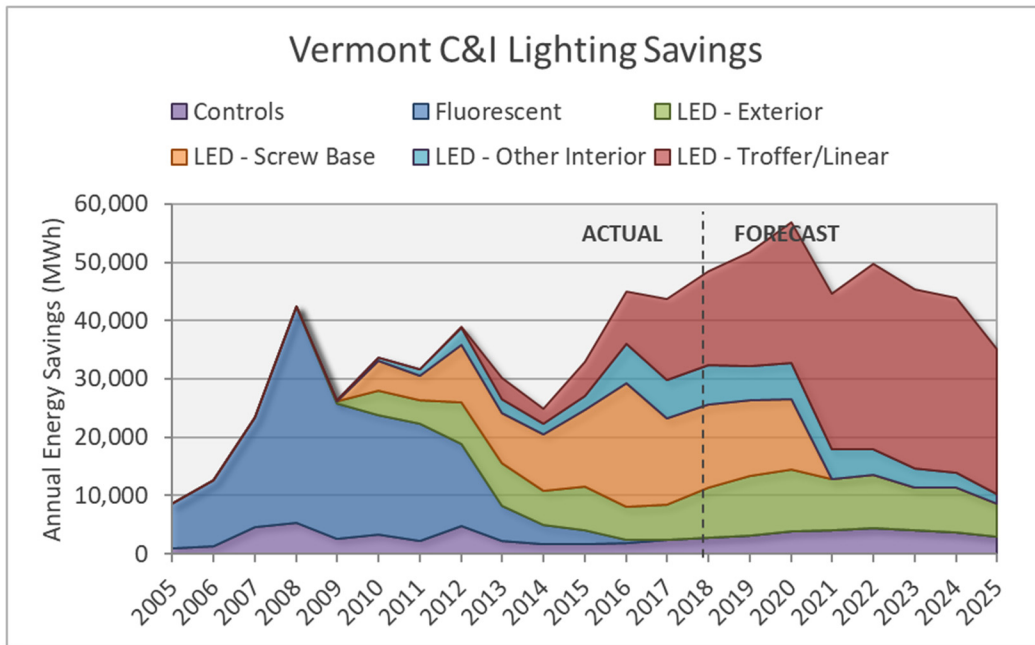


Figure 10: Efficiency Vermont C&I Lighting Savings, 2005-2025

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