A Win-Win-Win for Municipal Street Lighting:
Converting Two-Thirds of Vermont's Street Lights to LED by 2014

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ABSTRACT

Reducing energy costs and enhancing the nighttime environment with LED street lighting is by now well understood. However, few municipalities and utilities have successfully taken advantage of this opportunity to convert their street lighting operations to LEDs. Before a system-wide conversion of existing street lights can occur, a utility must obtain the large amount of required capital, identify appropriate LED street light equipment for their applications, consider changes in utility rate structures, and design effective methods for recovering costs. Using Vermont as a case study, this paper presents a partnership model among the statewide energy efficiency utility, the state's largest electric utilities, and several municipalities. The model was designed to overcome the challenges to widespread LED street light conversion. By 2014, more than two-thirds of Vermont's municipal street lights will be upgraded to LED technology. The conversion will: (1) provide municipalities with better nighttime street lighting and significant cost savings—at no additional capital expense to the municipalities, (2) deliver 8,000 MWh of cost-effective new savings to the energy efficiency utility, and (3) deliver financially attractive returns for Vermont's utilities. This win-win-win model is scalable and replicable, and is now being considered in Massachusetts and Rhode Island.

Introduction

The advent of LED technology for street lighting applications has brought about both new opportunities and a new understanding of street lighting systems. Although opportunities existed to improve the efficiency of street lighting applications, even prior to LED technology, few have pursued these opportunities in part because not enough decision-makers understand how to take advantage of them. Further, many decision-makers perceive that their own street lighting systems are already efficient. It is true that most existing street light systems do in fact use a relatively efficient light source in terms of the source efficacy, as shown in **Table 1.** However, the total efficiency of a street light system should consider both the efficacy of the light source as well as the optical efficiency of the luminaire. Many existing light fixtures emit only a fraction of the light actually produced by the source. Complicating matters further, lighting designers and decision-makers have historically not always understood control and distribution features of street lighting systems. However, LED manufacturers and vendors have used a system approach in selling LED technology, and have thereby expanded the efficiency opportunity that exists in street lighting applications. When the efficiency of the total street lighting *system* is considered, with luminaire optical efficiency and control, LED technology has significant advantages over incumbent technologies. In fact, LED technology can offer savings of 50% to 75% or more. This fact has created a significant opportunity for utilities and their customers to reduce costs, improve efficiency, and enhance the nighttime environment.

Table 1. Efficacy of Various Street Lighting Technologies

Street Light Technology	Percent Market Share[1]	Typical Source Efficacy (lumens per Watt)	Typical Luminaire Efficiency	Typical Net Efficacy[2] (lumens per Watt)
High-pressure sodium	59%	70 – 150	45%	32 – 68
Low-pressure sodium	10%	68 – 177	25%	17 – 44
Mercury vapor	20%	34 – 58	30%	10 – 17
Metal halide	5%	61 – 85	35 – 40%	21 – 34
Compact fluorescent	2%	50 – 70	60%	30 – 42
Incandescent	4%	10 – 17	60%	6 – 10
Induction	0%	60 – 80	60 – 80%	36 – 64
HE ceramic MH	0%	95 – 120	60 – 80%	57 – 96
LED	0%	60 – 100	60 – 90%	36 – 90

Source: Clinton Climate Initiative, 2010

Approximately 44.9 million street lights are installed nationwide, using 52 TWh / year of electricity and representing 7% of all lighting energy use (Navigant, 2011). If all of these street lights were converted to LED technology, the estimated energy savings would be 17.2 TWh / year[3] (Navigant, 2010). Compared to the average electricity use of a home in the United States, the potential energy savings would provide enough electricity to power 1.5 million homes each year.[4] Although this is a large number, there are other lighting technologies such as LED A-type lamps that are commonly found in both commercial and residential applications, offering even greater potential energy savings (84.1 TWh / year) (Navigant, 2010). What makes LED street lighting so enticing is that the vast majority of street lighting systems are owned and controlled by a relatively small number of entities, the electric utilities. There are 3,269 electric utilities in the United States (APPA, 2010), a much smaller number that must be engaged, compared to the millions of entities that offer other types of lighting energy efficiency opportunities.

Interestingly, although the utilities own the street lighting, the costs of purchasing, installing, operating, and maintaining the street lighting are most often borne by the utilities' customers: municipalities, businesses, or even private individuals. This fact creates an interesting dynamic in which the utilities' customers stand to save from the LED technology, but the decision to move forward with LED street lighting and to offer it to customers lies with the electric utility. Street lighting opportunities—including the options, costs, and monthly charges to customers—are governed by utility rate tariffs. Therein lies one of the most significant barriers to enabling and harnessing the LED street lighting opportunity: Before utility customers can move forward with LED street lighting, the utilities must offer the technology as an option

[1] Nationwide average.
[2] Excludes control and distribution of light.
[3] There is a discrepancy in the number of street lights between the Navigant 2010 *Energy Savings Estimates of Light Emitting Diodes in Niche Applications* report that estimates energy savings, and the Navigant 2011 *U.S. Lighting Market Characterization* report. Because the *U.S. Lighting Market Characterization* report is more recent and used a more accurate method, the energy savings estimates have been scaled back in a linear fashion, based on the number of street lights listed in the *U.S. Lighting Market Characterization* report.
[4] Assumes average electricity use per home of 11,496 kWh / year, according to data from the 2010 Energy Information Administration.

through regulator-approved rate tariffs, a step that most utilities have not yet taken. Utilities' hesitancy in moving forward with LED street lighting rate tariffs is rooted in two areas: technical concerns and financial concerns.

Barriers to Moving Forward and Strategies to Overcome Them

Utility Perspective: Why Not Move Forward, Right Now?

Many utilities do not want to move forward with a technology that they believe to be unproven. Utilities tend to be very risk-averse, and they are likely to question whether "now" is the right time to switch to LEDs for street lighting considering the reliability uncertainties and future potential gains in efficacy. For example, if they move forward with LED, will they create a lost savings opportunity because the technology continues to become more efficient? If the technology is constantly changing, will replacement components be an issue in the future?

In addition to the technology perspective, utilities also have financial perspectives that cause them to hesitate to pursue this opportunity. First, the high initial cost of the technology and its cost-effectiveness have a direct impact on the lease rate they can offer to consumers. This fact also provides another reason to ask the "now" question, since the cost of LED technology continues to decline. Second, the high initial cost increases the amount of available capital required to fund the installation of LED street lighting, even if a rate is offered and the costs are recovered over the long term through the rate tariff. Third, utilities have to account for the unrecovered costs of existing street lights that would be removed from service before they have reached end of life and fully depreciated. The utility typically cannot afford to assume this cost, nor can the cost be factored into a rate tariff. Finally, some utilities might be concerned about the loss of revenue from an LED street lighting rate tariff that is lower than the rate of older technologies. Many other factors can affect the scope of utilities' financial concerns, including utility type (investor-owned utility, municipal-owned utility, or a co-operatively owned utility), rate structure, and regulatory oversight.

Key to Moving Forward: A Willing Utility

First and foremost, a *willing* utility that is truly looking for ways to say "yes" to LED technology is a necessary element to adoption of the technology for street lighting. Given the obstacles described above, an uncommitted utility will have no shortage of reasons to delay or forgo an investment in LED technology. Whether it is because the technology is unproven, the cost currently too high, the necessary capital not available, or the regulatory obstacle too great, the utility can always continue to find reasons to say "no." This cycle will stop only when a utility is forced to move forward by others such as a regulatory body, is pressured by industry peers already moving forward, or has found that the concerns and reasons for not moving forward are no longer valid. This consideration is an important point, since few utilities have a reason to say "yes" to LED technology at this time. At this relatively early stage in the adoption of LED street lighting, efficiency program efforts are best spent with utilities that want to be leaders, are able to overcome their concerns with the technology, and ultimately show their peers and their customers that it can be done.

Addressing the Utility Technical Concerns

One of the key technical concerns that utilities have with LED technology is that the technology has not been fully vetted, tested, or proven. Indeed, viable LED products for street lighting have been in existence for only five to seven years. Given one of the key benefits and selling points of the technology is long lifetime (in some cases estimated at 20 years or more), utilities want to be sure that this long lifetime will be realized before they base customer rates on it. The problem is that the technology has not been in existence, much less installed, long enough to validate the manufacturers' claims about its lifetime without using predictive methods. This is a valid risk that utilities must consider.

Fortunately, there are several strategies to mitigate this risk. LED technology for street lighting applications is relatively new, but the components of an LED street lighting system and the science behind it are actually well understood. LEDs themselves have been around for decades. The electronics that drive LEDs are no different from many other electronic devices. What is new about LEDs for street lighting is that they are higher power devices than LEDs of the past, and they are being used in a new application where their performance truly matters. This new performance-driven application brings up many new concerns, but several resources in the industry can address them. There are well-regarded predictive methods that can be used to validate the claimed lifetime and performance of LED products. There is also a growing set of lighting standards that can be applied to help ensure the product performs as specified. There is research to support the long lifetime. In fact, there is no disagreement from the experts in the industry that LED street lighting has the ability to perform as promised. However, the challenge is to use the appropriate information and tools to ensure that the actual product delivers this performance. Utilities must tap into the best available knowledge, using the right standards, in the right way, to mitigate the risk of a product not living up to its manufacturer's claims. This can be done largely through a well-informed specification.

A template for this specification exists. Working with leading experts in the industry, the U.S. Department of Energy has developed a Model Specification for LED Roadway Luminaires, released in October 2011 (Municipal Solid-State Street Lighting Consortium, 2011). When used correctly, this specification drastically reduces the risk that an LED street light product will not realize its estimated lifetime and performance benefits. This specification is the key to mitigating many of the risks to utilities and other entities considering LED installations.

A second utility technical concern has to do with whether now is the right time to move forward with the technology given that LED performance is continuing to improve. If the technology is constantly changing, will replacement components be available in the future? This concern is also addressed through a specification. In fact, the more reputable manufacturers are making their street lighting luminaires "future-proof." That is, they have designed the LED components so that they can easily be upgraded with replaceable modules as the technology improves over time.

However, that is not the only concern with whether now is not the right time to move forward. The efficiency of LED technology continues to improve. The field of lighting controls for street lighting is largely undeveloped, but it holds great potential for additional energy savings in street lighting. Will energy savings be lost if the utility moves forward now? Or is it better to wait? This question is frequently asked about energy-efficient lighting. Each situation should be looked at individually, but most often the cost of waiting associated with increased energy and maintenance costs far outweighs the additional energy savings that might be gained by waiting and installing a newer technology later. This is partly due to the fact that the additional energy savings that result as the technology improves become incrementally smaller. For example, many LED street lights that will be installed using current technology will be 100 watts or less, compared to 200 watts or more for older technology, significantly reducing the “pool” of potential energy savings.

Regarding the concern about controls, this too is addressed through a specification. It is very important that LED street lights installed today are able to take advantage of the lighting control opportunities in the future. The DOE’s Model Specification for LED Roadway Luminaires contains an optional clause that requires the luminaire / driver to be able to accept a control signal and dim for future control.

In addition to the key technical issues above, some utilities may be concerned with power quality (harmonics, for example), others may be concerned about the weight, or even temperature ratings. All of these concerns will eventually be addressed. The key will be to find solutions to each technical concern, so that utilities will attain a comfortable or acceptable level of risk in order to move forward.

Addressing the Utility Financial Concerns

A utility’s financial concerns come from several places. The first concern has to do with the high current cost of the technology. With the cost of LED technology falling, does it make sense to lock in a rate at the current high cost, or should utilities wait until the cost comes down? A related concern has to do with cost-effectiveness. Some utilities have found that the high initial cost of the LED technology offsets all energy and maintenance savings in their rate tariff, resulting in a higher tariff rate compared to older technologies. If the tariff rate is higher than what it was with older technologies, then why would a customer want to convert to the newer technology?

Not all LED products are priced equally. In fact, more so than with any other lighting technology, the cost of LED street lighting luminaires varies widely, depending on light output. To reduce the cost, utilities must minimize the light output, while ensuring the lighting meets the intended design. This strategy of reducing light output cannot be stressed enough, but it can be challenging, given the conservative nature of street lighting design and the perceived safety risks.

Another strategy for reducing the luminaire cost is to select a luminaire manufacturer with competitive pricing. The cost of LED street light luminaires varies widely by manufacturer. Given that the cost of LED sources continue to decline, deciding when to lock in a price can be a challenging question. One solution is to revisit the rate tariff every few years, and adjust it. This might not be desirable by some utilities, because of the dynamic with regulators and utilities with rate cases. Another solution is to build a variable LED cost into the rate tariff—a cost that can be adjusted downward without full regulatory approval. This solution was recently implemented by Progress Energy Carolinas, in their LED rate tariff. (New Street Lights, 2010)

A second utility financial concern has to do with the stranded, unrecovered costs of existing street lights that would be replaced with LED. If existing street lights are removed from service before their end of life, and before they have been fully depreciated, then the cost of the street light has not been fully recovered through the rates by the utility. Someone must pay this cost if the light is replaced with LED. This is where a utility’s efficiency program or a state energy efficiency program can be extremely advantageous. Financial incentives can be offered to offset or reduce the stranded cost of the existing street lights. If a utility or state energy efficiency program does not exist, then this stranded cost must be factored into the rate tariff or billed to the customer, significantly reducing the cost-effectiveness of the upgrade.

A third utility financial concern is whether there is sufficient capital available to replace the street lights with LED. The costs of the product and installation are ultimately recovered through the street lighting rate tariff, but the utility must still provide the up-front capital to pay for the purchase and installation of the LED street lights. Utility capital is a complicated topic and is viewed differently by investor-owned, municipal, and cooperative utilities. Each utility will have different limitations on the capital available to it. To address these limitations, utilities can put a cap on the number of street lights they are able to install in each year. This cap can be filed with the rate tariff, and / or separately messaged to customers. This approach was successfully used by two utilities in Vermont.

Finally, some utilities might be concerned with the lost street lighting revenue if customers change to LED technology through a reduced rate tariff that results in lower customer bills compared to older technologies. However, it is important to understand that while Street lighting revenue for the utility may decrease, a utility's profit is just as likely to *increase*. Savings in fixed expenses—electricity and especially maintenance—can more than offset the loss of revenue. With a properly structured rate tariff, the customer can pay a lower rate, while the utility decreases its fixed expenses and increases its profit.

The Vermont Case Study

In Vermont, the barriers to moving forward with LED street lighting have been largely overcome. The state's three largest electric utilities, Green Mountain Power, Central Vermont Public Service, and Vermont Electric Cooperative, have filed rate tariffs for LED street lighting and received regulatory approval in 2011. The LED rate tariffs are financially attractive to the utility's customers, offering up to 25% in savings on utility bills. What's more, most municipalities and utility customers will be able to proceed with the LED conversion at no capital expense. All they have to do is simply proceed with the conversion, improve the nighttime environment, and begin saving up to 25% on municipal street lighting costs—in some cases much more. The barrier of stranded costs that result when existing street lights are replaced before they are fully depreciated will be eliminated by a financial incentive from the state's energy efficiency program, Efficiency Vermont. In turn, Efficiency Vermont will receive an expected 8,000 MWh of new cost-effective energy savings by 2014. It is also expected that by 2014, more than two-thirds of Vermont's municipal street lights will be converted to LED technology, representing approximately 18,000 street lights. Reaching this milestone required more than two years of discussions and negotiations with the electric utilities, and perhaps most important, a willing utility partner looking to find a way forward.

Efficiency Vermont began discussions with the electric utilities about LED street lighting in 2009. A growing contingent of the utility customers (who are also Efficiency Vermont's customers) was increasingly frustrated by the lack of options to move forward with LED street lighting. Many had heard of successful installations in other parts of the country and wanted the opportunity to save energy and improve their street lighting for themselves. Initially, none of Vermont's utilities was ready to move forward. The technology was unproven, and it was too expensive. In late 2010, a breakthrough occurred. Green Mountain Power, one of the state's largest investor-owned utilities, signaled to Efficiency Vermont and the regulators that they wanted to try to move forward and develop an LED rate tariff. Their reasons for doing so were partly driven by their customers, and their own desire to be a "green" company. Their customers were becoming unhappy with the lack of options, and the utility's unwillingness to move forward. At the same time, the utility was looking for a suitable low-maintenance "white light" source for street lighting that customers were increasingly asking for, they had been unsatisfied with the higher maintenance required of alternative "white-light" sources such as metal-halide. Green Mountain Power saw this as an opportunity to offer value to their customers, improve their company's image, and find a suitable low-maintenance technology for their future street lighting needs, so long as the other technical and financial barriers could be overcome.

Interestingly, once one utility in a state paves a way forward with LED street lighting and shows that the barriers can be overcome, it becomes much harder for others to continue to say "no." Only a short time after Green Mountain Power had submitted an LED rate tariff to the state's regulatory agency, the second of the state's largest utilities, Central Vermont Public Service, had submitted a tariff of its own. A few months later Vermont Electric Cooperative, the third-largest utility in Vermont, filed its own tariff. This is why having a willing utility partner to pave the way and show that the barriers can be overcome is really a critical component of moving forward.

It is worth noting that in May 2011, Vermont's Legislature passed a law requiring Vermont utilities to offer an LED energy-efficient street light option to their customers through an LED rate tariff. However, the legislation ultimately had little impact. By the time it passed, Vermont utilities had already filed or were in process of filing their LED rate tariffs.

Overcoming Barriers

One of the biggest concerns from the Vermont utilities had been the stranded costs of the existing street lights. For all street lights that had not yet been depreciated, this stranded cost somehow had to be paid for, before a street light could be converted. From the utilities' perspective, they did not want to put a rate tariff out to customers that was not financially attractive and that required customers to pay stranded costs before conversion. In essence, it would only cause more problems and potential complaints. One solution might have been to limit conversions only to replacements of very old street lights that had been fully depreciated, but this was also problematic. Even within a single municipality, the level of depreciation of individual street lights varies widely. The utilities wanted a solution that would take advantage of economies of scale, and would allow them to proceed in a system-wide or municipality-wide conversion. The breakthrough was made when it was determined that energy efficiency program funds could be used to offset or even completely pay for the stranded costs. The state's regulatory agency gave approval for the use of energy-efficiency program funds for that purpose. Second, the utilities had to look at a system-wide inventory of street lights and determine the average level of depreciation and remaining stranded costs. Across the entire system, the average stranded cost value was determined to be approximately $100 per fixture. This cost, on average, was at a level at which Efficiency Vermont could afford to pay it, through a financial incentive for the energy savings that would result. With the stranded cost barrier eliminated, customers were able to move forward without any capital cost.

A second concern of the utilities was the initial capital required to fund the purchase and installation of the LED street lights. Ideally, this cost needed to fit within the utility's capital budget and would not require any additional debt. How this capital is viewed and acquired depends on whether the utility is investor-owned, municipal-owned, or a cooperative. However, regardless of how this capital is viewed and obtained, the amount of available capital is generally limited. Further, a utility cannot afford to change all the street lights in its service territory all at once. To address this constraint, the utilities placed limits on the number of street lights they can replace in a given year. One utility, Central Vermont Public Service, wrote this limitation into their tariff itself. A first-come-first-served process determines which municipalities can move forward in any year, given the capital limitations.

A third concern of the utilities had been the high initial cost of the LED street lights. If this cost was too high, a financially attractive rate tariff would not be achievable. Fortunately, by the time the LED tariffs were written in 2010, a leading LED fixture manufacturer had introduced a very cost-competitive street light, specifically designed for the utility street lighting market. This fixture in most cases could be obtained for much less than $500. However, there was another critical component to reducing the cost of the LED street light that really enabled a financially attractive rate tariff. Because the cost of LED street lights varies according to lumen output, the utilities had to minimize the size and lumen output. It is important to recognize that a large proportion of the street lighting installed in the United States does not in fact meet the design standards established by the Illuminating Engineering Society of North America (IESNA). Rather, the street lighting is installed to provide what is estimated to be enough light, where there happens to be a utility pole. This offers significant opportunities to reduce and optimize the lumen output of the LED street light, so long as adequate and acceptable light is provided for the application. The utilities, Green Mountain Power in particular, pushed the envelope in the LED street light replacements they chose. To evaluate their choices, they installed many sizes of LED street lights and visibly and technically evaluated them to ensure they provided an acceptable amount of light and enhanced visibility. This approach resulted in LED replacement luminaires with surprisingly low lumen output. It effectively reduced the cost of the fixture, and significantly increased the energy and bill savings for customers. This approach worked for the large proportion of street lights that are not designed to IESNA standards. However, it should be recognized that this level of savings and minimization of lumen output might not be possible for street lighting designed to IESNA standards, as typically occurs with large highways, collector roads, and very urban environments. For these areas, a photometric analysis must be performed to determine the acceptable replacement.

Not all types of street lighting fixtures were addressed through the LED rate tariff. For example, the utility offers options for standard street lights (often called *cobraheads*), flood lights, and decorative options (often called *post-tops* or *acorns*). The vast majority of fixtures are cobraheads, and this is where LED technology is most advanced and most cost-effective. Because of this advancement in the technology and relative low cost, the LEDs are offered only as replacements of existing cobrahead fixtures, and not for flood or decorative luminaires. In the future, it is expected that LED options might be offered through a new rate tariff for flood or decorative luminaires.

Assess, Eliminate, and then Convert

Many of the street lights installed in Vermont and the United States were installed 20, 30, or even 50 years ago. They might have been installed for a purpose that no longer exists, or they might be significantly over- or undersized for current needs. In fact, it was determined that some street lights for which customers were receiving bills did not even exist. This is understandable, given the long period over which the lights were installed. Only in recent years has the street lighting system been electronically tracked and reported, using modern database systems or even a geographic information system (GIS). A desired outcome of all parties involved in the LED upgrades is to get an accurate inventory of the street lights installed in the system, and to correct any mistakes. Furthermore, the municipalities and Efficiency Vermont want to eliminate any unneeded street lights and those that no longer serve their intended purpose. This is the most effective way to increase the energy savings and bill savings from the upgrades. Some of the municipalities to use the program early on were able to eliminate over 30% of their street lights.

To facilitate the assessment of street lights before converting to LED, Efficiency Vermont required municipalities to sign a Memorandum of Agreement (MOA) to access the financial incentives for the program. This MOA requires the municipalities to assess their street lighting system before proceeding with an LED conversion. Efficiency Vermont developed a comprehensive guide and collection of technical resources to assist the municipalities in this process. The guide and resources go much beyond the technical process for evaluating the street lights, and provide guidance on such things as: (1) who should be involved, (2) what process should be used with the community, and (3) how best to obtain community support. Not all municipalities are interested in or successful at eliminating unnecessary lights, but many are successful and have eliminated 10% to 40% of their street lights, dramatically increasing energy savings and cost savings to the municipality, while also reducing light pollution.

A Partnership for Success

As of March 2012, 90 (out of 255) Vermont municipalities had signed MOAs with Efficiency Vermont and are in the process of identifying opportunities to remove unnecessary street lights and are exploring conversion. The utilities have developed systems for working with the municipalities that have signed the MOA, and are promoting the program to more of their municipal customers. Approximately 10 municipalities have already completed the conversion to LED. As more municipalities continue to sign on, the budget is being hit, and the limits to available capital are already being reached. The program is expected to continue to snowball and reach the maximum amount of LED conversions by 2014, accounting for more than two-thirds of Vermont's municipal street lights. Discussions are under way on how to take the program beyond municipal street lights to those that are leased by businesses or private individuals.

The program is truly a win-win-win for all involved. This model could not have been achieved without a strong partnership among Efficiency Vermont, the electric utilities, and their municipal customers. Perhaps most important, none of this could have been achieved without willing utility partners—those who were looking for ways to say "yes" to LED technology, overcome their technical and financial concerns, mitigate their risks, and move forward to a new street lighting future. This partnership model is both replicable and scalable, and is sufficiently transparent to be considered in other jurisdictions and states.

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