LED Traffic Lights: Signaling a Global Transformation

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ABSTRACT

As an alternative to incandescent light sources, light-emitting diodes (LEDs) offer tremendous energy and cost savings. To date, LEDs have been applied for signage, brake lighting, exit signs and increasingly in traffic lights. Traffic signals that use LEDs as a light source, offer state and local jurisdictions significant energy savings (approximately 80 to 90%), additional cost savings (from reduced maintenance), and the potential for improved visibility and safety. Some regions in the U.S. and Europe are taking advantage of these savings, but high product costs and lack of information limit market penetration in other regions. Additionally, the lack of a final LED traffic signal specification from the key U.S. standard-setting body or similar organizations world-wide, has hindered jurisdictions' pursuit of LED traffic signal retrofits.

This paper reviews LED traffic signal installation activity to date, presents key technical and market barriers that limit greater market penetration, and summarizes five market transformation efforts that strive to address these barriers. In particular, the authors highlight: the development of LED traffic signal specifications; a U.S. EPA/DOE ENERGY STAR® labeling program for traffic signals (in development)[1]; the Consortium for Energy Efficiency's (CEE's) LED Traffic Signal Initiative; New York State's Energy $mart Program, and the International Energy Agency (IEA) DSM Annexe III LED Traffic Signal Procurement. Although the approaches may vary, each of these efforts generally aims to increase comfort with, and awareness of, LED technology among local decision-makers. Together these activities offer significant potential to build lasting demand for LED traffic signals.

Introduction

Light-emitting diodes (LEDs) are one of the fastest growing technologies in the lighting industry today. Use of LEDs in the automotive industry (brake lighting) has led to significant technical advancements, including improved product quality, reliability and price reductions, allowing the technology to expand beyond simple stereo indicator lights to extensive applications such as exit signs, outdoor signage and traffic signals. Further, white LEDs have already been developed and research is underway to advance this technology as a source of general lighting.

As a result of the low power requirements and long life of LEDs, the energy efficiency community has begun to promote this technology for its energy benefits. LEDs can reduce power requirements by nearly 90% compared to incandescent applications. The most widespread use

[1] ENERGY STAR is a U.S. registered mark.

of LEDs for energy savings first appeared in the exit sign industry, saving facility managers and companies approximately $30 per year per sign on energy costs, not to mention maintenance cost savings, yielding a payback of less than two years. Traffic signals provide the next major opportunity for LED technology to be practically applied on a large scale, providing substantial advantages to end-users.

Most traffic signals in place today use incandescent lamps as a light source coupled with a colored plastic or glass lens to project the red, green, or yellow colors through to oncoming viewers. In contrast, LEDs emit specific wavelengths (or colors) of light, depending on their chemical composition. As a result, they produce colored light more efficiently than a white lamp/colored lens combination, and avoid wasted heat in the process. Traffic signals that use LEDs rather than incandescent lamps as a light source, offer municipalities, transportation authorities and other agencies substantial energy savings — on the order of 82 to 93% per signal. The energy savings potential from replacing incandescent traffic signals with LEDs amounts to 2.7 billion kiloWatt-hour (kWh) per year in the U.S. alone, saving American taxpayers an estimated $225 million per year, with substantial additional savings in international markets (EPA 2000). LED traffic signals also last considerably longer than incandescent signals (e.g., 5 to 10 years as opposed to 1 year) and fail less frequently, providing additional savings in reduced routine and emergency maintenance costs, as well as improved safety from avoided signal outages. Furthermore, they tend to be brighter than incandescent signals offering the potential for improved visibility. Collectively, these benefits contribute to lower traffic system operating costs and overall improvements in intersection safety.

Experience to Date in the U.S.

Leaders in the transportation community have begun to realize the significance of the energy savings and other benefits from LED traffic signals. As such, a number of state and local jurisdictions have pursued, and several utilities have promoted, traffic signal (e.g., ball or arrow) retrofits from incandescent sources to LEDs. In 1999, an estimated 400,000 LED traffic modules had been installed, representing an increase in new installations from 1% to about 5% of total traffic signal installations in 5 years (EPA 2000). Virtually all installations have been retrofits of either red balls, arrows or pedestrian hands, although recently, a number of localities have begun to purchase and install green (and in a few cases yellow) traffic signals to capture the added energy and maintenance benefits. To put these 400,000 LED signal retrofits in perspective, there are about 11 million signals in the U.S., including balls, arrows and pedestrian signals, and thus, a huge potential for additional savings and benefits exists. To date, the following state, municipal, utility, and national efforts have helped to pave the way for more wide-scale application of LED traffic signal.

State Activity

State departments of transportation have been key contributors to getting LED traffic signals into the market, principally through their efforts to develop state purchasing specifications in advance of a national specification by the ITE (see discussion below on status of national and international specifications). The California Department of Transportation

(Caltrans) and the Oregon Department of Transportation (ODOT) began researching the potential for applying LED traffic signals in the early 1990s. Specifications were developed and request for proposals issued in each jurisdiction. Several pilot projects have now been completed in California and Oregon, and many jurisdictions in these states are now pursuing retrofits of a substantial portion of their signals or complete changeovers to LED signals. For example, Caltrans has switched all of the red signals under its control (i.e., 75,000 signals) completely to LEDs and prepared and made publicly available its performance specification. Additionally, state transportation departments in Florida, Ohio, Michigan, Minnesota, Nevada, New Hampshire, New York, New Jersey, and Texas have developed (or modified other state's) specifications for LED traffic signals and are purchasing traffic signals based on these specs.

Municipal Efforts

Some municipalities have also gained experience with LED traffic signal retrofits, assisted in part by approved state specifications. Key areas of activity are listed below.

- The *City of Philadelphia* undertook City-wide retrofits of 2,900 intersections (28,000 signals) to red LEDs in 1997, funded in part by a grant from Public Technologies Incorporated (PTI). Total capital costs for the retrofits were an estimated at $2.2 million. The annual power cost savings from these retrofits is estimated at $576,000 (from annual energy savings of 9.5 million kWh) with additional cost savings of approximately $165,000 yearly from reduced maintenance and re-lamping costs. *New York City*, with the support of the New York Power Authority (NYPA), completed retrofits of 18,000 red traffic signals in the borough of Queens at an estimated energy cost savings of $275,000 and a maintenance savings of $376,000. NYPA is branching out to other communities in New York State, offering low-cost financing for LED traffic signal installations. The City Department of Transportation is also in the process of replacing both red and green traffic signals on Staten Island with LEDs.

- *The City of Boston*, with financial support from Boston Edison Company (now NSTAR), has retrofitted all of its 3,600 red balls, 200 red arrows and 460 pedestrian signals for estimated savings of approximately $215,000. In a sample of approximately 5 intersections, the City found that it was saving an estimated 35% of the energy previously used to power those intersections. Boston is also now considering retrofitting its green signals (Gallogly 1999). Additionally, several communities surrounding Boston, including the Cities of Newton and Woburn and the Town of Framingham have retrofitted both red and green signals (including red pedestrian signals). These communities are realizing savings on the order of 50-60% of their traffic systems' prior energy use (Suozzo 1999).

- In the Midwest, the Cities of *Madison, Wisconsin* and *St. Paul, Minnesota* both undertook large-scale red traffic signal retrofits. And the C*ity and County of Denver* converted 10,000 intersections to red LEDs at a cost of approximately $1.7 million with an estimated annual savings of $360,000 in energy, labor, and materials. These jurisdictions have also recently completed retrofitting all of their green traffic signals to LEDs as well.

- Numerous *California communities* have piggybacked on the Caltrans specification or a similar specification offered by the City of San Jose. These communities have installed red LED traffic signals – often jurisdiction-wide and typically with some utility financial support. The City and County of Sacramento, for example, retrofitted about 300 intersections with red (and in a few cases, green) LED traffic signals and are realizing savings of approximately $170,000 annually (from nearly 3 million kWh of saved energy). Many municipalities served by Pacific Gas & Electric Company and San Diego Gas & Electric, where electric rates are much higher than in Sacramento, have retrofitted their red LED traffic signals for a total energy savings of about 70 million kWh per year (CEE 2000).

The City of Philadelphia has also decided to push LED traffic signals to the next level through a challenge to manufacturers to produce all-LED traffic signals. Originally, the City approached six manufacturers regarding the challenge. While the manufacturers expressed interest, ultimately all but one, Precision Solar (working with controller manufacturer Eagle Signal), dropped out for technical, financial and other reasons (although later AtLite Inc., in Masspeth, New York elected to take the challenge). From these manufacturers two types of prototypes were developed. A three-color retrofit (in this case, retrofit kits replace incandescent lamps in each of the signals in a traffic signal head) and a more dramatic technology advance, an all-LED traffic signal developed and designed for LEDs by Precision Solar. These products are currently being tested on City streets. Philadelphia viewed such products to have several advantages, including:

- Reduced weight and profile, reducing the necessary signal support structure;
- Improved heat dissipation, as a result of lower heat given off by LED signals;
- Dramatically reduced maintenance costs;
- Lower controller voltages, improving worker safety;
- Battery back-up during power outages; and the
- Potential for solar-powered signals, making LEDs a reality for remote regions.

Based on initial findings from the prototype signals, the City estimated the potential costs and benefits of converting all of its signals to three-color signals with low-voltage, battery back-up controllers. Philadelphia estimated that the conversion would cost approximately $8.4 million dollars, but that the benefits (including energy, maintenance, and reduced liability) would amount to $2.7 million annually (PTI 2000).

Utility Efforts

Much of the activity throughout the country to retrofit traffic signals with LEDs has been motivated at least in part by utility promotions. Utilities, such as Boston Edison (now NSTAR), Pacific Gas and Electric (PG&E), Portland General Electric, Puget Power and Light, Public

Service Company of Colorado, and Sacramento Municipal Utility District (SMUD) either had or currently have rebate programs in place for LED traffic signal retrofits. Other utilities and public power companies offer financing for LED signal retrofits. For example, PG&E offers local governments financing for LED signal retrofits through its Energy Advantage program. Northern States Power provided St. Paul with a zero-interest loan to finance LED retrofits in that city. The New York Power Authority (NYPA) provided New York City with low-cost financing (at NYPA's cost of capital) for installing the red LEDs and enhanced-life green and yellow incandescent lamps in the borough of Queens. Finally, Northeast Utilities is financing LED retrofits in several Connecticut cities and Public Service Electric and Gas (PSE&G) is offering LED retrofit installation and maintenance services directly to customers in its territory in New Jersey.

A recent CEE initiative (discussed below) serves to facilitate coordination of its members' LED traffic signal promotions. Many of the utilities mentioned here participate in CEE's initiative. A review of their promotional activities, which is periodically updated, can be found on CEE's website at www.ceeformt.org.[2]

Barriers to Broader Market Penetration

While experience to date has been quite positive, several barriers hinder more rapid market penetration of LED traffic signals. The major barriers include high initial price, performance concerns, and some organizational inertia and constraints.

High Initial Price

A number of factors contribute to the high costs faced by purchasers of LED traffic signals. LEDs are inherently more complex than are incandescent bulbs, so LED traffic signals retrofit kits cost more to produce. Additionally, the application for LEDs in traffic signals is relatively new, and some manufacturers (particularly source die manufacturers) may have established prices at relatively high levels that allows them to more rapidly recoup their initial investment. Furthermore, manufacturers of the source material may be less responsive to traffic signal demand than to demand from other markets (the signage or brake light markets, for example).

Nonetheless, demand for LEDs in numerous applications, and innovations motivated largely by the goal of achieving high quality white light from LEDs, has led to industry changes, with a number of new players entering the business of producing LED source material (particularly green LEDs). These changes have spurred greater price competition, such that the prices of LED traffic signals have come down considerably over the last few years. About a year ago, volume-purchased 12-inch red LED ball traffic signals cost about $220. Today, the same red signal is a little over $100. Green signals have witnessed an even steeper price decline, falling from about $350 to about $140 in a little over a year. While these signs are encouraging,

[2] A table reviewing member promotions can be found at www.ceeformt.org/resrc/updates/00-04led/00-04led.html.

LED traffic signal cost continues to be a barrier to state and local investments in the technology, particularly when that cost is compared to a $2 to $4 incandescent bulb.

Lack of Information/Performance Concerns

There is a general lack of understanding and information about the proven technical performance and benefits of LED traffic signals. This, in turn, gives rise to concerns about liability risks and contributes to risk minimizing behavior (i.e., choosing not to invest). Questions that arise from uninformed traffic signal purchasers include: Will the signals provide the appropriate level of intensity so oncoming vehicles can see them under various driving conditions? Will they last as long as intended or will early failure result in catastrophe? In addition, jurisdictions may not feel confident in projected energy and other cost savings necessary to justify program costs. Many state and local governments lack data on the technology, lack the time and resources needed to gather the information, or view with some skepticism information provided by manufacturers. Absent reliable, accurate, and easy-to-use information (as well as local demonstrations and financial incentives that reduce risk), these jurisdictions will be reluctant to choose LED traffic signals.

Organizational Inertia and Constraints

Not all actors involved in state and local decisions to install LED traffic signals are in need of additional information on performance and savings, however. In a survey of traffic system engineers, one LED signal manufacturer found that this group, in particular, has a fairly high level of awareness about traffic signals. But city and county managers and elected bodies who make policy and budgetary decisions about LED traffic signal projects are perceived to have less information available to them on the energy savings and other benefits, and more constraints imposed by procurement rules and budgetary processes.

Many localities also face significant capital constraints, such that finding the capital for, or justifying, projects that pay back in any period greater than one budgetary cycle is challenging. Furthermore, different departments or agencies may conduct capital expenditure and operating cost accounting. In these cases, the agency requiring budget authority to perform an LED installation and the agency benefiting from the energy savings differ. Unless capital and operating budgets are located under the control of the implementing department or an agreement is established to reward the implementing agency, there are disincentives within local government to perform LED retrofits and other capital intensive projects despite their potential lifecycle cost benefits.

Other Issues

Another constraint to the widespread installation of LED signals is billing structures. Many utilities bill jurisdictions a flat tariff rate per signal or intersection rather than a rate based on actual energy usage (kWh) and/or demand (kW), particularly where signals/intersections are un-metered. This type of billing structure, typically based on predetermined estimates of average incandescent energy and/or demand use, does not allow a municipality to realize energy cost savings from an LED upgrade. Revising a tariff requires regulatory approval, and hence, can be a lengthy process. Alternatively, shifting from a tariff rate to a metered rate can be very costly owing to installation, maintenance and meter reading costs.

Breaking the Barriers

The good news is that a number of efforts are currently underway to address one or more of these market barriers. Table 1 summarizes the five activities highlighted in this paper; these are discussed in more detail below.

Table 1. Key Initiatives Supporting LED Traffic Signal Market Transformation

Activity/Key Elements	Barriers/Issues Addressed
LED Traffic Signal Specifications Establishes national/international industry specifications for LED traffic signals	▪ Reduces liability concerns ▪ Increases confidence in technology
U.S. EPA/DOE ENERGY STAR® Labeling Program Enables manufacturers to label energy-efficient products with a nationally-recognized brand, supported by national marketing campaign	▪ Provides purchasers an easy way to identify efficient products ▪ Offers other market actors (manufacturers, utilities, etc.) a common specification and marketing message to promote
CEE's LED Traffic Signal Initiative Aggregates utility promotion of LED traffic signals; often includes financial incentives	▪ Sends consistent message from utilities throughout the U.S. ▪ Reduce high cost barrier, where financial incentives are provided
New York State's Energy $mart Program Statewide awareness building and educational campaign	▪ Provides targeted demonstrations, technical assistance and education to decision-makes in NYS jurisdictions
IEA DSM Annexe III LED Traffic Signal Procurement Combines purchasing power of several European countries	▪ Increases demand and leverage for more competitive prices

National/International Specification Development

The development of specifications specifically for LED traffic signal technology can address performance uncertainties and improve user comfort with the technology. A nationally- or internationally-recognized standard can reduce user concerns about liability and enable them to more readily take on the risk of adopting newer technologies. For LED traffic signals, this can lead to an increased willingness to specify LED traffic signals and greater demand.

Internationally, efforts are underway through organizations such as the Commission Internationale de l'Eclairage (CIE), the International Energy Agency (IEA), and the European Committee for Standardization, to develop specifications for traffic signals using LEDs. Interestingly, there appears to be a philosophical difference between international specifications and North American specifications. In the U.S., different intensities are required for different-colored signals. For example, the specification for incandescent signals developed by the ITE requires that green signals be twice the luminous intensity of red signals, and yellow signals be more than four times the luminous intensity of red signals (ITE 1985). In contrast, standards in Europe (and Japan) specify equal luminous intensities for all three nominal signal colors.[3]

In the U.S., many states and municipalities have been reluctant to pursue LED traffic signal retrofits in the absence of a clear LED traffic signal standard from the Institute for Transportation Engineers (ITE), the organization responsible for setting performance specifications for traffic signals. In June 1998, the ITE made progress by publishing an interim specification for LED traffic signal modules (ITE 1998). This interim specification differs from the ITE specification for incandescent traffic signals (ITE 1985) in several important ways, most notably in reduced luminous intensity requirements for LED modules. The required luminous intensity of LED signal modules is 85% of that required for incandescent signals. The precise visibility implications of this 15% reduction in signal intensity is not entirely understood. The National Cooperative Highway Research Program (NCHRP) has initiated a research project to investigate visibility requirements of traffic signals; results are expected in late 2000. The findings of this research will inform the development of a final ITE specification. In the interim, Pacific Gas & Electric Company (PG&E) and LumiLeds Lighting supported research conducted by the Lighting Research Center (LRC) at Rensselaer Polytechnic Institute to provide preliminary data that might be used by ITE in its ongoing deliberations about specifications.

In 1999, LRC completed its initial study of luminous intensity requirements, which was presented at the annual meeting of the Transportation Research Board in January 2000 (Bullough et al. 1999). This study investigated visual responses to simulated traffic signals using incandescent and LED light sources by young (age 25 to 35 years), normal-sighted observers. The study apparatus simulated the onset of a 200-millimeter (mm) signal viewed from 100 meters (m), or a 300-mm signal viewed from 150 m. Researchers measured response time to the onset of a signal, missed signals (response times longer than 1 second were considered misses), signal color identification, and subjective ratings of brightness and conspicuity.

There were no significant differences in any of these responses between incandescent and LED signals having the same nominal color and luminous intensity. Both types of signals were presented using a shutter that rendered their onset times equivalent; in the field, LED signals have shorter onset times than incandescent signals (~20 milliseconds (ms) versus ~100-200 ms). Research is currently underway to investigate whether signals with shorter onset times offer any visual benefits over those with longer onset times.

There were, however, significant differences among the red, green and yellow signals in terms of response time and missed signals, when these colored signals had the same luminous intensity. Specifically, red signals resulted in shorter response times and fewer missed signals than yellow or green signals of the same intensity. Green signals resulted in the longest response times and greatest number of missed signals of the three colors. Subjective ratings of brightness and conspicuity also resulted in red signals being rated brighter and more conspicuous than yellow and green signals of the same intensity. Thus, if equivalent responses to each of the signals colors are desired, it may be appropriate to specify different luminous intensities for the

[3] For comparative information on traffic signal specifications, visit the LRC's website at www.lrc.rpi.edu/Ltgtrans/led/led-table.html.

three signal colors (as ITE has done). However, the current ITE specification results in a green signal that gives longer reaction times and more missed signals than yellow or red signals. Because the green signal does not have the same safety implications as a yellow or red signal, this may be acceptable to the traffic engineering community, although the question is currently being intensely debated.

U.S. EPA/DOE ENERGY STAR® Program

Building on the ITE specification, the U.S. EPA/DOE are in the process of developing an ENERGY STAR® labeling program for LED traffic signals. The label will make it easier for end-users to identify environmentally preferable traffic signals and to enable them to use ENERGY STAR® criteria in specifying new signals. At this point, EPA has conducted background research, and developed and revised a draft specification based on its research and comments received from various interested parties. The current draft ENERGY STAR® specification references a the ITE interim specification, but adds energy performance criteria. EPA anticipates having a final specification available and a program developed in mid- to late-2000 (EPA 2000; Schmeltz 2000). Because the ENERGY STAR® label facilitates specifying and purchasing high-efficiency equipment, many states, localities, and utilities are likely to be interested in using or promoting the ENERGY STAR® specification. A number of utilities and states, in fact, have expressed interest in using the ENERGY STAR® criteria as the platform on which to build LED traffic signal promotion programs.

Consortium for Energy Efficiency Initiative

The Consortium for Energy Efficiency (CEE) is a national non-profit organization that aggregates the influence of member utilities and other organizations to transform markets for highly efficient technologies. In December 1999, CEE approved an initiative to promote a consistent signal specification, with the ultimate aim of improving market acceptance of LED technology in traffic signal applications.

The initiative focuses initially on single color signal retrofits (particularly reds and greens), which are market-ready, but plans to address fully integrated LED traffic signals as the market for these products matures. The goals of the initiative are four-fold and include:

- Increasing installations of energy saving LED traffic signal replacements;
- Supporting development and widespread acceptance of the ITE specification for LEDs;
- Improving the level, quality and availability of information addressing the energy and non-energy benefits of LED signals; and
- Raising decision-makers' awareness of LED traffic signals and their benefits.

To accomplish these goals, CEE provides several key services, including: (i) establishing a forum for its members to discuss technical issues as well as market developments; (ii) encouraging conservation members to expand their efforts to include an LED traffic signal program component; (iii) representing its members collectively at national forums, such as the

ITE LED specification meetings; and (iv) working closely with EPA on the development of a national ENERGY STAR® specification for LEDs.

New York State Energy $mart Program

To address the lack of awareness and to build demand for LED traffic signals, the New York State Energy Research and Development Authority (NYSERDA) has launched an market research and technical and educational outreach program to promote LED traffic signals in the New York Energy $mart territory. Key to this effort will be local demonstrations and case studies, to more tangibly illustrate the energy savings and other benefits of LED traffic signal installations, as well as targeted and broad educational outreach. Additionally, the project team will work with relevant market actors to reduce the disincentives created by flat tariff billing, which is prevalent in a large portion of the state.

Currently, the program is in its initial phase. The program implementation team has formed an advisory committee of industry market players and market transformation experts and is compiling current information on LED traffic signals including the latest visibility research, installation case studies, and market specific information to establish the baseline against which additional activity will be measured. This phase of the program should be complete by June 2000. During the second phase of the program, the team will develop a model performance and purchasing specification, conduct roundtables with key market actors, initiate several LED traffic signal demonstrations, and develop and disseminate educational and technical outreach materials (including case studies and a lifecycle cost analysis tool). The educational tools, lifecycle cost calculator and cases studies will be used in a broad outreach effort to provide concise, objective information to municipal decision-makers on the benefits of LED traffic signals. As a CEE member, NYSERDA coordinates its program effort with the CEE initiative, and plans to support the ENERGY STAR® labeling platform, once available.

IEA DSM Annexe III Programme for Cooperative Procurement

Independent of efforts in the U.S., the International Energy Agency (IEA) initiated an effort to coordinate procurement of LED traffic signals, based on other successful European efforts to drive down the price of products through technology procurement and volume purchase activities. The IEA DSM Annex III was established to create demand-pull programs that result in more energy-efficient and environmentally adapted products, to test the approach used, and to report on 'lessons learned' for future actions. One of Annex III's seven tasks is to develop and test cooperative procurement strategies. Future-oriented buyers and their needs are at the core of the process; these buyers specify the function of products they would like to see on the market. Their purchasing power is then pooled to achieve the greatest possible market impacts.

LED traffic signals were identified as a key target for cooperative procurement. A working group was established, including representatives of energy agencies, municipalities and others from the United Kingdom, the Netherlands, Sweden and Finland. Several questions were identified as critical to defining the appropriate approach for LED traffic signal procurement: (i) How can the market for LED traffic signals be accelerated? (ii) What is the common ground for an international cooperative procurement? and (ii) How can standards and practices support a cooperative procurement.

A workshop held in Stockholm in September 1999, led the working group and institutional buyers to determine that the LED traffic signal procurement effort should proceed along two main lines: a short-run strategy to develop specifications for LED retrofit signals, possibly for use in an internationally coordinated procurement process, and a longer-term strategy focusing on developing a specification for a future signal system, in which the controller, interface, etc. are reconsidered in light of LED technology.

In the short-term, Finland under Motiva and the three largest Finnish cities volunteered to draft a specification for LED retrofit signals. The Finnish group also inquired whether there was interest in their organising a cooperative procurement process in which other cities and road administrations were invited to participate. Insufficient interest, due largely to difficulties in defining a single specification suitable for multiple cities and countries, led Finland to elect not to coordinate such an effort. The specification now being considered is a basic specification that can be used by various procuring agencies, which goes beyond that of the European standard for traffic signals, but provides enough flexibility to be useful in practice by individual cities or countries. Instead of a co-operative procurement, a formalised information exchange process has been established to accelerate the transformation to LED traffic signals. This is being facilitated through an email discussion list (see www.stem/se/IEAprocure).

For the longer-run strategy, the Dutch Rijkswaterstaat has been active in developing a specification for a fully integrated LED-based system. The Rijkswaterstaat draft specification has already resulted in several prototypes. The working group is currently considering whether to use the Rijkswaterstaat specification as the basis for a technology competition in which manufacturers are invited to supply technical solutions or in which the winning entry/entries are invited to deliver a few systems for field tests.

The LRC, CEE, and EPA have each been involved in technical meetings sponsored by the working group to ensure the continual flow of information across borders. Substantial difference in current specifications render it difficult for North Americans and Europeans to consider coordinated market transformation efforts at this point, however.

Conclusions

While some momentum has been generated among local, state, and national governments that either have or are making a commitment to installing or promoting accelerated adoption of LED traffic signals, barriers remain that limit greater market acceptance of this technology. Several of these, principally high cost, lack of information, and performance uncertainties, are being addressed by a number of initiatives that are currently underway.

In the U.S., the development of an interim ITE industry standard for LED traffic signals is a major first step in increasing local and state governments' comfort with adopting LED traffic signals. Building off of this, an ENERGY STAR® program, which is in development, will enable purchasers to more easily identify and justify the purchase of quality, energy-saving traffic signals. Additionally, it will provide manufacturers with a nationally-recognized seal of approval for use in marketing their signals. Through national organizations, such as CEE, and the efforts of regional groups, such as NYSERDA, targeted information and education centered around a common specification, such as the ENERGY STAR® specification (when available), can be disseminated to local decision-makers and transportation officials. Assuming these efforts will have the intended market development effects, awareness of and recognition of the Energy Star label and the benefits of LED traffic signals, will help sustain market demand and provide an exit strategy for publicly-funded programs.

Together these initiatives offer the potential to dramatically reduce existing barriers impeding the wide spread acceptance and implementation of LED traffic signals in the U.S. Coordination of these efforts with specification development activities in Europe (particularly for new, fully integrated signals) will facilitate a global transformation from incandescent to LEDs in the traffic signal market.

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