LED Traffic Signal Initiative Description
Consortium for Energy Efficiency – 12/99

I. Introduction

Traditionally, traffic signals were illuminated with the same technology residents used to light their homes. Over the last decade, an alternative has become available to traffic signal purchasers. Now when drivers are at an intersection, they can see several tiny lights arranged in a traditional array of a signal. These tiny lights are light-emitting diodes, or LEDs. The technology has evolved into a reliable alternative that has tremendous energy and non-energy benefits. LED traffic signals are 80-90% more efficient and last many years. Incandescent bulbs need to be replaced at least once a year and burn out unpredictably. The longer life of LEDs extends the frequency of maintenance, thereby decreasing the cost to the town, city, county, or state.

To maximize the energy saving opportunity in traffic signal applications and ultimately encourage new energy-saving LED applications, the Consortium for Energy Efficiency (CEE) and its members are interested in accelerating market acceptance of LEDs. To effectively understand the national signal market, CEE commissioned a market assessment in 1998 identifying key market players, drivers and trends. During this same period, several CEE members were building local market experience by offering financial incentives for LED signal installations. With a significant level of market knowledge and several positive market developments – i.e. downward price trend, National Institute of Transportation Engineers (ITE) specification (interim) in place and an increasing number of signal manufacturers – the time is right to address this important opportunity.

II. Market Assessment

A. Market Structure

LED Industry

The principal industry actors in the market for traffic signals are the component manufacturers (components include light source material or material packages, controls, and traffic signal housing), and the traffic signal manufacturers. Relatively few manufacturers supply the traffic signal market with LEDs. As of 1999, the key manufacturers for red LEDs include Toshiba, Hewlett Packard and UEC (a division of a China semiconductor). The primary manufacturers of green LEDs are Nichia and Toyota Gosai. Hewlett Packard is also in the process of developing its own green die.

LED traffic signal manufacturers assemble packages of LEDs produced by die manufacturers and others into traffic signal retrofit kits. The LEDs are arranged in arrays or strings, which are fitted into a fixture, typically with a reflector, and connected to a power supply that transforms and rectifies alternating current (AC) to the direct current (DC) required by the LED signals. These retrofit kits are designed to easily fit into the housing for incandescent

signals. Dialight and Ecolux (Canada) are the dominant manufacturers of LED traffic signals, serving more than 80 percent of the market. Several other manufacturers, including Precision Solar Controls, Electro-Techs (the first LED traffic signal manufacturer), Tassimco, National Sign and Signal, and Relume Corporation, serve smaller market niches.

Other Stakeholders

In addition to the LED industry on the supply side, other stakeholders include equipment specifiers and purchasers, such as state department of transportation personnel, county and municipal energy office staff, traffic engineers, equipment installers, and maintenance staff. Typically, purchasing is in the purview of the state or local agencies, while installation, and in some cases, maintenance may be out-sourced. New York City, for example, has out-sourced both equipment installation and service to Energy Service Companies. In some cases, utilities manage installation and ongoing maintenance of traffic signals in their territories, and in many cases, utilities have been instrumental in stimulating the market for LED traffic signals. A total of 15 CEE members have programs that promote the installation of LED traffic signals. Several other utilities nationwide are investigating this possibility as well. Figures 1 defines each market player and Figure 2 displays their relationship with one another.

Figure 1. Key market player Definitions

Purchasers: There are 50 states, 3000 counties, and 200+ cities with traffic or transportation departments. Within each there are engineers, department heads, and others who make traffic signal purchasing decisions.

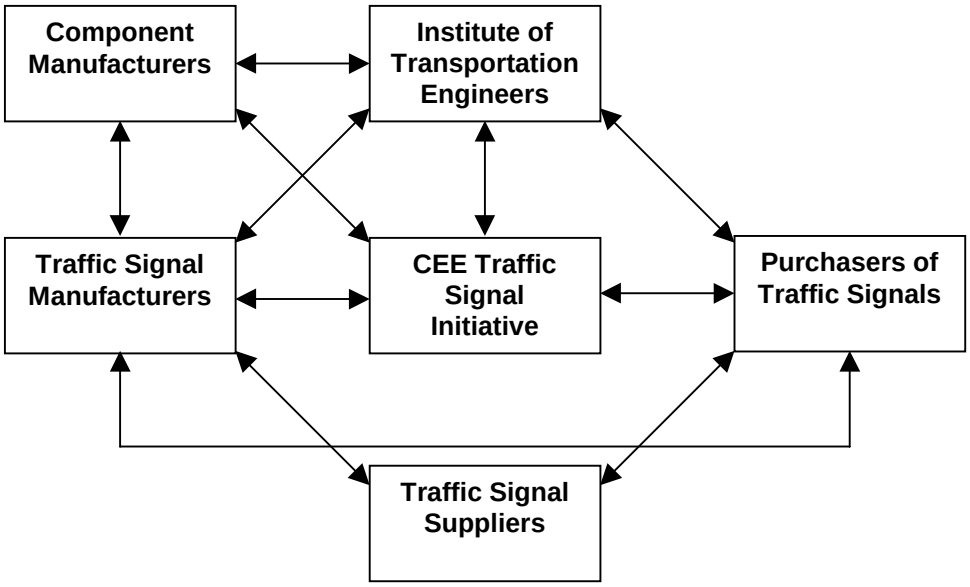
Manufacturers of LED Components: These manufacturers produce individual light emitting diodes, controllers, and housing that used to create LED traffic signals.

Manufacturers of LED Traffic Signals: This group of manufacturers uses components from the above manufacturers to produce LED traffic signals. Suppliers usually distribute LED traffic signals to interested purchasers.

CEE LED Traffic Signal Initiative: This national program is working towards transforming the traffic signal market by promoting the LED traffic signal technology. This includes CEE members who may have programs that offer incentives for LED traffic signal installations. CEE members also work with the above purchasers within their individual service territories.

Institute of Transportation Engineers: This national organization has a specification for LED traffic signals that is written for the Federal Highway Administration.

Figure 2. Relationship of LED Traffic Signal Market Players



B. Market Status

As of April 1996, 25,000 LED traffic signals in the United States had been retrofitted with LEDs. By the end of 1997, more than 150,000 signals had been installed, and an estimate of 1998 installations (by ACEEE's Margaret Suozzo) was 300,000. In a 1998 ACEEE report entitled, "Assessing Potential Candidates for National Market Transformation Initiatives," Suozzo and Steve Nadel note that "LED traffic signals are a good candidate for what could be a relatively easy market transformation effort."

Energy Savings Potential

An estimated 3 billion kWh in electricity could be saved annually by replacing incandescent traffic signals with LED signals. Most of the savings (i.e., approximately 2 billion kWh or nearly 70 percent) could be derived from switching out red signals alone. Typical red LED balls and arrows use 90 to 95 percent less power than the 150 W incandescent light source that they replace (e.g., 12-inch red balls require 15 W, saving 135 W and 12-inch arrows require 9 W, saving 141 W per signal). More than 900 million kWh could be saved by replacing green incandescent signals with green LEDs. The savings are less because of the lower duty factor and typically smaller size of green traffic signals.

Non-Energy Savings Potential

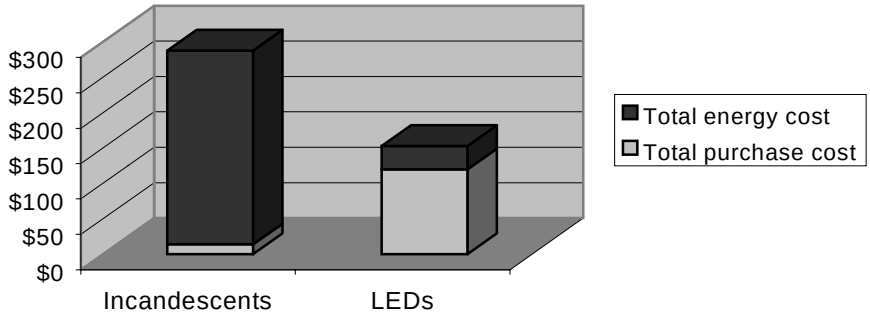
LEDs also last much longer than incandescent lamps (e.g., 5 to 10 years as opposed to 1 year), which has enabled many jurisdictions to reduce their maintenance schedules from every year to every other year, while avoiding replacement incandescent lamp costs (for the life of the LED). In estimating LED project costs and benefits, a few states and localities have included routine maintenance cost savings, as well as other benefits including reduced emergency maintenance costs and liability associated with less frequent lamp burn out. Some jurisdictions and utilities may also find that LED retrofits can reduce the need for metering intersections or reduce the frequency of meter readings, thereby reducing the costs of operating or serving the intersection.

Lifetime Cost

A typical incandescent bulb for traffic signals costs a jurisdiction about $2 to purchase. LED signal retrofit kits can be purchased at a significant premium. But the cost of red, green, and yellow LED retrofit kits varies considerably as a function of the number of die suppliers, market demand for the signal color, and intensity requirements. As of 1999, red LED retrofit kits are available for less than $130. As a result, red LED balls pay for themselves in energy savings in about 2 to 5 years, depending on the electricity rate. In Figure 3 and Table 1 below, there is a life cycle cost comparison between red LEDs and incandescents. The table indicates that the purchase and use of a red LED will cost about $134 less than incandescents do over the useful lifetime of a single red signal.

TABLE 1	Incandescents	LEDs
Annual energy use (kWh)	559	67
Energy use for 7 years (kWh)	3,912	472
Energy cost ($)	$273.86	$33.05
Lamp cost ($ per)	$2	$120
Lamp cost over 7 years ($)	$14	$120
	Incandescents	**LEDs**
Total purchase cost	$14	$120
Total energy cost	$273.86	$33.05
Total Cost over 7 years	$287.86	$153.05

FIGURE 3 **Comparison of Lifecycle Cost for Red Traffic Signals**



National Specification

The Institute of Transportation Engineers (ITE) writes standards and specifications for vehicle control devices. The current standards by which incandescent traffic signals are specified were initially developed by the ITE in the early part of the century. For the past several years, an ITE working group has been in the process of developing a specification for LED traffic signals. A specification was approved in 1998, although visual requirements remain tied to the incandescent signal specification. A revision of the current ITE LED traffic signal specification is pending results of a human visibility requirement study by the National Cooperative Highway Research (NCHRP). This study is expected to be completed in early 2000. The current specification could assuage the liability concerns of some state and local governments and pave the way to more rapid market transformation.

Procurement Potential

State departments of transportation and utilities have been leaders in getting LED traffic signals into the market. 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. Several pilot projects have been completed in California and Oregon, and many jurisdictions in these states are now pursuing large-scale retrofits or complete changeovers to red LED signals. Caltrans has converted over 65% of its red balls and arrows to LED traffic signals. Caltrans is planning to convert all 48,000 + red signals to LEDs and are working with local municipalities in California to change as well (Prey, 1999).

The cities of Denver and Philadelphia were also early adopters of the technology. The city and county of Denver have installed some 10,000 LED red balls and red arrows. Philadelphia has also completed a citywide retrofit of its red signals to LEDs and is demonstrating two prototype three-color LED traffic signals. With funding from Public Technologies Incorporated (PTI), Philadelphia conducted an evaluation of its early retrofits and developed a purchasing specification that other regions including New York City and New Hampshire have drawn on in developing their LED traffic signal purchasing requirements.

The states of Florida, Ohio, Michigan, Minnesota, Nevada, New Hampshire, New York, New Jersey, and Texas and a host of municipalities have also specified LED traffic signals, primarily for a few pilot installations. And the New Hampshire Department of Transportation is reportedly also planning extensive retrofits of both red and green signals and has experimented with retrofits of all three colors. Given the trend in other regions of the country, the experience of these states and municipalities is likely to lead to broader installations of the technology.

Utility Interest

Because of the energy savings potential, many utilities (including 15 CEE members) have programs that promote the installation of LED traffic signals. Three types of programs have

been identified through a CEE member survey (please see "LED Traffic Signal Survey of Members", June 1999): prescriptive; customized; and standard offer. The prescriptive programs offer a standard rebate to each customer purchasing traffic signals. Customized incentives are established on a case-by-case basis. Through standard offer programs, utilities pay a set amount per kilowatt-hour saved for LED traffic signals as well as other qualifying technologies or practices.

Potential ENERGY STAR® Label

The United States Environmental Protection Agency (US EPA) and the US Department of Energy (US DOE) are currently investigating the possibility of labeling LED Traffic Signals as **ENERGY STAR** products. By providing consumers with accessible, credible information on efficient traffic signal products, this effort could have a large impact on the market and help to initiate more installations at a faster pace than what might otherwise occur. The proposed CEE initiative will complement US EPA/DOE efforts whenever possible.

C. *Barriers to Market Acceptance*

Several barriers hinder more rapid market penetration of LED traffic signals. The major barriers include high initial price, undefined positions on performance, as well as some organizational inertia and constraints.

High Initial Price

A number of factors contribute to the high costs faced by purchasers of LED traffic signals. First, LEDs are inherently more complex than are incandescent bulbs, and thus LED traffic signals cost more to produce. Second, there are relatively few LED traffic signal manufacturers. Third, the application for LEDs in traffic signals is relatively new, so some manufacturers (particularly the source die manufacturers) may be establishing prices at a level that allows them to quickly recoup their initial investment.

The market dynamics somewhat limit the influence that organizations pursuing market transformation strategies can have on LED traffic signal costs. For example, the cost of LED traffic signals appears to depend largely on prices established by a few die manufacturers who may be less responsive to traffic signal demand than to demand from other markets (e.g., the signage or brake light market). As a result, a number of traffic signal manufacturers consider activities such as bulk purchases a relatively ineffective means of driving down prices in this market. Nonetheless, structural changes in the industry are proceeding fairly rapidly with a number of new players poised to enter the business of producing LED source material (particularly green LEDs). The main driver for current activity is achieving high quality white light from LED. Also, ongoing research on traffic signal visual performance may demonstrate that current intensity requirements are higher than necessary for yellow and green signals. Results of these studies and corresponding changes to national specifications could lead to lower signal costs.

Undefined Positions on Performance

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 amount 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, 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, budgetary processes, and others.

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.

III. Initiative Goals and Objectives

This initial focus of this initiative is to promote market acceptance (primarily decision-makers and the channels supporting them) of the light-emitting diode (LED) technology in traffic signal applications. As such, particular emphasis will be given to single color signal retrofits as opposed to fully integrated signals. Upon successful accomplishment and barriers addressed, the focus may shift toward other appropriate LED applications such as fully integrated fixtures. Accordingly, current goals are as follows:

1. Increase installations of energy saving LED traffic signal replacements.
2. Support development and widespread acceptance of an ITE LED specification.
3. Improve the level, quality and availability of information addressing energy and non-energy benefits of LED signals.
4. Raise decision-makers' awareness of LED traffic signals and their benefits.

IV. Initiative Scope

A. Geographic Coverage of the Initiative

The initiative is focused on the North American market for LED traffic signals. The program will seek participants and industry partners from the United States, Canada and Mexico. To the extent practicable, CEE will also track and coordinate with ongoing activities in Europe.

B. Covered Equipment and Market

Most traffic signals in place today use incandescent lamps as a light source and a colored plastic or glass lens to project the red, green, or yellow colors through to oncoming viewers. Because incandescent signals produce white light and must filter all colors other than the red, green, or yellow desired, incandescent light is an inherently inefficient source of light for traffic signal applications. Additionally, incandescent bulbs produce considerable light outside of the visible spectrum, which is emitted in the signal head as heat. LEDs minimize both wasted light and heat, thus saving substantial energy. Further, LEDs offer safety benefits and last longer than incandescents, reducing maintenance costs.

Since the early 1990s, a number of municipalities and state governments have purchased LED signal head retrofit kits to replace incandescent signals. LEDs are semiconductor devices that use solid-state electronics to create light at distinct wavelengths (i.e., colors) of light. A single LED light source is known as a die. Anywhere from 18 to 600 of these light sources may be packaged in an array for use in a traffic signal head. Most retrofits have focused on replacing red LEDs because of their safety benefits and good economics. Increasingly

municipalities are replacing greens signals with LEDs as they recognize additional maintenance and other benefits.

Traffic signals that use LEDs as a source of light are covered by the initiative, including red, green, and yellow LED traffic signal retrofit kits as well as fully-integrated three-color LED traffic signals. Pedestrian signals will be considered in the future.

V. Key Activities to Overcome Barriers

A. CEE Committee

By completing the activities below, the committee will be better equipped to address the initiative barriers strategically. Specifically, strategies will be developed to address high initial price, undefined positions on performance, and organizational inertia and constraints. The following are activities for the CEE LED Traffic Signal Committee:

- Evaluate and research purchasers needs and issues in regards to traffic signals.
- Identify purchasers' knowledge and the related information gaps.
- Find commonly beneficial tools, information, communication vehicles, and case studies. Then develop the supplemental information to educate the purchaser addressing the known information gaps. Possibly may include materials such as a web site, brochure, database of products, life cycle cost tool.
- Effectively deliver the informational pieces through communication channels above and through relevant associations including NASPO, NASEO, NIGP, NACo, etc.
- Continually monitor participant activities and progress and summarize the national picture for all relevant stakeholders,
- Continually assess the direction of the initiative and the appropriateness of its activities.
- Meet regularly by phone conference or at quarterly member meetings to discuss market developments, initiative status, and other important matters.
- Appropriately interface with national stakeholder organizations (such as ITE, manufacturers, etc.).
- Maintain a web site, fact sheet and newsletter for relevant initiative materials.
- Actively encourage new initiative participants through outreach via appropriate conferences, publications, and other venues.

In addition to the activities above, there are two specific areas for the CEE Committee to monitor, ENERGY STAR labeling program and the ITE specification process. Future possible areas to investigate are briefly described below as well.

Pursuit of an ENERGY STAR Label

The United States Environmental Protection Agency is currently evaluating the possibility of labeling LED traffic signals as **ENERGY STAR** products. If the labeling process moves forward, the Initiative will have a significant platform to carry its message. To help make the **ENERGY STAR** label for LED Traffic Signals a reality, the CEE LED Traffic Signal Committee can communicate regularly with the US EPA, sharing information, comments and other details.

Defining a Revised National Specification

A meaningful national specification is key to the success of the initiative. As such, the CEE LED Traffic Signal Committee will regularly communicate with the Institute of Transportation Engineers (ITE) LED Specification Committee and attend their meetings as appropriate. The CEE committee can share relevant research with ITE to aid any revision of the LED specification. Upon ITE revising its national specification, the CEE committee may elect to propose the specification for adoption by the Board of Directors.

Opportunities Beyond Single-Color Retrofits.

Three-color signals may have additional benefits to single color retrofits. The cost of supporting traffic signals may be reduced because the integrated signal housing will likely be lighter in weight and controls may be altered. Also, the occupational hazard to installation and maintenance crews could be reduced because of the lower required voltages relative to incandescent lamps, e.g., 12 volts instead of 120 volts. LED pedestrian signals may also be investigated in the future as a part of this initiative.

B. CEE Regional Committees

Due to the nature of the operating environment (signals exposed constantly to nature's elements) and complexity of the purchasing function (balancing safety concerns, consideration of a relatively new application of technology, multiple decision makers, etc.), regional "support" committees can add significant value to the initiative. National efforts cannot consider all relevant factors that may affect a final decision. Regional groups would have the ability to discuss the unique factors of a region such as weather, landscape, and regulations. Possible roles include the following:

- Identify regional allies such as associations of traffic engineers, regional chapters of national associations, etc. Once identified, these organizations can be tapped as an excellent vehicle for educating decision-makers and key influencers.
- Convene forum to discuss the unique factors of a region and how they may impact implementation. Includes factors such as weather, landscape, and regulations.
- Conduct research and case studies relevant only to the area covered and still provide economies of scale to otherwise individual programs.

VI. HOW TO PARTICIPATE

To be considered a participant in this initiative, an organization voluntarily agrees to the following:

- Incorporate the ITE specification into regional/local programs
- Communicate the scope, duration and key aspects of regional/local programs
- Evaluates research and other opportunities for joint funding
- Allow the use of the organization's name and program information for achieving the initiative's goals

To be recognized an official Initiative Participant, please contact Melissa Lucas at (617) 589-3949 ext. 205 or email at mlucas@ceeformt.org.

VII. Bibliography

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