Accelerating the Commercial Market's Acceptance of LED Light Sources through Strategic Utility & Public Benefit Program Partnerships

Melissa L. Lucas, Consortium for Energy Efficiency, Inc.
Rachel Schmeltz, U.S. Environmental Protection Agency
Paul Vrabel, ICF Consulting
Edward Wisniewski, Consortium for Energy Efficiency, Inc.

ABSTRACT

Lighting represents a significant portion of energy consumption in the United States, and has been the focus of utility and other public benefit programs for the past two decades. Advances in various types of lighting including electronic ballasts, fluorescent lamps and colored light emitting diodes (LEDs) have allowed tremendous energy savings to be realized in both widespread and niche lighting applications. However, the rapid advancement, marketing, installation and ultimate energy savings of these technologies would not have been realized at the current levels without the support of various federal, state, and utility public benefit programs and their interaction with industry. In the not too distant future there lies an emerging technology that has the possibility of significant energy savings–white LEDs. In addition, there are many untapped niche applications for colored LEDs. Focused efforts through government–utility–industry partnerships can continue to help overcome technological, procurement and market barriers that prohibit widespread acceptance of LEDs in certain commercial and residential lighting applications. This paper discusses a strategy for advancing LED lighting through government–utility–industry partnerships.

Introduction

Utility and state public benefit programs have a history of helping to accelerate markets for new technologies. Much of their success is due to the tremendous impact of third party, independent promotions and their ability to educate and influence end-users and other market players; appropriately integrate programming within existing distribution channels; and use financial incentives to pull products through new and existing channels.

Recently, utilities and program implementers successfully overcame market barriers and helped to accelerate the acceptance of energy-efficient commercial lighting, which includes certain applications of LEDs. LEDs offer a large energy savings potential, as red and green LEDs use up to 80-93 percent less electricity than incandescent lighting. LED exit signs and traffic signals are becoming more prevalent, as 70 percent of all exit signs are LED and 20 percent of all traffic signals in the U.S. are LEDs (ENERGY STAR 2002; Larocca 2002). Today, applications for LED are increasing and becoming more diverse, as current markets now include lighting for transportation, navigation, architecture, flashlights, signage (channel lettering, outdoor message boards), and electronic equipment (stereos, cell phones). Some emerging applications for LEDs include display lighting (retail), LCD monitors, mini-projection displays, medical devices, and flood lighting (Craford 2001).

In addition to examining past successes with these technologies and lighting programs, this paper presents a suggested strategy for initially promoting colored LEDs in

commercial lighting applications through cross-sector partnership opportunities, as well as suggest program approaches to increase white LED market acceptance when the technology is ready. While, colored LEDs currently can replace colored lighting in certain applications, white LEDs are not yet technologically advanced enough to replace all conventional light sources, but there is significant potential. The mention of LEDs in this paper is intended to include both LEDs and organic LEDs (OLEDs).

Utility/State Public Benefit Programs

Public benefit programs are a mechanism by which energy-efficient technologies are promoted to consumers, businesses, and governments with the overall goal of achieving a societal benefit through accelerated market development. Public benefit programs are often required of utilities and other organizations by state regulators to improve system reliability, avoid costs of generation (new power plants, infrastructure), increase the competitiveness of energy supply and distribution, comply with Federal regulations, and/or reduce energy costs. Programs are also successful at accelerating the adoption of efficient technologies by stimulating product availability, helping to lower costs, and encouraging product demand. The programs accomplish this by promoting the use of efficient technologies, encouraging the reduction of energy consumption, and/or educating customers on the benefits of efficient technologies. Utilities may also choose to provide public benefit programs in the absence of a mandate to avoid the cost of new generation or to foster relationships with customers.

Using the systems benefit charge, which is an additional kilowatt-hour charge imposed on customers, utilities are able to design, administer, and implement programming. Approximately 1.65 billion dollars is currently available for these programs in the US scattered among twenty different states. Seven more states are now in the process of determining their funding levels for energy efficiency programming (ACEEE 2001). In some states, the design, administration and implementation of programming are being shifted to organizations other than utilities. For example, in Wisconsin, the State Division of Energy is responsible for administering public benefit programs rather than each individual utility.

ENERGY STAR®, a voluntary labeling program jointly sponsored by the U.S. Department of Energy (DOE) and the Environmental Protection Agency (EPA), helps to support these efforts at the national level by identifying efficient products. Manufacturers that are ENERGY STAR Partners can use the ENERGY STAR label on products that meet certain energy efficiency requirements. A recent study showed that over 40 percent of households in the U.S. recognize the ENERGY STAR label (Goldberg, Rosenberg & Pettit 2001). Utilities capitalize on this label recognition by using the label in their promotional and outreach efforts to encourage their customers to purchase energy efficient products.

The Consortium for Energy Efficiency (CEE) is a national, non-profit public benefit corporation that leads several national energy-efficiency initiatives. CEE members include electric, gas and water utilities; research and development organizations; state energy offices; and regional energy programs. CEE encourages utilities and other partners to pool their market influence by voluntarily adopting common programs and efficiency specifications. CEE helps to provide strategic direction for voluntary sustainable programming and a central location for program implementers to share their experiences with others across the country. The large number of organizations and financial resources behind public benefit programs

has a great influence on the adoption of energy-efficient technologies such as commercial lighting. This past success can help to further certain LED lighting applications.

Public Benefit Programs, ENERGY STAR and Commercial Lighting

Utilities and government entities have a long history of working to promote energy-efficient commercial lighting. Through various programs and partnerships, a wealth of research and experience has been collected, and significant progress has been made toward acceptance of efficient lighting sources in the commercial market. Programs have employed a number of different strategies to influence this market, including cash incentives, financing, direct installation measures, tax credits and marketing to target audiences. These successful commercial lighting programs have promoted the use of efficient fluorescent lighting and electronic ballasts as well as LEDs in certain applications. The knowledge obtained from these programs is helpful when utilities and states are looking for new ways to impact the LED market including identifying decision makers, determining how they are influenced, and learning about the various market players. By examining each program example provided below, methods of market intervention could be extracted and replicated to help further develop the market for other LED technologies.

Commercial Lighting Programs

Pacific Gas & Electric (PG&E) has been administering commercial lighting programs for over a decade and has laid much of the groundwork necessary for widespread acceptance of LEDs. Some of their program strategies have included: the distribution of cash incentives to help offset purchase price, the dissemination of information to lighting designers through the Pacific Energy Center, the creation of tools for designing efficient lighting, and performing energy audits for commercial building owners (Rosenberg et al. 1998). Although many of these strategies were used to promote efficient fluorescent lighting, they could apply to furthering LEDs as well. Through their years of experience, PG&E has established relationships with many of the key decision-makers within California. Leveraging these relationships is key when applying these strategies to other efficient technologies like LEDs.

The New York State Energy Research and Development Authority (NYSERDA), is currently implementing the *New York Energy $mart^{SM} Small Commercial Lighting Program* to promote efficient lighting among contractors, product distributors, and other commercial lighting decision-makers. The program provides tools for aiding design and installation of high performance lighting, training for distributors and contractors, cash awards for lighting design competitions, lighting demonstration projects in small commercial areas, and incentives to help with incremental costs and for professional lighting certification (NYSERDA 2001). Each one of these resources would be logical places to incorporate information on LEDs. NYSERDA's Energy $mart Program is one example of programs that are targeted toward industry instead of focusing on the end-user.

The Environmental Protection Agency's Green Lights Program began in 1991 to encourage building owners and operators to upgrade lighting in at least 90 percent of their building spaces. In exchange, these partners received technical assistance and public recognition. After nearly 10 years of Green Lights, over 2,000 partners committed to upgrade lighting in their buildings. This program has since been rolled into a larger

EPA/DOE program called ENERGY STAR for Buildings, which now serves the same audience by providing a benchmarking tool that can be used to compare energy costs with those of similar organizations. In addition, the program helps users measure a building's total energy consumption, improve their bottom line through increased energy and environmental performance, purchase energy efficient products, and establish an energy performance target for new building design. Although ENERGY STAR's focus is broader than commercial lighting, its ties with the commercial building market would be helpful in educating lighting decision makers about the benefits of purchasing LEDs for certain applications.

Electronic Ballasts

During the late 80's early 90's commercial electronic ballasts were expensive and had some technical issues that still needed to be resolved. Manufacturers responded to these technical issues, by offering free replacement ballasts and a $10 labor allowance per ballast to purchasers who experienced any problems. Electronic ballasts continued to be marketed and sold by manufacturers wherever possible, even though technical problems had not yet been completely solved. Utility program rebates and U.S. EPA's Green Lights program helped to overcome some of these challenges by the mid-1990's. Although the technical difficulties existed, marketing the benefits of electronic ballasts created interest among facility managers, so when the ballasts did improve they were quickly adopted. The interest generated by utilities and Green Lights not only helped create a market demand, but also provided manufacturers the impetus for additional research and development to lower ballast failure rates. In addition, as the market matured, the price of this "new technology" came down to a more competitive price. Efforts by utilities and Green Lights had a hand in realizing significant energy savings and helped to set the stage for DOE's recent rulemaking, which will effectively require the use of electronic ballasts. This experience is useful when considering that certain technical issues still need to be addressed with LED lighting.

LED Exit Signs

The success of LED exit signs is attributable in part to utility programming and the ENERGY STAR label for exit signs. Because the purchase price of LED exit signs was higher than signs using incandescent bulbs, utilities helped to offset initial costs by offering financial incentives to their commercial customers. In addition, utilities have educated exit sign purchasers on additional benefits including reduced maintenance and improved visibility. Saving on maintenance was often a greater motivator for purchasers than energy savings, highlighting how important utility programs are in educating end-users.

The ENERGY STAR label for exit signs offered a simple way for utilities and purchasers to identify efficient exit signs. In many cases, utilities required their customers to purchase ENERGY STAR labeled exit signs in order to be eligible to receive incentives. ENERGY STAR saved utilities a considerable amount of time by identifying which products were efficient and establishing credibility among the purchasers. ENERGY STAR labeled exit signs use no more than five watts of electricity per face; they meet higher luminance and visibility requirements than existing standards and are required to have a 10-year manufacturer warranty. In the Spring of 2002, 34 different manufacturers offer ENERGY STAR labeled exit signs, including 25 brands and 264 different models (ENERGY STAR 2002).

LED Traffic Signals

Utilities and states have also been successful in helping to further the market for LED traffic signals. As with exit signs, the purchase price of LED traffic signals is significantly higher than that of incandescent lamps. Utilities and states have been instrumental in helping municipalities overcome this barrier by offering incentives to ease the initial financial outlay needed. Because LED traffic signals also provide municipalities substantial maintenance savings, utilities and state governments have worked to educate their municipal customers on all benefits of LED traffic signals. As a part of this education, CEE and its members created an educational brochure and the web-based Case Study Resource Center to further educate purchasers on the benefits of installing LED traffic signals, thereby helping utilities make their programs more effective because of CEE's third-party credibility.

ENERGY STAR has also assisted utility and state programs by allowing traffic signal purchasers, states, and utilities easy identification of the most efficient signals through the use of the ENERGY STAR label. During the summer of 2001, utilities offered over 34 million dollars in incentives to California municipalities for purchasing ENERGY STAR labeled traffic signals. Through ENERGY STAR, California utilities were able to simplify implementation of these programs and spend the time saved on other peak demand reduction programs.

Today, about 20 percent of all traffic signals use LEDs, and that percentage is growing rapidly, as some estimate a 60 percent market share by 2005 (Larocca 2002). The cost of LED traffic signals is decreasing considerably, helping to escalate the rate of replacement. Over the past five years, the cost of a red signal has decreased nearly 60 percent (based on the author's experience). This lower price will help further the technology, as it gives industry additional capital to work on other LED technological barriers.

White LEDs and the Commercial Lighting Market

While LED exit signs and traffic signals have resulted in significant reductions in power consumption, an even greater opportunity lies within the general commercial lighting market. Although white LEDs are currently available, the technology still needs to make significant gains in lighting quality and cost effectiveness in order to be a viable replacement for most conventional light sources including incandescent and fluorescent. There are several manufacturers, government and research organizations, including DOE and the Sandia National Laboratory, working to advance the technology significantly within the next 10–20 years by investing approximately $50 million each year in R&D. According to a study completed for DOE, the feasibility of white LEDs replacing fluorescent, incandescent, and other types of lighting depends on how quickly the technology will advance as well as how fast LEDs become cost effective over the next 20 years. The study models three different scenarios and predicts the energy savings potential, market penetration, technology improvement, and price resulting from each scenario over a 20-year period. The *Base* case illustrates current advances remaining at the same level; the *Technology Breakthrough* case considers a more assertive technology development; and the *Price Breakthrough* case shows the price of LEDs radically drops with a technology breakthrough (ADL 2001). DOE has other research on its Office of Building Technology, State and Community Programs web site at http://www.eren.doe.gov/buildings. Although it is unknown when white LEDs will be

ready for the market acceptance, there is still a role for public benefit programs to help advance this technology by creating additional market demand.

Manufacturers continue to make progress in improving efficacy. For example, Lumileds announced in the spring of 2002 that their 5-watt white LED achieved a light output of 120 lumens, breaking the 20 lumens per watt milestone. It would take 8 of these new LEDs (total of 40 watts) to create the equivalent lumens of a 60-watt incandescent lamp (900 lumens). Although this energy savings is not significant enough to justify widespread replacement, this example highlights the progress manufacturers are making on improving the efficacy of white LEDs (EREN 2002). It should also be noted that the current industry average for an LED is about 15 lumens per watt according to the Lighting Research Center (Narendran & Bullough 2001).

While white LEDs are not ready for widespread inclusion into programs, utilities and states should monitor developments, as some organizations do their planning every year, and need sufficient lead-time to include new technologies in their programs. Other organizations such as NYSERDA, the Northwest Energy Efficiency Alliance and the Northeast Energy Efficiency Partnerships plan on a longer-term basis, making it even more important to inform public benefit programs of new colored and white LED lighting developments. According to the Energy Information Administration, lighting energy use is increasing over time, although efforts by utilities and states help to keep the growth to a minimum. This is also mentioned by E-Source in their Technology Atlas, "Lighting energy use is increasing in all sectors, but efficiency improvements through federal government programs, utility efficiency efforts and national codes and standards will considerably slow that growth" (Travisono 1997). Utility and state programs will continue to have a key role in the lighting market, as they have the experience, knowledge and resources to help expedite the market transformation of LED lighting.

Strategy for Advancing LED Lighting

As the above program information demonstrates, there are clear opportunities for colored LED applications to be incorporated into existing energy-efficiency programs and for white LEDs to be included when technologically advanced enough to be appropriate. The rest of this paper outlines suggestions for a strategic approach to include these technologies in current energy-efficiency programs. First steps in the strategy should be to establish a national working group, identify a few niche opportunities and applications, and then develop a national program structure and communications/marketing plan to advance colored LEDs and keep sharp tabs on white developments.

Establish National Working Group

Establishing a national working group to advance LED lighting in commercial applications is a valuable first step. Information about LED lighting is constantly changing, making it difficult for individual utilities and states to keep abreast of technological and economic advances. Working group members could include program implementers, utilities, states, non-profits, and Federal government representatives from both the EPA and DOE-that is, those that do not have financial ties to the sale of LEDs. A neutral organization, like a

nationally based non-profit, could facilitate and help guide the group's activities. Working together, the group's participants could achieve economies of scale by learning from one another's program experiences and preventing duplication of efforts. The group's neutrality would leave them in a better position to share unbiased information with lighting purchasers. The national working group could provide the following:

- Encourage participants to incorporate LED technologies that are ready for market into their planning and programming. By including applications that use LEDs into existing public benefit programs, utilities and states could spread the word about LEDs and add value to the end-user by offering another efficient lighting option.
- Work to educate purchasers on various technical issues that may arise.
- Facilitate networking and resource sharing among participating organizations.
- Assist participants with understanding the commercial lighting and LED markets.
- Keep participants informed of white/color LED technology developments.
- Help program implementers determine the energy savings potential of specific LED applications and understand other market parameters that must be considered.
- Develop relationships with manufacturers and distributors so they can gain a better understanding of the value of utility and state public benefit programs, while participants could have an easy way to reach key national manufacturers.
- Devise an action plan to advance LED lighting in certain commercial applications including identification of specific barriers to the widespread acceptance of LEDs in those applications and development of activities to overcome those barriers. This plan could also include pilot testing of an application that is technologically ready to use white LEDs as a way to condition the market for widespread acceptance of the technology. One example is the recent white LED lighting retrofit project completed at the Jefferson Memorial in Washington, DC through cooperation with the National Park Service, the National Park Foundation and Osram Sylvania Partnership.

Promote LED Niche Market Applications

According to one LED manufacturer, "specialty and niche applications will drive market penetration and technology acceptance of LEDs" (Arcand 2001). By pushing these selected applications, the first cost of LEDs can be driven down, thereby making their practical usage in other lighting applications easier. Regardless of the LED color, a few niche applications of LEDs, such as traffic signals and channel-lettering signs, can be brought to the attention of program implementers. While LED traffic signals are already included in some utility and state public benefit programs, their market share is still only 20 percent Also, this 20 percent is somewhat concentrated in states like California, but is much lower in other states including Texas and New York. Therefore, this application could continue to play a valuable role in some public benefit programs. Other applications for LED traffic signals can also be promoted including flashing signals, railroad crossings, and underground subway signals.

LEDs are now starting to make their way into channel lettering signage. In the past, neon has been the only light source available for channel lettering signs, which have both outdoor and indoor applications. The energy savings potential for retrofitting signs with

LEDs is about 10-15 watts per lineal foot. Using LEDs as a light source also offers reduced maintenance needs (as signs typically last about 10-15 years) and possible safety benefits (require a lower voltage than neon). LED signs are also less susceptible to breakage, because unlike neon, no glass is used in the sign. The main barrier to widespread usage is the high first cost of the LED signs. To overcome this barrier, PG&E, San Diego Gas & Electric and Southern California Edison are offering financial incentives to encourage purchasers of channel-lettering signs to consider using LEDs instead of neon.

Because LEDs are a relatively new light source for commercial applications, there is the potential for variation among products in their quality and energy performance. Specifications can help purchasers, who may not be equipped with enough technical knowledge, decide which LED products are best for their needs. In addition, specifications help program implementers administer incentive programs, as they can be a measurable and verifiable source of information about a particular technology. Specifications also help to move markets forward by increasing manufacturers' understanding of the need for efficient technologies. If developed for a few LED applications, manufacturers could also use these specifications in helping purchasers and program implementers identify their product as one that meets predetermined criteria.

Draw on Commercial Lighting Organizational Resources

By establishing partnerships with industry and becoming involved with existing program partnerships, the national working group could further promote the application of LEDs. Within the commercial lighting market, there are several existing efforts that are working to advance efficient lighting into design practices including the DesignLights™ Consortium, the Light Right Consortium, and the New Buildings Institute. The working group should consider partnering with these efforts to encourage an information exchange so that these other efforts are aware of technological developments and possibly include LED lighting within their individual scope of work.

DesignLights™ Consortium. The DesignLights™ Consortium is a "regional collaborative of utilities and other organizations whose purpose is to facilitate the implementation of improved design practices in all parts of the commercial lighting market such that high-quality energy-efficient lighting design becomes common practice" (Mernick, Dagher & Kates 2000). Facilitated by the Northeast Energy Efficiency Partnerships (NEEP), the Consortium targets property management firms, retail chains, state governments, and municipalities. DesignLights participants conduct market research, provide customer outreach and education, offer incentives, develop technical guidelines, and conduct contractor training. DesignLights has also formed a strategic alliance with the National Council on Qualification for the Lighting Professions (NCQLP) to incorporate the ideals of DesignLights into the NCQLP certification exam (Mernick, Dagher & Kates 2000). The working group could take advantage of the opportunity to educate DesignLights on the LED industry and DesignLights could help the working group utilize certification organizations.

Light Right Consortium. The Light Right Consortium is another partnership that the LED working group could leverage. Managed by Batelle's Pacific Northwest Division, this

partnership includes government agencies, non-profit organizations, and lighting and building industry representatives. The group's goal is to "use research as a basis for market transformation towards Ergonomic Lighting, …(which) is quality, energy efficient, and economical" (Light Right Consortium 2002). Members are involved in prioritizing and conducting research in order to link lighting practices to organizational/ human benefits by demonstrating increased productivity and energy savings (Light Right Consortium 2002). The working group should capitalize on the opportunity to work with another facet of commercial lighting and potentially reach a different group of lighting decision makers.

New Buildings Institute, Inc. The New Buildings Institute (NBI) is a non-profit organization that is "helping to make buildings better for people and the environment through policy development, planning and research. NBI works with national, regional, and state organizations, as well as utilities" (Benya et al. 2001). NBI's Advanced Lighting Guidelines serves as a technical resource for those making decisions about lighting design to encourage efficient use of lighting. Within the 2001 Guidelines, a section on LEDs describes their operational characteristics, performance and application guidelines. The working group could monitor NBI's work on the Advanced Lighting Guidelines and help keep NBI informed of LED technical developments as they become available. The Advanced Lighting Guidelines have become an important resource for lighting designers and decision-makers and therefore could be a good venue to advance LED lighting in commercial applications.

There is tremendous value in partnering with efforts such as the DesignLights™ Consortium, the Light Right Consortium, and the New Buildings Institute. Yet another option is to create a new partnership as an extension of the LED working group by establishing a committee including industry representatives. This committee could leverage funding from both working group members and industry sources to promote any number of elements of the LED technology at some point in the future. It remains to be determined if this concept would be feasible and necessary once the other strategy steps have been taken.

Consider Industry and Program Partnerships

American Lighting Association. The American Lighting Association (ALA) is a trade association whose members include residential lighting manufacturers, showrooms, distributors, and component manufacturers. Part of ALA's "2002 Action Agenda" includes partnering with ENERGY STAR, working with Underwriters Laboratory (UL) and the Canadian Standards Association (CSA) (ALA 2001). While ALA's focus is residential, their relationships with these organizations could help the LED working group as UL and CSA focus on commercial applications as well residential. Considering the size of their membership ALA has valuable insight into how to best reach these organizations and provide valuable leverage when trying to adopt standards and specifications for LEDs.

National Electric Manufacturers Association. The National Electric Manufacturers Association (NEMA) represents about 450 electric product manufacturers in North America. The NEMA Lighting Systems Division serves about 50 lighting manufacturers and is divided by product categories, including a section for solid-state lighting (LEDs, laser diodes, OLEDs). NEMA's Solid State Lighting Section is currently working on, "developing and

prioritizing a matrix of codes and standards in order to identify gaps and overlaps; serving as a clearinghouse and a liaison with organizations and firms; legislative work and research and developing educational materials for solid state lighting" (Pitsor 2001). This partnership would be a good opportunity for the working group to have access to both the LED industry and a good source of information on LEDs. Additionally, NEMA's interests coincide with the working group's, to further LEDs because of their efficiency, safety and design benefits.

Optoelectronics Industry Association. The Optoelectronics Industry Association (OIDA) has been involved in several solid-state lighting activities including the *OIDA Technology Roadmap for Light Emitting Diodes*. This document was a collaborative project among members of industry, government (DOE, etc.) and research organizations to identify opportunities for research and development of solid-state lighting. Three goals were identified including improving efficacy of white LEDs, reducing cost of solid-state lighting, and developing new solid-state lighting products as well as named a number of technical issues that still need to be addressed (OIDA 2001). Working with OIDA would help utilities and states better understand and plan for advances in LEDs.

Vision 2020: The Lighting Technology Roadmap. In 2000, the Department of Energy's Building Technology, State and Community Programs (BTS) and eight industry lighting associations co-sponsored an effort to develop *"Vision 2020, the Lighting Technology Roadmap"*. This roadmap identified important market transformation and technology development strategies and for successfully impacting and developing the commercial lighting market. Although the focus of this technology roadmap was the entire commercial lighting market, several of its strategies apply to LED lighting. This wealth of information could be utilized by the working group to understand how to further advance selected applications of LED lighting (DOE BTS 2000).

Next Generation Lighting Initiative. At the time of writing this paper, the U.S. Senate passed Bill 517, which included a provision called the "Next Generation Lighting Initiative." This provision, if kept through House and Senate Conference and passed by President Bush (the U.S. House passed similar bill, H.R. 4), will allow a 10-year solid-state lighting program to be established through DOE. In addition, a consortium of industry, government and research laboratories will be established to further the development of white LEDs. Although the future of this consortium and the DOE program are somewhat uncertain, it would be key for the working group to be involved and aware of this planned collaboration. Because the focus of the working group is more market-driven and not focused on R&D, there isn't a danger of duplication, but instead the working group would be complimentary.

Conclusion

LED lighting can be considered the most dramatic change in electric lighting since the fluorescent lamp was introduced at World's Fair in 1937. Red, green and other colors of LEDs now replace inefficient, incandescent sources in some applications. White LEDs need further technical advancement but have wider application potential as general light sources. Utilities, government agencies and energy-efficiency organizations are well positioned to

help advance LED technologies and stimulate the market. These organizations have laid the groundwork through other efficient lighting applications, such that end-users and mid-stream market actors are primed for embracing energy-efficient lighting alternatives. Establishing a national working group is a first step in bringing these organizations together to pool resources, work with manufacturers, educate distribution channels and stimulate market demand. A national working group that integrates activities, partners with industry and utilizes natural distribution channels will help to achieve the next lighting revolution.

References

American Council for an Energy-Efficient Economy (ACEEE). 2001. "Summary Table of Public Benefit Programs and Electric Utility Restructuring." http://www.aceee.org/briefs/mktabl.htm. Accessed February 2002.

American Lighting Association (ALA). 2001. *Action Agenda 2002*. ALA Strategic Plan Including 2002-2005. Dallas, Tex., American Lighting Association.

Arcand, H. 2001. "LED Signals: The Real Opportunity." Presentation at the Consortium for Energy Efficiency Program Committee Meeting, Boston, Mass., June 11-12.

Arthur D. Little, Inc. (ADL). 2001. "Energy Savings Potential of Solid State Lighting in General Lighting Applications." Report prepared for the U.S. Department of Energy Office of Building Technology, State and Community Programs. Washington, D.C.: Department of Energy.

Benya, J., L. Heschong, T. McGowan, N. Miller, and F. Rubinstein. 2001. *Advanced Lighting Guidelines*. White Salmon, Wash.: New Buildings Institute.

Craford, G. Intertech. 2001. "Overview of High Brightness LEDs and the Progress Toward High Power LED Illumination." Presentation made at Intertech's Light Emitting Diodes 2001, San Diego, Calif., October 17-19.

Department of Energy Office of Building Technology, State and Community Programs (DOE BTS). 2000. "Vision 2020: The Lighting Technology Roadmap." Washington, D.C.: Department of Energy.

Energy Efficiency and Renewable Energy Network (EREN). 2002. "EREN Network News April 24, 2002." http://www.eren.doe.gov/newsletter/archives/2002/april24_02.html. Accessed May 2002.

ENERGY STAR. 2002. "ENERGY STAR Exit Signs." http://yosemite1.epa.gov/estar/consumers.nsf/content/exitsigns.htm. Accessed February 2002.

Goldberg, M., M. Rosenberg, and T. Pettit. 2001. *CEE ENERGY STAR® Household Survey Report (2000)*. Report prepared for the U.S. Environmental Protection Agency. Washington, D.C.: Environmental Protection Agency.

Larocca, C. (GELcore, Inc.). 2002. Personal communication. February.

Light Right Consortium. 2001. "Light Right Consortium Program Description." http://www.lightright.org. Accessed March 2002.

Mernick, M., S. Dagher, and B. Kates. 2000. "The Success of the DesignLights™ Consortium: Moving the Commercial Lighting Market Beyond Technology and Into the Design Community." *Proceedings of ACEEE on Energy Efficiency in Buildings*, 6.277-288. Washington, D.C.: American Council for an Energy-Efficient Economy.

Narendran, N. and J. D. Bullough. 2001. "Light Emitting Diodes as Light Sources." In *Proceedings of the 9th International Symposium on the Science and Technology of Light Sources*, 329-336. Ithaca, N.Y.: Cornell University Press.

New York State Energy Research and Development Authority (NYSERDA). 2001. "The Small Commercial Lighting Program." http://lrc102.lightingresearch.org/sclp/homepage.html. Accessed February 2002.

Optoelectronics Industry Development Association (OIDA). 2001. "The Promise of Solid State Lighting for General Illumination." Washington, D.C.: OIDA.

Pitsor, K. 2001. "Setting Standards for Excellence 1926-2001." Presentation made at Intertech's Light Emitting Diodes 2001, San Diego, Calif., October 17-19.

Rosenberg, M., M. Rufo, A. Besa, and M. O'Drain. 1998. "The Market Effects of SDG&E's and PG&E's Commercial Lighting Efficiency Programs." In *Proceedings of the ACEEE 1998 on Energy Efficiency in Buildings*, 7.287-298. Washington, D.C.: American Council for an Energy-Efficient Economy.

Travisono, J., ed. 1997. *Lighting Technology Atlas*. Technology Atlas Series, Volume 1. Boulder, Color.: E-SOURCE.