

# The Internet as a New Tool for Implementing Energy-Efficient Lighting

EVAN MILLS

Lawrence Berkeley National Laboratory, U.S. Department of Energy  
MS 90-3058, Berkeley, California 94708, USA  
Tel: +1.510.525-7655, Fax: +1.510.525-8433, email: emills@lbl.gov

## ABSTRACT

This paper presents examples of how the Internet is being used to implement energy-efficient lighting, and discusses problems that remain to be resolved. The global Internet is fast becoming one of the most important energy efficiency information resources. Used since the 1960s by a small number of government and academic institutions, recent developments in networking technology and software have attracted as many as 70 million users, including lighting and energy-related groups such as utilities, buildings professionals, and a wide variety of private companies. The Internet's multimedia-based World Wide Web represents a particularly important innovation by simultaneously offering access to text, searchable databases, photographs, sound recordings, interactive calculations, and video images.

## INTRODUCTION

The mouse normally isn't considered to be the fastest creature on Earth, but "pointing-and-clicking" a computer mouse along the information super-highway mobilizes resources on energy-efficient lighting faster than any other means available. Since the lack of information is commonly cited as one of the major barriers to improve energy efficiency, the emergence of the Internet provides an important new tool (Mills 1996).

With the Internet, in a matter of minutes one can accomplish such diverse tasks as viewing documents from the US EPA on how to participate in the Green Lights Program, checking the latest stock prices for Osram-Sylvania, searching a detailed database of residential compact fluorescent fixtures, reviewing an up-to-date list of publications from the Lighting Research Center, investi-

gating Ontario Hydro's lighting programs, analyzing the latest U.S. electronic ballast sales data, sending a question about daylighting controls to 400 expert members of an international discussion group on lighting, downloading new lighting design software, calculating the electricity used for lighting in a specific home, registering for the Right Light conference, or reading the latest lighting jokes.

Existing and emerging applications of the Internet and the World Wide Web promise to make the Internet an even more useful tool for implementing energy efficient lighting. Following are six major examples:

1. Communications
2. Posting Text and Graphical Information
3. Document Retrieval and Software Downloading
4. Dynamic Databases
5. Remote Monitoring, Diagnostics, and Data Visualization
6. Interactivity and On-line Tools

## THE INTERNET EXPLOSION

The global Internet is fast becoming the number-one energy efficiency information resource. Used since the 1960s by a small number of government and academic institutions, recent developments in networking technology and software have attracted millions of users, including energy-related groups such as utilities, buildings professionals, and a wide variety of private companies.

The advent of the Internet's multimedia-based World Wide Web represented a particularly important innovation by simultaneously offering access to text, searchable databases, photographs, sound recordings, interactive calcula-

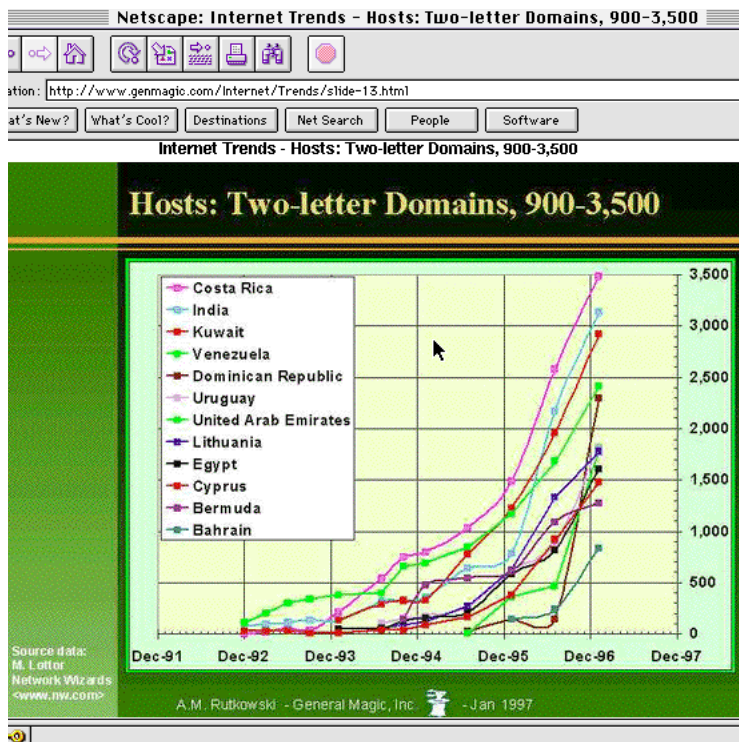


Figure 1. The use of the Internet is growing rapidly, even in less-developed countries. Shown here are trends in the growth in numbers of hosts for two-letter domains in selected countries. [http://www.genmagic.com/Internet/Trends/slide-13.html]

The page displays the following categories and links:

- Businesses, Products & Services
- Energy & Global Climate Change
- Energy Efficiency Around the World
- Fun With Lighting
- Hot Topics: Torchiere Fixtures
- Industry & Professional Organizations
- Lighting Design & Analysis Tools
- Lighting Publications & Other Information Sources
- Major Lighting Programs & Initiatives
- Market Data
- News Groups & Discussion Groups
- Research Centers
- Solar Photovoltaic Lighting
- Other Lists Of Lighting Web Sites

Figure 2. IAEE's Lighting Crossroads. The first category (Businesses, Products & Services) has been selected, from which the visitor can currently link to 39 related sites, and the other Lighting Crossroads categories are shown at the top of the results page. [http://eff.nutek.se/IAEEL/IAEEL/LXR/LXR.html]

tions, and video images. It also brought new degrees of user-friendliness to the Internet. So-called "browser" software allows users to explore the Internet much more easily than was the case in the past.

As measured by number of "hosts", about 16 million computer servers were providing 80 million web pages of content onto the Internet as of January 1997, vs. only 2 million in January 1994, and the number is doubling annually (General Magic 1997; San Jose Mercury News 1997).<sup>1)</sup> Approximately 85,000 new domain names are being added each month (WWW 1997a). These span nearly 200 countries at all levels of economic development (Figure 1) (Doyle 1997). The number of users globally—estimated at 71 million by early 1997—has been doubling every year (Doyle 1997; WWW 1997b). In the US, 14% of all households were using the Internet as of late 1996.

According to an international survey of 15,000 Internet users in late 1996, the demographic trend is towards a slightly older user group, an increasing share of female users, and a significant displacement of television viewing time by Internet usage time (Georgia Institute of Technology 1997). For those interested in more details, the Internet Society compiles extensive information on the history and current status of the Internet (Internet Society 1997). A history of the Internet is offered by Leiner et al. (1997).

The Internet is becoming an increasingly powerful communications tool. It is less expensive and often more efficient and reliable compared with conventional modes of communication. Information is often available over the Internet before it is published in hardcopy. By using "hypertext", documents can be extensively and conveniently linked to other documents, even if the linked document happens to be stored in a computer on the other side of the world.

#### SIX LANES OF THE INFORMATION SUPER-HIGHWAY

Listed below are six major ways in which the Web can be used to assist in the implementation of energy-efficient lighting.

*Communications:* A wealth of information can be found on web pages, but in addition to this is the possibility for the communication and the exchange of ideas among individuals at all corners of the Earth far easier and more affordable than ever before.

E-mail, the most familiar use of the Internet, is a well-known tool for day-to-day correspondence among individuals. In fact, at least 14 of the total 71 million users go on-line only for email (Doyle 1997). Thousands of topical e-mail discussion groups have emerged, including groups focused on utility issues, lighting, and HVAC. Messages sent by a given subscriber (typically no charge) reach all other subscribers, and thus a large number of people can participate in a discussion – kind of like a virtual conference call. The NIST lighting discussion group, for example, has about 400 members worldwide (NIST 1997). The Lighting Research Center offers a web-based search engine to facilitate access to 4,200 archived conversations from the NIST group (LRC 1997). "Chat rooms" are also being used to enable real-time discussions, as exemplified

by the five Internet-wide chats that have been held on power quality (lighting and non-lighting issues).

One of the real advantages of discussion groups is the access they provide for people from developing countries, where alternative forms of communication are especially difficult or expensive. One of the real disadvantages is the quantity of correspondence that can quickly build up -- pick the groups you subscribe to carefully!

More advanced Internet-based communications features such as video-based communications make it possible (and affordable) for efficiency experts from disparate places around the world to participate in virtual design sessions at virtually no cost aside from the time required for the interaction. The Internet is also regularly used as an efficient aid to collaborative writing projects, especially where authors are geographically separated.

*Posting Text and Graphical Information:* We have identified and organized over 100 Web sites having to do with energy-efficient lighting, now available via the IAEEEL Website's Lighting Crossroads index (IAEEL 1997). The general categories shown in Figure 2 gives an idea of the lighting-related information available via the Internet. The breadth of information is enormous, and includes lighting product literature, trade organization information, design tools, newsletters, and market statistics.

The pervasive nature of the Internet, combined with the low cost of having a presence there, has great significance for the efficient lighting community. It allows people who would otherwise be geographically isolated to have access to useful information, and it helps small firms who have products or services to sell gain a level of visibility to consumers that was formerly the exclusive domain of major companies with large advertising budgets.

*Document Retrieval and Software Downloading:* More and more publications are being posted on the Internet, and many libraries are systematically cataloging links to this information. Similarly, databases of published literature (books, articles, newspapers, etc.) are increasingly searchable via the Internet. These trends all apply to the particular case of lighting. Many information products now exist only in Internet form (i.e. not in hardcopy).

The Internet can be used as a way to distribute large documents such as software or detailed graphics. For example, the Radiance and Superlite software can be downloaded from their developers at Lawrence Berkeley National Laboratory. Internet sites can house regularly changing information related to software tools so that it does not get out of date (as it would if published in static form on-disk). For example, an international library of imagery at the site allows users from many countries to easily view examples of Radiance renderings produced by colleagues from other countries (Lawrence Berkeley National Laboratory 1997).

*Dynamic Databases:* The Web can be used to provide searchable databases of energy-efficient products. For example, the powerful inter.Light databases (Figure 3) allow users to search for specific efficient-lighting products (e.g. lamps, ballasts, fixtures, controls) (inter.Light 1997). Dynamic databases allow for customized searches to meet the needs of specific users. The Lighting Research Center

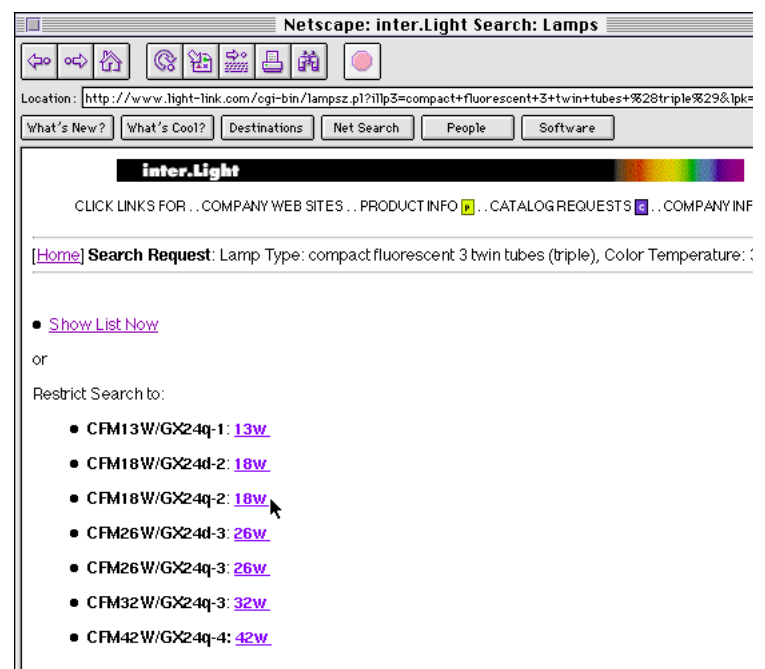
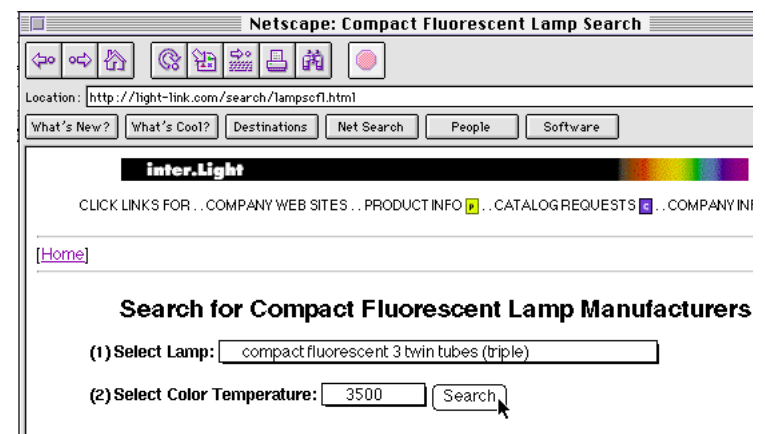
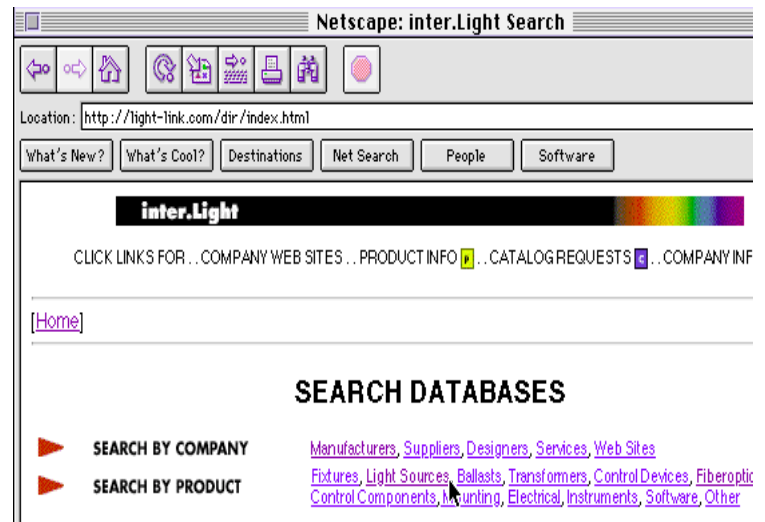


Figure 3 a-c. inter.Light, an example of dynamic searchable databases of lighting products. As shown in the three-part figure, a sequence of three screens brings the user to a choice of specific CFL products, which can be still further narrowed by limiting the remainder of the search to a specific wattage [http://light-link.com/dir/index.html]

Netscape: Home Energy Saver - Lighting (Detailed View)

Location: <http://eande.lbl.gov/CBS/VH/db/light.qry?>

Virtual Home Energy Advisor

### Home Energy Saver - Lighting Module

This tool lets you build a 'Virtual Home' to estimate your home's lighting costs. It can help you explore ways to save money, energy, and prevent pollution by improving your home's energy efficiency.

Please enter information about your lighting fixtures in the table below. Complete one row for each fixture.

Calculate Detailed Lighting Usage

Fixture Location	Bulb Type	Number of bulbs in fixture	Sum of wattages for all bulbs in fixture	Usage (Hrs/day)
Living Room	<input checked="" type="radio"/> Incandescent <input type="radio"/> Compact Fluorescent <input type="radio"/> Fluorescent tubes	1	15	6
Bathroom	<input checked="" type="radio"/> Incandescent <input type="radio"/> Compact Fluorescent <input type="radio"/> Fluorescent tubes	2	120	2
Utility	<input checked="" type="radio"/> Incandescent <input type="radio"/> Compact Fluorescent <input type="radio"/> Fluorescent tubes	4	160	3
	<input checked="" type="radio"/> Incandescent			

Netscape: Home Energy Saver - Lighting

Location: <http://eande.lbl.gov/CBS/VH/db/light.qry?function=Update>

Virtual Home Energy Advisor

### Home Energy Saver - Summary

Here we've summarized the annual lighting costs for your house. Thank you for using the Home Energy Saver Lighting module.

#### Annual Lighting Bill by Room (Total = \$222)

Room	Cost
Living Room	\$44
Dining Room	\$37
Kitchen	\$22
Outdoors	\$24
Bathroom(s)	\$20
Bedroom(s)	\$20
Family Room	\$16
Hall(s)	\$7
Utility Room	\$5
Master Bedroom	\$8
Bedroom(s)	\$20
Closet(s)	\$4
Other	\$15

Figure 4a-b. Portion of Home Energy Saver lighting module. Shown are annual lighting energy cost estimates based on user-specified information about the number, type, and operating hours of fixtures in the home.

[[http://eande.lbl.gov/CBS/VH/db/light.qry?function=Start&session\\_id=748](http://eande.lbl.gov/CBS/VH/db/light.qry?function=Start&session_id=748)]

## Torchiere Calculation Results

## Your Input

Number of torchieres: 1

Average on-hours per lamp per day: 4

## Money Saved from Energy Reduction

Cost per:	Halogen Torchiere	Energy-Efficient Torchiere
Day	\$0.13	\$0.03
Month	\$4.03	\$0.87
Year	\$48.38	\$10.48
Annual Savings	\$37.90	
Payback Time	10.28 months	

## Assumptions-

**Halogen:** Fixture Cost = \$20; Replacement Bulb Cost = \$6; Bulb Life = 2,000 Hours; Power = 65 W  
**CFL:** Fixture Cost = \$70; Bulb Life = 10,000 Hours; Power = 65 W  
 Energy cost = Average for your state (Alaska : \$.112 per kW)

has introduced a database of lighting experts that can be selectively used by lighting manufacturers to conduct on-line focus group evaluations of new product concepts.

*Remote Monitoring, Diagnostics, and Data Visualization:*

The effective monitoring, diagnostic analysis, and visualization of energy data is an important component of any program designed to save energy (Meyers et al. 1996). The Internet has the potential of becoming a widespread energy management and control system, as people begin to use it to gather real-time building energy performance information. Data, as well as audio and video information, can be collected and viewed on a real-time basis from a remote location. A large scale application along these lines shows the minute-by-minute status of traffic speeds on the entire Southern California freeway system (California Department of Transportation 1997). As an example of prospective energy applications, it is not far-fetched to imagine building managers using the Internet to keep track of lighting levels and energy use in hundreds of locations. Potential future directions may include actual building operations via instructions sent over the Internet.

*Interactivity and On-line Tools:* A much higher level of web application involves on-line calculation tools that can now be offered on the Web. Web-based tools (as distinguished from software downloaded from the Internet and run on the local computer) have many advantages: they are available to users of any computing platform (Mac, PC, etc.) and the software does not need to be physically distributed since it resides on a single Web server (and thus can be updated often). The user interface of such tools also becomes a doorway into the multitude of related decision-support resources on the Internet.

The first example of an on-line energy tool is The Home Energy Saver (HES), an interactive residential tool from Lawrence Berkeley National Laboratory. Figure 4 shows part of the HES lighting module. The HES has several hundred links to energy-related resources, many of which have to do with lighting, elsewhere on the Internet. Figure 5 shows an interactive calculation within the HES for estimating energy savings from using energy-efficient torchiere light fixtures. The HES currently has hundreds of users each month.

**CYBERCOMMERCE**

A central question is whether the Internet will ultimately become a more hospitable place in which to conduct business. One recent estimate places the current level of electronic commerce at \$2.6 billion (\$350 million of which is in Europe), with more than 4,000 so-called "cybermalls" available for purchasing products and services today, and bullishly forecasts a \$223 billion market by 2001. The single-most profitable product vendor on the web is Amazon.com, a bookseller whose inventory is larger than any traditional bookseller. Amazon's offerings include every English-language book in print, or five-times as many titles as offered by the largest bookstores. They saw revenues grow to \$114 million in its first two years of operation, and were able to cut prices of 45% thanks to cost savings made possible by doing electronic commerce (International Herald Tribune 1997). Will efficient lighting

Figure 5. Interactive user-driven calculation of payback time for energy-efficient torchiere fixtures.

[<http://eande.lbl.gov/BTP/LSR/torch.qry?function=form>]

products be sold through cyberspace at this kind of scale? Only time will tell.

The inter.Light database of lighting product information receives about 200,000 hits per month from 15-20,000 users, about a quarter of which are from countries outside North America. The user profile is: 75% designer, architect, electrical engineer, facility manager, consultant, electrical contractor, business end-user; 25% other, including government and utility users. Visitors to the site send about 4,000 requests for specific product information to manufacturers each month (Burtner 1997).

**PROBLEMS WITH THE INTERNET & CHALLENGES FOR THE FUTURE**

Despite the prospects, the Internet is not free of problems. Respondents to a 15,000-person international survey named censorship, privacy, and navigation as the three most important issues concerning the Internet (Georgia Institute of Technology 1996).

The risks of information overload and invasion of privacy rise with the quantity of information flowing over the Internet. Developing more sophisticated search engines and indices is an important need in this respect. A related problem is that information posted on the Internet is not archival; when websites are closed down the information becomes unavailable to the Internet community.

With increased ease of publication afforded by the Internet, there is the potential for poor-quality or inaccurate information to circulate widely. On the other hand, traditional print media is just about as vulnerable to accuracy problems. As with any form of information, consumers must be prepared to use their own judgment in evaluating and verifying information received via the Internet.

Another key issue is that the Internet is not currently available to or used by all players concerned with energy efficiency. Groups that are not computer-literate (or

wealthy enough to own computers) do not have easy access to information on the Internet. Issues such as preferential access to government resources and voting information have spawned a debate about the need for universal access to the Internet (Wasserman 1997).

In poor communities (even if located within wealthy countries), Internet access can be limited or unavailable altogether. In developing countries, phoneline access or power to run computers may not even be available. In India 78% of all households lack electric power; even in Bangalore, India, "the Silicon Valley of South Asia", power outages of eight to 10 hours per day are common (Robinson 1997). As the Internet grows, it is important to provide access for all those who stand to benefit from it. Fortunately, remedying this situation does not require computers, power, and phone service in each home; access at the community or neighborhood level would be a significant step forward. ●

#### ENDNOTES

1) Note that analysis of the number of hosts has limited value as a measure of Internet size or activity level. For example, the number of hosts per capita says virtually nothing about the pervasiveness of Internet access, because hosts aren't points of access (Internet service providers, ISP's, are). A single ISP (like America Online) supports an enormous number of users. At the extreme, a hypothetical country could have no hosts but have all of its citizens on line. Meanwhile, the number of hosts, at best, says a little about the quantity (not quality) of information that might be available. Even this is a pretty loose connection, as a host can contain one web page or it can contain many thousands. The number of hosts does, however, give some sense of the diversity of Internet content that might be available in a given country.

#### REFERENCES

- Burtner, D. 1997. Personal communication; representative of inter.Light.
- California Department of Transportation. 1997. Online, real-time traffic reports [http://www.scubed.com/caltrans/la/la\\_small\\_map.shtml](http://www.scubed.com/caltrans/la/la_small_map.shtml)
- Doyle, Roger. 1997. "Access to the Internet." *Scientific American*, 7/97, <http://www.sciam.com/0797/issue/0797scicit3.ht>
- General Magic. 1997. "Statistics on Internet Size and Growth Trends." <http://www.genmagic.com/Internet/Trends/index.html>
- Georgia Institute of Technology. 1996. Graphic, Visualization, & Usability Center's (GVU). Results of a survey run from October - November 1996. Average age: 35 years; 31% female and 69% male (versus 95% male in Jan. 1994); 50% of respondents use the web more than 10 hours/week (versus 28% in April 1995); 50% use for work; 67% say it replaces television at least once per week, of which 37% say it replaces television viewing on a daily basis; modem speed - 51% at 28.8 kb/sec, 20% at 14.4 kb/sec - [http://www.cc.gatech.edu/gvu/user\\_surveys/survey-10-1996/](http://www.cc.gatech.edu/gvu/user_surveys/survey-10-1996/)
- IAEEL. 1997. *Lighting Crossroads* index of energy-effi-

cient lighting web sites:

- <http://eff.nutek.se/IAEEL/IAEEL/LXR/LXR.html>
- inter.Light. 1997. See website <http://light-link.com/dir/index.html>
- International Herald Tribune. 1997. "Business to e-Business: Retail", p. 11, and "Buying a Book? Try Cyberspace", p. 13. (October 15)
- Internet Society. 1997. Home Page as of February 28, 1997. <http://ftp.isoc.org/indextxt.html>
- Leiner, B.M, V.G. Cerf, D.D. Clark, R. E. Kahn, L. Kleinrock, D.C. Lynch, J. Postel, L.G. Roberts, and S. Wolff. 1997. "A Brief History of the Internet", [www -- http://ftp.isoc.org/internet-history/](http://ftp.isoc.org/internet-history/)
- Lighting Research Center. 1997. Archive of NIST lighting group discussions --<http://www.lrc.rpi.edu/> (follow "Discussion Group" link).
- Meyers, S., E. Mills, A. Chen, L. Demsetz. 1996. "Building Data Visualization for Diagnostics, Operator Feedback, and Performance Optimization", *ASHRAE Journal* (June), pp. 63-73. world wide web - <http://floyd.lbl.gov/srm/www/DV/ASHRAE.4.html>
- Mills, E. 1996. "Lighting on the Internet", *Newsletter of the International Association for Energy-Efficient Lighting* (1/96), pp. 4. world wide web - [http://eff.nutek.se/IAEEL/IAEEL/news/1996/ett1996/LiRes\\_a\\_1\\_96.html](http://eff.nutek.se/IAEEL/IAEEL/news/1996/ett1996/LiRes_a_1_96.html)
- NIST. 1997. To subscribe to the lighting group, send email to "lighting-request@garnet.nist.gov" with the command "subscribe" in the body of the message.
- Robinson, A. 1997. "Electricity Woes Could Leave India A Cyber-Outcast", *San Francisco Examiner*, March 16, 1997, p A-14.
- San Jose Mercury News. 1997. "Behind the Wave", March 2, pp. 10S.
- Wasserman, E. 1997. "Paying the Price", *San Jose Mercury News*, March 2, pp 2S.
- World Wide Web. 1997a. Number of new domain names added monthly, <http://www.openmarket.com/intindex/97-02.htm>
- World Wide Web. 1997b. According to the website <http://www.mids.org/ids3/pr9510.html>, Internet usage can be divided into three major categories. (1) Core Internet: as of October 1995 there were 16.9 million users of 7.7 million computers that can distribute information by interactive TCP/IP services such as WWW or FTP. (2) Consumer Internet: 26.4 million users of 10.1 million computers that can access information by interactive TCP/IP services such as WWW or FTP as of October 1995. (3) The Matrix 39 million users of electronic mail as of October 1995.
- Lawrence Berkeley National Laboratory. 1997. RADIANCE software website <http://radsite.lbl.gov/radiance/HOME.html>

#### ACKNOWLEDGMENT

This work was funded by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technologies and State and Community Programs, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.