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ENERGY & ENVIRONMENT DIVISION

ENERGY EFFICIENT LIGHTING PROGRAM

Chapter from the Energy and Environment Division Annual Report 1979

December 1979

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ENERGY EFFICIENT LIGHTING PROGRAM

ANNUAL REPORT 1979

FROM: Energy Efficient Buildings Program Chapter

Energy & Environment Division

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ENERGY EFFICIENT LIGHTING PROGRAM

S. Berman, R. Clear, J. Klems, F. Rubinstein, S. Selkowitz, and R. Verderber

INTRODUCTION

The Energy-Efficient Lighting Program of the Lawrence Berkeley Laboratory is carrying out comprehensive research, development, and demonstration activities emphasizing the commercialization of energy-efficient and cost-effective lighting.

Lighting accounts for 25% of the electrical energy generated in this country every year or about 6% of total energy consumption. This amounts to some 440 billion kilowatt-hours of electricity, which may be broken down by end-use as follows:

	Percentage
Residences	20
Stores	19
Industry	19
Offices	10
Outdoors	8
Schools	7
Streets and highways	3
Other indoor uses	14

We estimate that approximately 50% of the electrical energy consumed for lighting, or about 12% of total electrical sales, could be saved by replacing existing lighting with energy-efficient lighting. This changeover is timely, given the widespread concern about the rising cost of electrical energy. Furthermore, the rapid turnover in most lighting stocks is conducive to the substitution of new, more efficient products.

The broad objectives of our program are:

1. To foster the development of energy-efficient lighting technologies, strategies, and design methods by helping the lighting community (product manufacturers, design firms, professional organizations, and government agencies) to achieve energy-efficient lighting.

2. To minimize any possible adverse social, economic, and environmental impact connected with introducing energy-efficient lighting technologies and lighting-design practices.

3. To provide information so that lighting users, designers, and purchasers can make informed choices on lighting effectiveness and cost/benefit.

4. To assist in removing institutional barriers to adopting efficient lighting.

An important activity of the Energy-Efficient Lighting Program is to make the public aware of LBL's commercialization efforts. We provide information by distributing reports, giving public addresses, and holding meetings, and by maintaining contacts with private persons and many public and professional organizations concerned with lighting.

Among the more prominent organizations with whom we regularly exchange information are the Illuminating Engineering Society, the Institute of Electrical and Electronic Engineers, the American Institute of Architects, the American National Standards Institute, and the Underwriter's Laboratory. As for consumer organizations, we have contacts with trade associations such as the Building Owner's Management Association and government purchasing groups such as the General Services Administration. Most of our information comes from research and development carried out by subcontractors, by the LBL Lighting Laboratory, and by the demonstration projects managed by LBL.

Prior to 1979 we worked primarily on developing new lighting technologies for the commercial and industrial sector. In 1979 we extended our work to the residential sector. The technologies being developed are described in the following paragraphs.

ACCOMPLISHMENTS DURING 1979

High-frequency Solid-state Fluorescent Ballast

The two-and-a-half-year project on developing high-frequency solid-state fluorescent ballasts for the two 40-watt T-12 lamps is expected to be completed this year. The ballasts were developed for LBL by Stevens Luminoptics and IOTA Engineering, and have been used successfully for over a year and a half in a demonstration project at the Pacific Gas and Electric Company (PG&E) headquarters office building in San Francisco. The ballasts reduced energy consumption for in situ lighting by at least 25% and operated safely and reliably, causing no discomfort to users. In 1980, small quantities of these solid-state electronic ballasts will be available for purchase, and stocks will be built up rapidly in the following years. A summary report on the demonstration data was presented at the International Illuminating Engineering Society meeting in Japan in August 1979. The general lighting community concurs with LBL that the project has been a success.

Complementary to the work of the lamp industry, a test of standard fluorescent lamp life has been carried out in the LBL Lighting Laboratory (located in Wurster Hall at the University of California, Berkeley), and the positive result has advanced the commercialization of the electronic ballast. The fluorescent lamps driven by the Stevens ballast are still functioning properly after 12,000 hours of testing, confirming that operation at high frequencies will not shorten lamp life.

Efficient Fixtures

The successf 1 work on the electronic ballast stimulated an attempt to develop an energy-efficient fixture that would take advantage of the lighter-weight ballast and use coatings to increase transmission and reflection abilities.

A lighting fixture has a pronounced effect on the overall efficiency of a lighting system by virtue of its coefficient of utilization. One way of raising the coefficient is to increase the useful light delivered by a fixture by improving the reflectivity and transmissivity of reflectors and lenses. The Optical Coating Laboratory, Inc., under contract to LBL, has applied multilayered, thin-film coatings to reflectors and lenses to see how the coatings would affect fixture performance. Two types of high-intensity-discharge (HID) fixtures have been designed, one for outdoor and one for indoor use. The outdoor fixture employs a high-pressure sodium lamp and the indoor fixture a metal halide lamp. The fixtures have been tested for efficiency with and without the thin-film coatings; results are given in Table 1.

Table 1. Reflectance of Coilzak(R) specular lighting sheet with and without optical coatings.

	(Percentage)			
	Single reflection		Multiple Reflections	
	Hemispherical Total**	Specular**	2nd	4th
Coated	94	92	85	72
Uncoated	83	78	61	37

*Dian TR-1 Reflectometer
**Cary 14 Spectrophotometer
(R) Alcoa Trademark

For a single reflection, the reflectivity of the coated Coilzak(R) improves by more than 10%. For multiple reflections (very common in fixtures), the improvement is more than 50%. According to Lighting Science, Inc., an independent testing laboratory, the improved performance increases the coefficient of utilization as follows:

Reflector	Lens	Coefficient of Utilization (%)
Uncoated	Uncoated	63.55
Coated	(No lens)	79.73
Coated	Coated	75.42

In further studies, we intend to determine the cost-effectiveness of the coating procedure.

Residential Adaptive Circline Fluorescent Lamps

LBL awarded a contract to the EETech Corporation to develop a solid-state ballast for the operation of a circline fluorescent lamp. The system will be packaged with an Edison-type base so that it will fit standard residential incandescent light-bulb sockets.

The ballast circuit has been designed to be manufactured as an integrated circuit, which will reduce the size, weight, and cost of the ballast. The light output is equivalent to that of a 150-watt incandescent bulb (2,200 lumens). In addition, the ballast permits the fluorescent lamp to be dimmed to accommodate different lighting needs.

EETech has delivered eight ballast-lamp systems to LBL. Table 2 compares the performance of the EETech system using the electronic ballast with other circline lamps operated with commercial core-coil ballasts and incandescent lamps. As indicated, the EETech design is >10% more efficient than the core-coil types.

Note: The lamp designations may be decoded as follows: "FC" is circline fluorescent; "12," "6," "10," is the lamp diameter in inches; "T10," "T9" is the diameter of the lamp tube in one-eighth inches (i.e., 10/8 inches); "ww" means warm white color; and "sw" means soft white color. The second set of data (in parentheses) for the EETech system shows its performance when dimmed.

Figure 1 shows two photos of the adaptive circline lamp and ballast fitted into the ceiling socket for a standard incandescent lamp. Once the diffuser is in place (Fig. 1b), the occupant cannot tell whether the lamp is fluorescent or incandescent. Compared to the incandescent lamp, the circline fluorescent improves efficiency by more than 60%.

Switching and Controls

Few buildings today have lighting-control systems; yet the energy savings that could be achieved if controls were used is estimated at over 50%. Our objective is to compare the performance and cost-effectiveness of several systems and to publicize our findings. We anticipate that the widespread commercialization of control systems--those available today as well as those still in the research and development stage--will gain in importance and that demand for these systems will increase as their usefulness becomes known.

LBL has organized two demonstrations to assess the energy savings of different switching and control strategies. Honeywell, Inc. has supplied the lighting-control system for the first demonstration, and we have installed it on one floor of the San Francisco PG&E building and are collecting data. The system controls groups of lamps and can dim the lamps over a continuous range of lighting levels. General Electric will supply the control system for the second demonstration, to be carried out in the World Trade Center in New York. This system allows only on-off control, but fixtures can be individually controlled. The second demonstration will start in early 1980. Both contractors have done marketing studies that indicate a large potential market, primarily for new construction. At present, it is not cost-effective to install these control systems in existing buildings because of the block manner in which lighting systems have been wired. However, wiring codes in California require that the periphery light-

Table 2. Comparative performance of circline fluorescent-lamp systems and 100-watt incandescent lamps.

	Commercial products with core-coil ballasts			EETech system with electronic ballasts	Incandescent
Lamp	FC12T10ww	FC6T9ww	FC10T9sw	FC10T9sw	
Power (watt)	35	21	44	44 (19.5)	100 W
Light (lumens)	1226	700	1812	2018 (790)	1750
Efficacy (lumens/watt)	35	33.3	41.2	45.8 (40.5)	17.5

ing of new buildings be independent of the interior lighting, a modification that will substantially reduce the cost of installing automatic control systems.

The demonstration data on the two systems will help in evaluating different control strategies, such as daylighting, group vs. single, continuous vs. step-dimming. For instance, the data will be used to verify the accuracy of a computer program being developed by Smith, Hinchman, and Grylls, under subcontract to LBL, to predict the energy savings that can be realized by using various types of lighting controls, strategies, and maintenance practices.

Daylighting projects related to lighting controls are covered in the Windows section of this report.

Solid-state Ballasts for High-intensity-discharge Lamps

LBL awarded contracts to three firms for developing a solid-state ballast for operating high-intensity-discharge (HID) lamps. Each contractor has been required to deliver six units for testing at the LBL Lighting Laboratory. The preliminary results indicate that high-pressure-sodium (HPS) lamps are 15-20% more efficient when operated at high frequency with solid-state ballasts (combined ballast and lamp efficacy).

Energy-Efficient Light Bulbs

During 1979, we also made preliminary plans for initiating a new project to develop an energy-efficient replacement for the standard incandescent lamp. The project will begin in 1980 with a public competition inviting companies in the lamp-development field (by a Request for Proposal procedure)to elaborate a cost-sharing proposal aimed at achieving accelerated commercialization of an energy-efficient incandescent replacement. The project will have three phases, the first of which should be completed in the latter part of 1980 with the delivery of a pre-manufacturable prototype for testing at LBL. We intend to have several firms working on the problem so that a number of different concepts can be evaluated.

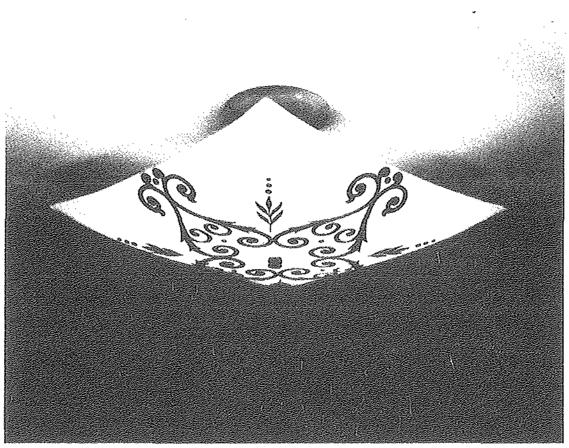

Fig. 1a. Adaptive circline fixture. (CBB 790-15389)

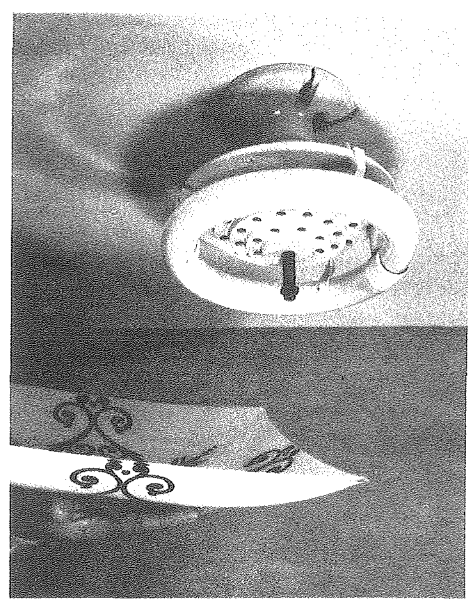

Fig. 1b. Adaptive circline fixture with diffuser. (CBB 790-15387)

PLANNED ACTIVITIES FOR 1980

Besides continuing the above projects, we will begin work in two new program areas: sensors and controls, and visual performance. To study sensors and controls we will set up two new demonstration projects. The sensors project will test the energy that can be saved by introducing a personnel detector that senses room occupancy, turning lights on or off according to the presence or absence of occupants. The demonstration will take place in an office building in New York City; work will be carried out in conjunction with the New York State Energy Research and Development Authority and the Tishman Research Company. The controls demonstration, which will also take place in an office building, will determine the appropriate placement of photodetectors to optimize the performance of control systems in daylit spaces.

The visual-performance program will analyze the theoretical implications of previous research and initiate simple and direct experiments in cooperation with the faculty of the University's School of Optometry. We intend to examine the information requirements that relate energy efficiency in lighting to lighting standards. We will consider the impact of visibility, visual performance, and overall productivity on both the introduction of new lighting technologies and the development of energy-performance standards for the entire building.

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