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# Rensselaer Polytechnic Institute

## Lighting Research Center

### Profile #57

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<b>Executive Summary</b>	<b>2</b>
<b>Program Overview</b>	<b>3</b>
<i>LRC Projects Table</i>	
<b>Implementation</b>	<b>5</b>
<i>Marketing; Delivery; Safety and Security: An Ongoing LRC Research Project; Partner Profile: New York State Energy Research and Development Authority; Staffing Requirements</i>	
<b>Monitoring and Evaluation</b>	<b>10</b>
<b>Program Savings</b>	<b>11</b>
<i>Participation Rates</i>	
<b>Cost of the Program</b>	<b>12</b>
<i>Costs Overview Table; Total Program Cost (chart); Funding Sources Table; Cost Effectiveness; Cost Components</i>	
<b>Lessons Learned / Transferability</b>	<b>14</b>
<b>References</b>	<b>15</b>

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# Executive Summary

In March 1988, the Lighting Research Center (LRC) was established within the School of Architecture at Rensselaer Polytechnic Institute in Troy, New York. The LRC is the largest university-based research center for lighting in the United States. The center emphasizes lighting research and development, technology transfer, and education. The LRC has ties with other lighting laboratories and centers, and receives input from all sectors of the lighting, building, and utility industries.

Current LRC activities include the Partners program, the National Lighting Product Information Program (NLPIP), the Graduate Education in Lighting program, the Research and Development in Efficient Lighting program, the Research and Development in Human Factors program, the Technology Transfer program, and the Outreach Education program.

Research topics covered by the LRC include: lighting and safety, lighting and security, visibility of exit signs, illuminance levels, and people's acceptance of efficient lighting technologies. The LRC also looks at the needs of DSM and energy conservation programs, as well as longer-term issues that relate to efficient lighting.

LRC expenditures for FY 1988 through FY 1992 total \$6,686,200, with expenditures of \$2,162,000 in FY 1992. Funding for the center comes from a diverse group of sources including government (44%), utilities (34%), manufacturers, associations, universities, and consulting firms.

The Lighting Research Center has helped to fill a critical information niche in the efficient-lighting industry, focusing its projects on areas where little information exists. A real emphasis has been placed on conducting the LRC as a business rather than a "typical" university-based research organization in order to avoid being cast as a group of "academics" whose work does not focus on everyday business needs. Perhaps the most unique feature of the LRC is its publication of product specific performance information, which other organizations either cannot or will not publish.

The staff of the LRC believes that it has greatly impacted the lighting manufacturing industry through its product performance reports which affect manufacturer sales, manufacturer marketing, and lighting specifier product selection.

## Lighting Research Center

Organization: Rensselaer Polytechnic Institute

Sector: Commercial and industrial

Measures: Energy - efficient lighting technologies

Mechanism: Lighting research and education projects including the Partners program, NLPIP, and Graduate Education in Lighting program

History: Opened in March 1988

## Program Data

1992 LRC costs: \$2.16 million

1988 - 1992 LRC costs: \$6.69 million

## Conventions

For the entire 1993 profile series all dollar values have been adjusted to 1990 U.S. dollar levels unless otherwise specified. Inflation and exchange rates were derived from the U.S. Department of Labor's Consumer Price Index and the International Monetary Fund's International Financial Statistics Yearbook: 1991.

The Results Center uses three conventions for presenting program savings. **Annual savings** refer to the annualized value of increments of energy and capacity installed in a given year, or what might be best described as the first full-year effect of the measures installed in a given year. **Cumulative savings** represent the savings in a given year for all measures installed to date. **Lifecycle savings** are calculated by multiplying the annual savings by the assumed average measure lifetime. **Caution:** cumulative and lifecycle savings are theoretical values that usually represent only the technical measure lifetimes and are not adjusted for attrition unless specifically stated.

# Program Overview

The Lighting Research Center (LRC) is the largest university-based research center for lighting in the United States. It is housed in the School of Architecture at Rensselaer Polytechnic Institute (RPI), located in Troy, New York. The center emphasizes lighting research and development, technology transfer, and education. Additionally, the LRC has gained a national, interdisciplinary perspective by forming ties with other lighting laboratories and centers, and encouraging input from all sectors of the lighting, building, and utility industries. The primary goal of the LRC "is to change architecture in the next ten years, through lighting that is energy efficient and responsive to human needs." When the LRC was planning the specific areas of study on which to focus, it selected the areas of technology transfer of efficient lighting information and human factors in lighting as these were areas where major research gaps existed.[R#1,6]

In October 1985 EPRI presented a study by Hart, McMurphy, and Parks in cooperation with W.I. Whiddon and Associates, that called for the creation of a center of excellence for lighting to meet the needs of a diverse constituency. This study concluded that the ideal lighting research center would have a single location and be associated with a major university. The target market of beneficiaries for the center included lighting and electric utility industries, government regulatory agencies, other lighting research and educational organizations, lighting design professionals, instrumentation and control specialists, architects, engineers, developers, along with building owners, operators, and occupants.[R#1]

The New York State Energy Research and Development Authority concurred that such a center was warranted and pursued EPRI's goal by issuing a request for proposals. RPI was chosen as the site for this project based on the comprehensiveness of their proposal. In March 1988, the LRC was formally established within the School of Architecture at RPI. The New York State Energy Research and Development Authority committed multi-year funding to ensure the growth and development of the LRC.[R#1]

The LRC has four administrative programs: the Graduate Education in Lighting program, the Technology Transfer program, the Research and Development in Efficient Lighting program, and the Research and Development in Human Factors program. The administrative programs are separated by area of expertise, but an interdisciplinary approach is taken to complete projects, combining the skills of the staff members from the different programs.

## LRC PROJECTS

Applications of Algorithms for Electric Lighting Using DOE 2.1 D  
Commercial Lighting Efficiency Program Phase 1 Feasibility Study  
Commercial Lighting Efficiency Resource Book and Workshop  
Design and Evaluation of Lighting Technologies and Applications (DELTA)  
Egress Marking (Exit Sign) Workshop  
Illuminating Engineering Society (IES) Lighting Handbook  
Imaging Control Hardware  
Lighting as a Source of Environmentally - Generated Positive Affect  
Lighting Curricula for Utility Marketing Staff  
Lighting Evaluation Tools  
Lighting, Visibility, and Vigilance in a Nuclear Power Station Control Room  
State Energy Codes  
Variability and Human Response in the Luminous Environment  
Visibility of Exit Signs  
An Approach to Assessing User Satisfaction with Lighting Installations in Office Buildings  
Attitudes Towards Fluorescent Lighting  
Brightness Enhancing Glazing and Performance  
Daylight Modeling Probe  
Dedicated Table Lamps for Compact Fluorescents  
Guide to the Responsible Disposal of Ballasts  
IES Certificate of Technical Knowledge  
IES Recommendations for Quality/Quantity of Illumination  
Lighting Controls: Scoping Study  
National Lighting Product Information Program (NLPIP)  
Options for Residential Energy-Efficient Lighting Brochure  
Residential Energy-Efficient Lighting Pattern Book  
Utility Voltage Stability  
VDT Lighting System

The Graduate Education in Lighting program has a two-year Master of Science curriculum that prepares students to work for lighting manufacturers, electric utilities, the government, academic institutions, and research organizations. The program takes a multidisciplinary

# Program Overview (continued)

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approach that looks at impacts of energy, engineering, architecture, psychology, and biology on lighting and human behavior. The Research and Development in Efficient Lighting program focuses on the needs of DSM and energy conservation programs, as well as addressing longer-term issues that relate to efficient lighting. The Research and Development in Human Factors program focuses on research to assure that lighting provides value for people such as safety, security, visibility of exit signs, illuminance levels, and people's acceptance of efficient lighting technologies. LRC research projects often overlap between the Efficient Lighting program and the Human Factors program. The National Lighting Product Information Program (NLPIP) is one of the major LRC-wide projects, but it is not an administrative program. The NLPIP provides product-specific test results to lighting specifiers. [R#1,2]

The direction that the LRC takes is determined by many factors. In order to meet the needs of its diverse constituency the LRC obtains input from several sources including the Director's Council, the Technical Consortium, and LRC Partners. The Director's Council consists of senior policy makers from industry, government, and utilities. The Council advises the LRC Director regarding the growth of the LRC, and priorities for future research and educational activities. The Technical Consortium is made up of experts in lighting research, design, and application. They provide technical advice upon the request of the Director. The LRC Partners program facilitates interactions among the LRC, utilities, industry, and government, and LRC Partners have a great deal of impact on what research projects the LRC pursues. The LRC is designed to meet the needs of the lighting industry and as such it welcomes input from as many sources as possible. [R#2]

The LRC also interacts on a regular basis with other like-minded organizations such as, The Association of Energy Engineers, the Illuminating Engineering Society of North America, Seattle City Light's Lighting Design Lab, Lawrence Berkeley Laboratory, EPRI and E-Source. LRC involvement with these organizations includes telephone conversations, paper writing, producing handbooks, writing magazine articles, conference presentations, and seminar participation.

## LRC FACILITIES

Rensselaer Polytechnic Institute (RPI) is a university emphasizing the study of technology and science in both their isolation from and their interaction with humanistic

and social concerns. RPI's philosophy is based on the study of humanistically oriented technology. Founded in 1824, RPI has approximately 4,000 undergraduate students. There are graduate level degree programs offered in 37 subject areas and RPI has a full time faculty of 400.

The metropolitan area surrounding the RPI campus has a population of approximately 750,000 and includes the cities of Albany, Schenectady, and Troy. To complement the academic experiences offered at RPI, there are 40,000 college students and a dozen universities in the local area. [R#12]

The LRC administrative and technology transfer facilities are located on RPI's campus in Troy, New York. Most of the LRC's office spaces and laboratories are located across the Hudson River in RPI's Watervliet, New York facility. RPI and all of the LRC facilities are located in the area surrounding Albany, New York. The Niagara Mohawk Lighting Research Laboratory (NMLRL) covers 14,000 square feet and is located in the Watervliet facility. NMLRL has several designated laboratory spaces including: photometry/image analysis, efficient lighting/power quality, and human factors. This lab is owned by RPI and named in recognition of contributions made by Niagara Mohawk Power Corporation. [R#2]

The LRC resource collection contains books, journals, and periodicals on lighting, daylighting, lighting design, energy conservation, and manufacturers' product literature. Also included in the collection are videotapes, software for lighting design and analysis, and an electronic database of lighting references. [R#2]

The Watervliet facility is filled with demonstrations of lighting products and principles. These demonstrations are designed to help communicate lighting technologies to the lighting decision makers. Demonstrations include optics, glazing and daylighting controls, and office and conference room lighting applications. There are also demonstrations of residential lighting, video display terminal lighting, fluorescent lighting technology, along with lamp types and operations. [R#2]

The LRC has access to RPI's School of Architecture classrooms, workshops, darkroom, computer-aided architectural design laboratory, along with campus facilities in electric power engineering, materials science, and human productivity studies. ■

## MARKETING

The LRC does not have a formal, active marketing program but gains much of its exposure by publishing pieces in trade journals and technical magazines. In addition, the LRC staff makes dozens of presentations at various lighting and energy conferences each year, effectively spreading the word about the scope and capabilities of the LRC. Partners of the LRC receive a quarterly newsletter. The LRC has also sent out an international, 9,000-piece mass mailing of their publications catalog. Frequently the LRC uses its coded database to send out mailings of between 50 and 300 pieces that describe ongoing activities at the LRC.

## DELIVERY

To achieve its goals, the LRC attempts to use all of its resources in a synergistic manner. Current LRC activities include over 40 research and education projects which are organized into the Partners program, the National Lighting Product Information Program, the Graduate Education in Lighting program, the Research and Development in Efficient Lighting program, the Research and Development in Human Factors program, the Technology Transfer program, and the Outreach Education program.

## THE PARTNERS PROGRAM

The LRC designed the Partners program to encourage interaction among the LRC, utilities, industry, and government. The LRC hopes that cooperation amongst similarly forward-thinking groups can produce more efficient, higher-quality lighting in a short period of time.

Each Partner is required to donate at least \$50,000 annually to the LRC. (Currently there are nine Partners.) In return, the Partners have a great deal of steerage in the research projects performed by the LRC. In addition, the LRC helps Partners that are involved in collaborative ef-

forts with technology transfer or any other necessary research. In a sense, the LRC becomes a broker for its Partners, trying to match up Partners with similar lighting interests and goals. LRC Partners are also eligible for co-funding from the LRC for research projects that are in an area of interest to the LRC. The minimum donation required of Partners has remained the same since the LRC opened and is not likely to be lowered. The LRC hopes to add two to three new Partners each year for the next five years, and a diverse group of Partners is sought including foreign Partners.

LRC's Outreach Education program and a recently announced demonstration program called DELTA (Design and Evaluation of Lighting Technologies and Applications) are offered primarily to Partners. Partners often develop close working relationships with individual LRC faculty, staff, and students. These working relationships are facilitated by having quick telephone access to all LRC experts to answer any lighting questions. LRC Partners are also entitled to discount rates on LRC publications, early release of these publications, the opportunity to hire MSc Lighting graduates, and LRC database access. Partners wishing to access the LRC database simply call up the LRC researcher, who produces a bibliography that is faxed to the Partner. LRC representatives visit Partners at least once each year.

The nine current Partners are: Bonneville Power Administration, Consolidated Edison Company of New York, GE Lighting, The Genlyte Group, the New York State Energy Research and Development Authority (See Partner Profile, page 9), Niagara Mohawk Power Corporation, Northeast Utilities, Ontario Hydro, and PPG Industries. (PPG Industries has contributed to LRC research on brightness-enhancing glazings as well as sponsoring research on glare and light transmission related to automobile glazings).[R#2] 

# Implementation(continued)

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## **NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM (NLPIP)**

The National Lighting Product Information Program was established in October 1990 to create an objective source of manufacturer-specific performance information for efficient lighting products. Until this project began, utilities trying to promote energy-efficient lighting products through energy conservation programs lacked objective and easily accessible information on efficient lighting products. NLPIP was designed to fill this information gap.[R#7]

An advisory board of NLPIP sponsor representatives suggests and allocates program funds to research projects, with each project resulting in a publication. Currently there are five NLPIP sponsors: the Wisconsin Center for Demand Side Research, Northern States Power, New England Electric Companies, U.S. Environmental Protection Agency, and NYSERDA. There are two levels of sponsor funding, with Level 1 sponsors donating \$100,000 and Level 2 sponsors donating \$50,000. Level 1 sponsors are entitled to two advisory board votes on project funding, additional product testing performed at cost, and 400 complimentary copies of each NLPIP publication. Level 2 sponsors receive one advisory board vote, additional product testing at cost, and 200 copies of each NLPIP publication. NLPIP does not accept research funding from lighting product manufacturers.

Using sponsor recommendations as a guide the NLPIP project team develops evaluation protocols, gathers product and manufacturers' data, conducts tests, and produces the publications. The types of equipment tests performed vary by product type. Some products are tested using complete standardized tests, with other products the NLPIP creates new testing procedures, and some product

information presented is based on manufacturers' tests. Each publication goes through extensive internal and external review before it is published. The cost of producing individual NLPIP reports has ranged from \$60,000 to \$180,000.[R#4]

NLPIP has completed three types of publications: Specifier Reports, The Guide to Performance Evaluation of Efficient Lighting Products, and Lighting Answers. These publications are sold worldwide with orders coming from as far away as Guam, Syria, Thailand, and Sweden.

Specifier Reports are geared towards facilities managers, utilities, lighting designers, electrical contractors, and architects. Each report contains an introductory educational text, followed by brand-name performance information for the given efficient lighting product category. To date, reports on electronic ballasts, power reducing devices, specular reflectors, occupancy sensors, compact fluorescent lamps, and parking lot luminaires have been published. Future topics include exit signs, cathode-disconnect ballasts, and retail display lighting. These reports are 10-30 pages long, and single copies cost \$30. Greatly reduced prices are available for orders of ten or more copies. All reports are reviewed by outside technical experts before publication.[R#7]

The Guide to Performance Evaluation of Efficient Lighting Products (the Guide) is designed to simplify specification writing and utility program development. For many of the performance issues discussed in this guide, there are no industry-recognized test methods or established performance standards. The guide cross-references performance issues, testing methods, regulations, and standards for several efficient lighting technologies. Also included is a glossary of lighting terms for non-technical

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readers. Product performance information sheets are provided which are compilations of manufacturers' information. Other information in the Guide includes listings of independent laboratories, other related lighting publications, and organizations that develop standards. A single copy of this report costs \$20.[R#7,10]

NLPIP has also begun to produce Lighting Answers, a serial publication which focuses on specific technologies. The first report on T8 (fluorescent) lamps has been completed. A Lighting Answers on lighting polarizers is being developed. These reports are modeled after the Specifier Reports but they are shorter (averaging six pages in length), and their content is geared towards a broader audience. Lighting Answers are less expensive (\$8 for a single copy) than the specifier reports, and there is less of a focus on product testing. A question and answer format is used to present the information.

#### **THE GRADUATE EDUCATION IN LIGHTING PROGRAM**

Rensselaer Polytechnic Institute's School of Architecture in association with the LRC offers a Master of Science in Lighting degree to students who have successfully completed the two-year curriculum. The program provides a broad education designed to equip students with a comprehensive scientific and humanistic understanding of the interactions of all elements of lighting. Physics, engineering, architecture, psychology, and biology all affect the understanding of light and human vision. This program is designed to help future lighting professionals face these multidisciplinary challenges. Students work with psychologists and vision scientists in human factors laboratories; with architects and lighting designers on building design projects; and with materials, mechanical, industrial, and electric power engineers on development of lighting products, systems, and simulations. Students are exposed

to real life in the lighting community through multidisciplinary research projects. Student costs total approximately \$40,000 for the two-year program with a stipend included. The LRC also solicits support from the lighting industry for scholarships.[R#9]

Classrooms and workspaces are located in the Niagara Mohawk Lighting Research Laboratory. The lighting displays in this lab provide an ongoing demonstration of various lighting applications. A biweekly LRC Colloquium Series features guest speakers from outside the LRC. In addition, field trips focusing on specific aspects of lighting design and application add to the classroom and laboratory learning experiences. The faculty for this program comes from around the world and faculty members are well known in their respective fields. Almost all of the faculty is from the LRC.[R#1,9]

In 1990, the program was offered for the first time and three students enrolled. Currently there are 19 students from around the world enrolled in the program. The LRC plans to have a maximum of between 20 and 24 students enrolled in the program with 12 students graduating each year. The LRC attempts to recruit students for the Masters program with diverse experiences, including students with science, engineering, and architecture backgrounds. [R#1,2,4]

The Graduate Education in Lighting program has several unique features. The faculty was recruited worldwide, based on a desire to get experts from diversified lighting fields. The classes offered cover a broad focus, but the number of students is kept low, usually between eight and ten students. In addition, the projects performed by the graduate students are driven by the needs of the lighting industry and thus students learn which research topics are relevant and timely to pursue. ☞

# Implementation(continued)

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Currently there are no other universities offering a graduate degree in lighting, though the University of Colorado and Pennsylvania State University offer masters in architectural engineering degrees with emphases on lighting.

## **RESEARCH & DEVELOPMENT IN EFFICIENT LIGHTING AND RESEARCH & DEVELOPMENT IN HUMAN FACTORS**

These two often overlapping research programs provide reports on very specific lighting topics. New topics are added as projects are completed. Research topics in recent years include lighting system performance, new technologies, residential and commercial lighting, glazing, perception of lighting quality, vision, and productivity. Through these two programs the LRC has completed close to 100 research projects in the past five years.

## **TECHNOLOGY TRANSFER**

The Technology Transfer program essentially provides an internal and external communications function. This program provides information and production services to faculty, staff, and students of the LRC. The program assists with all LRC projects, ensuring that the projects proceed in an appropriate manner, accomplish their mission, and are of interest and applicable to lighting specifiers. The Technology Transfer staff is made up of technical writers, visual communications specialists, a librarian, and editors. The staff helps LRC researchers complete projects in the proper form, be it a video, book, or report.

Tools available to support this effort include tabletop displays, desktop publishing and production equipment, and a resource collection containing books, periodicals,

## **SAFETY AND SECURITY: AN ONGOING LRC RESEARCH PROJECT**

A safe and secure environment is what many people desire: safe in the sense that one is likely to avoid unexpected obstacles, to see how to operate dangerous machinery, and to see and understand warning signs at distances that give a person time to take the necessary actions; secure in the sense that one is unlikely to be bothered by criminals at home, work, or on the street.[R#1]

Lighting plays a large role in creating a safe, secure environment. Adequate light enhances safe mobility. Warning signs that are clearly visible under all viewing conditions facilitate safety. Lighting which allows detection and recognition of possible criminal intent helps to discourage crime.[R#1]

The goal of LRC's research in this area is to better understand the relationships between lighting and safety and security. Some research focuses on the visibility of warning and directional signs. Such signs can be evaluated on the basis of their visibility, legibility, conspicuity and understandability, and the range of conditions in which they can be seen. Research also addresses which form of emergency exit sign is most visible in smoke, the legibility of changeable highway message signs, and the effect of color on the conspicuity of warning and directional signs.[R#1]

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#### **PARTNER PROFILE: NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY**

The New York State Energy Research and Development Authority is a public benefit corporation that was created in 1975 by the New York State Legislature. NYSERDA's mission is to develop innovative solutions to New York's energy and environmental problems. One primary responsibility of NYSERDA is to sponsor a program of energy research, development, and demonstration projects to develop and apply efficient technologies to ensure that New York has secure and economical future supplies of energy, while protecting the environment and promoting economic growth.

In its research program, NYSERDA consults and collaborates with other organizations, including utilities, universities, industries, private engineering and scientific research firms, local governments, and state and federal agencies. Presently NYSERDA has more than 250 ongoing research projects. The LRC is working with NYSERDA to develop projects in energy-efficient lighting.

NYSERDA was one of the first three LRC Partners and in 1988 committed core funding to the LRC for five years. NYSERDA also supports the LRC with research co-funding, and is a sponsor of the NLPIP.

reprints, lighting software, a literature database, and manufacturer catalogs. The program actively promotes LRC publications and presentations. The Technology Transfer Program staff also conducts tours of the LRC. LRC researchers are assisted by Technology Transfer staff who perform market surveys, file applications for patents and copyrights, and examine licensing options for LRC products.[R#1]

#### **OUTREACH EDUCATION PROGRAM**

This LRC program focuses on creating educational programs for diverse audiences that include representatives of utilities, facility managers, architects, and building contractors. The program is geared primarily towards LRC Partners providing services such as education and training. Services for other customers have been provided including customized lighting educational programs for utility customer representatives and development of a new curriculum for lighting engineers and specifiers.[R#1,2]

#### **STAFFING REQUIREMENTS**

The Director of the Lighting Research Center is Dr. Mark Rea who devotes all of his time to the LRC. The Associate Director is Professor Russell Leslie who also works full time at the LRC. These two administrators oversee four administrative programs: Graduate Education in Lighting, Research and Development in Efficient Lighting, Research and Development in Human Factors, and Technology Transfer. Each of these interconnected programs is run by a faculty member who is responsible for initiating, managing, and completing projects, and for maintaining open and frequent communications among all staff members.[R#2]

Overall the LRC has 26 full-time equivalents (FTEs), faculty and staff. In addition there are 19 graduate students enrolled in the Graduate Education in Lighting program, and there are 14 adjunct or associated faculty.[R#4] ■

# Monitoring and Evaluation

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Unlike more conventional utility-run DSM programs, monitoring and evaluation at LRC takes the form of monitoring and evaluating research results rather than the specific delivery mechanism of the program and its impacts. Also the LRC is constantly monitoring and evaluating the efficient-lighting industry in terms of both current lighting products and developing technologies.

The NLPIP specifier reports provide very detailed evaluations of specific lighting technologies. The “Guide to Performance Evaluation of Efficient Lighting Products” provides a centralized source of information designed to help lighting specifiers beware of the complexities in evaluating any lighting solution. For each product category covered, lighting specifiers can use the “Guide” to find out what the performance issues are, what the performance issues mean, what standardized test procedures exist, and what the industry-accepted performance standards for these issues are.[R#10]

All of the Research and Development in Efficient Lighting and Research and Development in Human Factors projects evaluate lighting products, designs, and human perceptions of lighting.

In terms of self evaluation the LRC publishes an annual summary of the LRC. This report summarizes all the facets of the LRC along with the accomplishments for the year for each component of the LRC. However, these reports are not process or impact evaluations in the traditional sense.

In terms of external evaluation, the LRC has an annual Partners meeting in June where the Partners make recommendations on projects for the upcoming year based on achievements of the previous year. Using these recommendations, the LRC drafts a project plan for the upcoming year. LRC staff members then visit each individual Partner to discuss their specific research needs. Afterwards another draft of planned programs is sent to the Partners for review.

Partners also evaluate their commitment to the LRC to decide whether they are receiving value in terms of completed projects and subject matter.

NYSERDA is the largest contributor to the LRC, donating \$700,000 annually and as such each year NYSERDA performs a formal review of its involvement with the LRC to assess continued funding. ■

# Program Savings

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Promoting objective information on energy-efficient lighting products that produce quality lighting for people is clearly the primary goal of the LRC. The LRC's stated research and education goals for 1993 are performance evaluation and demonstration. By pursuing these stated goals the LRC will in turn be providing information on and demonstrations of existing energy-efficient lighting products while also encouraging development of future lighting technologies that are even more energy-efficient.

It is clear that many facets of the LRC have already led to increased sales of energy-efficient lighting products. The NLRIP specifier reports have had such an impact that some manufacturers of lighting technologies report increases in sales after the release of these reports, while others see a decline in sales. In addition, all of the LRC's Partners actively promote energy-efficient lighting products.

Unfortunately, it is impossible to assign specific energy and capacity savings to the LRC. To do so would require tracking the purchases and uses of energy-efficient lighting products that were based solely on the influence of the LRC, a virtually impossible task.

## **PARTICIPATION RATES**

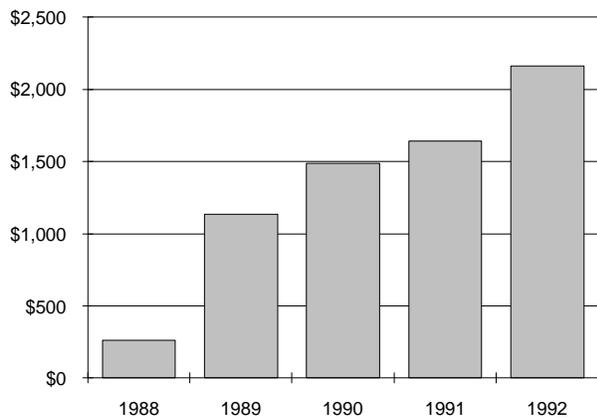
With the LRC there are many different types of "participants." More than 1,000 visitors come to the LRC each year for workshops, visits, and demonstrations. Several hundred contractors and utility representatives participated in LRC Outreach Education programs during the past year. Currently there are 19 students enrolled in the Master of Science in Lighting program. In addition the LRC has sold approximately 35,000 copies of its various publications, not including the reports that the LRC has produced for EPRI and IESNA.

Currently the LRC limits the number of visitors in order to concentrate staff time on research. Almost all visitors to the LRC are by appointment. Since the LRC opened there have been three open houses for the general public. In regard to the sales goals for LRC publications, the LRC hopes to have a specifier report on the desk of every lighting specifier in the country. ■

# Cost of the Program

<b>Costs Overview Table</b>	<i>Operation (x1000)</i>	<i>Research (x1000)</i>	<i>Graduate Education (x1000)</i>	<i>Outreach Education (x1000)</i>	<i>Facilities (x1000)</i>	<i>Program Support (x1000)</i>	<i>Total Program Cost (x1000)</i>
1988	\$75.3	\$86.8	\$0.0	\$0.0	\$20.5	\$77.8	\$260.5
1989	\$247.1	\$396.8	\$0.0	\$0.0	\$248.5	\$241.7	\$1,134.1
1990	\$294.4	\$558.8	\$19.1	\$0.0	\$246.9	\$367.8	\$1,487.0
1991	\$286.2	\$693.2	\$88.2	\$0.0	\$59.7	\$514.5	\$1,641.9
1992	\$285.0	\$1,017.6	\$129.8	\$108.1	\$53.6	\$568.4	\$2,162.6
Total	\$1,188.1	\$2,753.4	\$237.1	\$108.1	\$629.3	\$1,770.2	\$6,686.2

**TOTAL PROGRAM COST (x1,000)**



**Data Alert:** LRC's fiscal year begins July 1 and ends June 30 of the listed year. For example, FY 1992 runs from July 1, 1991 through June 30, 1992.

From FY 1988 through FY 1992 the Lighting Research Center's expenditures totaled \$6,686,200. LRC expenditures have increased consistently since the LRC opened. Expenditures for FY 1988 (4 months only) totaled \$260,500. In FY 1989 costs jumped to \$1,134,100, reached \$1,487,000 in FY 1990, and increased to \$1,641,900 in FY 1991. For FY 1992 the LRC cost \$2,162,600. [R#2]

<b>Funding Sources Table</b>	<i>Government (x1000)</i>	<i>Utility (x1000)</i>	<i>Manufacturer (x1000)</i>	<i>Association (x1000)</i>	<i>University (x1000)</i>	<i>Consulting (x1000)</i>	<i>Total Program Cost (x1000)</i>
1988	\$203.0	\$0.0	\$0.0	\$0.0	\$57.6	\$0.0	\$260.5
1989	\$579.5	\$355.9	\$9.8	\$0.0	\$188.9	\$0.0	\$1,134.1
1990	\$586.3	\$545.5	\$106.2	\$5.6	\$243.4	\$0.0	\$1,487.0
1991	\$778.8	\$481.5	\$148.1	\$4.4	\$229.0	\$0.0	\$1,641.9
1992	\$820.2	\$885.9	\$191.9	\$104.3	\$108.0	\$52.3	\$2,162.6
Total	\$2,967.7	\$2,268.9	\$456.0	\$114.3	\$826.8	\$52.3	\$6,686.2

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Government contributions have made up 44% of program funding to date with large sums coming from the New York State Energy Research and Development Authority. Currently NYSERDA provides \$700,000 annually. Utility funding has provided for 34% of the LRC's expenditures, and the remainder has been provided by manufacturers, associations, universities, and consulting firms.[R#2]

## **COST EFFECTIVENESS**

The LRC has not performed any formal cost-effectiveness evaluations and prefers to evaluate its effectiveness in terms of its impact on the lighting industry. As a result of LRC work, lighting specifiers are selecting products differently than before. With the information available from the LRC, specifiers can make more objective lighting choices.

For example, in order for lighting products to qualify for its lighting programs, Northern States Power requires that lighting products be tested by NLPIP. If the product has not been previously tested by NLPIP, then the manufacturer must have NLPIP test the product, or the manufacturer must perform the same tests performed by NLPIP.[R#14]

The LRC has also witnessed a change in the type of product information presented by lighting product manufacturers. Many manufacturers are now providing more detailed product information to potential customers because of the type of information contained in the NLPIP specifier reports. Research projects done at the LRC have encouraged manufacturers to speed up product development. Currently LRC manufacturing Partners are teaming up with LRC utility Partners to develop new energy-efficient lighting systems. Finally, the LRC has raised the level of expertise within the lighting specifier community.[R#4]

## **COST COMPONENTS**

Of the total spent to provide LRC's services (\$6,686,200), operating costs have totalled \$1,188,100, research costs: \$2,753,400, graduate education: \$237,100, outreach education expenses: \$108,100, and facilities costs: \$629,300. Program support costs which include research co-funding, travel to sponsor and committee meetings, proposal development, and LRC development and marketing, total \$1,770,200.[R#2]

In terms of funding sources from 1988 through 1992, Government sources contributed \$2,967,700, utilities have given \$2,268,900, manufacturers provided \$456,000, associations (such as IESNA, NEMA, the Canadian Standards Association) gave \$114,300, consultants provided \$52,300, and RPI has contributed \$826,800. ■

# Lessons Learned / Transferability

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## LESSONS LEARNED

The Lighting Research Center has done an outstanding job of filling a critical information niche in the efficient-lighting industry. The LRC has made a concerted effort to focus its research on subject areas where there has been a dearth of existing information. The LRC believes the key to its success was taking the time and effort to carefully design goals for the LRC. The LRC had many initial requests for research projects and contract values could have determined which projects were selected. Instead, the LRC decided to look at what other lighting researchers were doing and to attempt to fill major research gaps. [R#4]

The LRC also made it a development priority to avoid the stigma of most university research organizations which are characterized as “academics” and thus not truly understanding of real world issues. The LRC wanted to create a partnership between the university and industry, with an emphasis on conducting the LRC like a business.

The LRC realized that its target customers need research results quickly and they need results that can be easily applied to day-to-day operations. The LRC wanted to avoid producing research reports that were of interest only to other researchers. Thus a strong emphasis has also been placed on effective and relatively fast technology transfer. (Of course in addition to these specialized projects, the LRC performs basic long-term research.) [R#4]

The work of the LRC has several features that make it unique. The LRC is able to present product specific information, which other organizations either cannot (such as EPRI or IESNA) or will not publish. Many organizations fear the liability risks associated with publishing such documents. Through a careful risk management process that includes extensive peer review, LRC can report the results of product performance by listing individual manufacturers' critical information for lighting specifiers and utility program managers.

An in-house staff of writers and visual communications specialists work together from the beginning of a project to ensure that the final product achieves its goals and the format is readily useful to the target market. The LRC also has the benefit of access to and internal review by a staff of experts, which facilitates quick delivery of products.

One of the most important lessons learned is the incredible impact that the LRC has on the lighting product manufacturing industry. The reports issued by the LRC can make or break a manufacturer in the eyes of consumers. As a result the LRC hears from some manufacturers who are elated with the write-up that their product has received, while other manufacturers contacting the LRC are upset because of a less than favorable product report. Similarly, several utilities discontinued power reducers as a DSM option, and certain occupancy sensor manufacturers have changed their advertising claims as a result of LRC publications. [R#4,13]

## TRANSFERABILITY

The LRC believes that because of its capabilities in covering a wide range of lighting research topics there is not a real need for another multidisciplinary research lighting center of the same magnitude. The LRC does not, however, claim to fill all lighting research needs.

There are a few other university lighting programs, including programs at Parsons, the University of Colorado, and Pennsylvania State University. These programs are smaller in size, with one or two full time lighting faculty. Because of their size, these programs specialize in one area of expertise. The LRC also believes that it has been blessed with a university (RPI) that is open-minded and allows the LRC a great deal of latitude in its research topics and interaction with industry.

It is unlikely that another lighting center with the capabilities of the LRC will be opened. Instead of creating a similar lighting center that contains all of the LRC features, it would be more valuable to imitate individual components of the LRC. The LRC maintains that there is not as much need for additional graduate lighting programs as there is for improved undergraduate education and outreach education programs. There is a great deal of interest in the LRC outside of the United States and it is possible that a foreign lighting center on the scale of the LRC could be developed.

Currently, there are several facilities that are devoted strictly to lighting demonstrations and education or have a lighting demonstration component, such as the Lighting Design Lab run by Seattle City Light, the Energy Resource Center run by Portland General Electric (see Results Center profiles #27 and #55), and the Pacific Energy Center operated by Pacific Gas and Electric. ■

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