Rensselaer

REDUCING BARRIERS TO USE OF HIGH EFFICIENCY LIGHTING SYSTEMS

Final Report

Year 3: March 2003 – January 2004

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II.	**Project Sponsor:**	US Department of Energy
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IV.	**Prepared by:**	Lighting Research Center, Rensselaer Polytechnic Institute

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EXECUTIVE SUMMARY

With funding from the US Department of Energy (DOE), the Lighting Research Center (LRC) at Rensselaer Polytechnic Institute completed year 3 of the project, *Reducing Barriers to Use of High Efficiency Lighting System*. The project's objectives were to:

1. identify barriers to widespread penetration of lighting controls in commercial/industrial (C/I) applications that employ fluorescent lamp technologies
2. make recommendations to overcome these barriers.

Year 1

Over the first year of the project (2001/2002), the LRC focused on identifying the barriers to the widespread use of lighting controls. These findings are presented in the Year-1 report (Tasks 2.1-2.15). The LRC reviewed existing research, technologies, patents, and market data related to lighting controls, interviewed manufacturers, surveyed control installers, and conducted peer group review to improve and validate a proposed set of recommendations. The LRC identified two distinct categories of effort, each with their own set of barriers: dimming controls (load-shed dimming and photosensor-activated daylight dimming) and automatic shut-off controls (occupancy sensors and time clocks)[1]. Participating experts in lighting agreed that the tasks associated with the latter category should be geared towards market transformations activities while the tasks to be performed under the first category should be focused on technological investigations and solutions.

Year 2

The second-year scope of work focused on identifying and proposing solutions for each of the categories identified during the first year (Tasks 4.1- 4.8). In the category dealing with automatic shutoff controls, two tasks were undertaken. The first of these two tasks (4.7) was directed toward developing fixed values for energy savings from occupant sensors so state and regional agencies in the U.S. could use these values in their market transformation activities. Based upon an extensive review and analysis of the literature, the LRC developed fixed values for energy savings. The second of the two tasks (4.8) was directed at developing a best practices document that helps both manufacturers and installers improve the likelihood of installing and commissioning occupancy sensors.

In the category dealing with dimming, which represented the majority of the effort for the second year, the focus was on investigating and proposing specific technological parameters for product improvement.

[1] Architectural dimming is excluded from this project.

The LRC identified manufacturing partners to begin discussion about these technological solutions (e.g., development of a load-shed ballast) and conducted limited testing. The LRC focused on economic, perceptional (human), and technical issues associated with whole-building and local control strategies, and undertook five tasks. In addition to developing a review of the progress in whole building control systems (4.1), great progress continues to be made in developing communication systems for lighting control systems. Problems still exist, however, with standardization and cost. These systems have developed their own momentum and only time will tell if and when the US market embraces whole-building lighting control systems.

Neglected in most discussions of lighting controls is the lamp-ballast system used. Tasks 4.1, 4.2, 4.3, 4.4 and 4.5 concentrated on understanding lamp-ballast performance issues, which we believe must be at the core of developing any successful fluorescent lighting control system for C/I applications. The major issues to consider are occupant response, initial equipment cost, and lamp life. Heating the electrodes prolongs lamp life by minimizing the damaging effects of sputtering from both switching and dimming. These systems are commonly three to five times more expensive than systems that do not provide heat to the electrode. Without question, these systems reduce lamp life due to sputtering from starting and dimming. Interestingly however, a non-linear relationship exists between operating current and life. The technical and economic issues associated with dimming instant start systems were a central focus for the latter part of this project.

The LRC concluded year 2 by reviewing the significance of dimming for occupants and proposing recommendations for integrating these findings with lamp-ballast system performance. Task 4.6, utilizing the findings of tasks 4.1 to 4.5, focused on developing recommendations for improved components and systems, as evaluated in Task 2 of the project (technology assessment).

Year 3

The scope of work in year 3 included: the development of a detailed technology transfer plan; publication of technical papers in professional journals, as well as articles in industry related periodicals; presentations of technical papers at national meetings; participation in meetings of applicable standard specification setting, industry, and professional organizations, and the development of a dedicated web site.

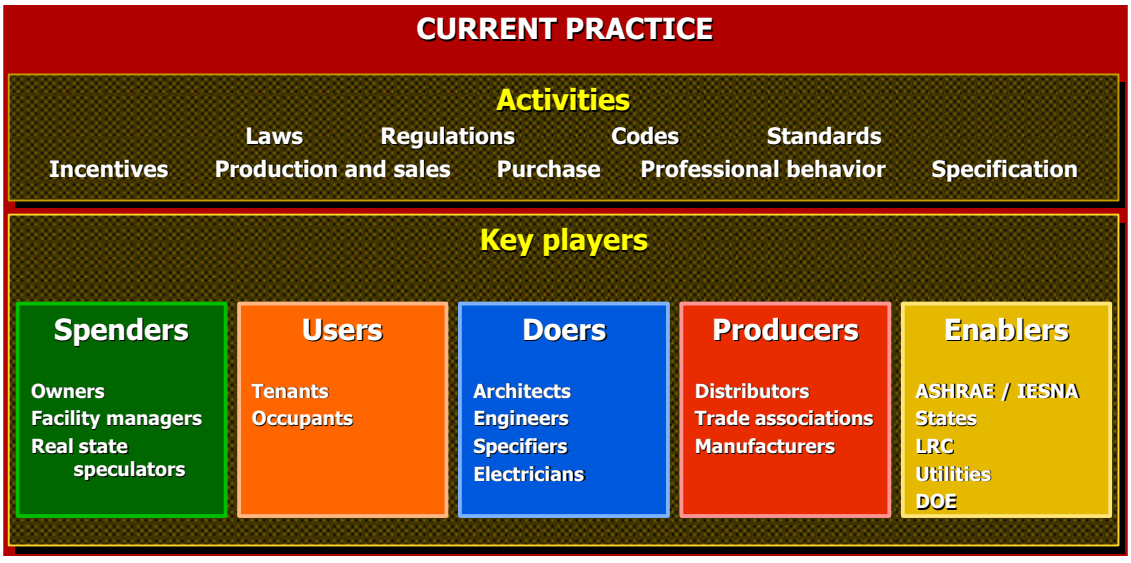
YEAR 3 – TECHNOLOGY TRANSFER ACTIVITIES

The LRC developed a technology transfer plan to bring to market improved, integrated lighting and control systems, which would significantly reduce energy used for lighting in commercial buildings. The plan, which was peer-reviewed, served as a roadmap for the actions taken during year 3 of the Reducing Barriers project. A detailed version of the technology transfer plan is included as Appendix A.

The ultimate goal of technology transfer is to have the technology so widely used that the impact of the technology is written into laws, regulations, codes and/or standards. The LRC, after developing the technology transfer plan, utilized a technology transfer model to identify the technical foundation and marketing enabling mechanisms associated with each new technology, as well as the organizations, companies and representatives that interact with these mechanisms.

Figure 1, through identifying the key players, as well as the activities they pursue in today's current practices of technology transfer, represents the first phase of the technology transfer model.

Figure 1. Technology Transfer Model: Identification of Key Players and Activities



Key players include:

- **Spenders** – These are building owners, facility managers, real estate speculators and developers. They make the ultimate buying decision but are influenced by the other types of key players and what they read and see in different types of communication outlets.
- **Users** – These are the ultimate users of the technologies such as building tenants and occupants. They must be satisfied with the technology's performance and the ability to deliver its claims.
- **Doers** – These are the architects, consulting engineers, specifiers and installers of the technology. They have great influence over the *spenders*. When *doers* recommend or install a technology, they risk their reputation on whether product will perform as advertised.
- **Producers** – These are the people who make and distribute the technology and their respective associations/organizations. They must have a reliable and marketable technology that will earn profits for the company. Besides the key role of manufacturing the technology, they act as marketer.
- **Enablers** – These are the organizations that write laws, regulations, codes and/or standards such as state and federal governments, American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), National Electrical Manufacturers Association (NEMA) or Illuminating Engineering Society of North America (IESNA). Also included are organizations that influence law, regulation, and code and/or are standard writers such as Natural Resources Defense Council (NRDC) or American Council for an Energy Efficiency Environment (ACEEE). *Enablers* are also represented by organizations such as the Lighting Research Center who has relationships and partnerships with all of the key players within an industry and is able to bring these dissimilar types of players together in collaborative and mutually beneficial efforts to successfully perform technology transfer. Also included with this grouping are utilities and state/regional organizations such as Xcel Energy and the Northwest Energy Efficiency Alliance, which are charged with the responsibility for implementation of energy efficiency programs.

Figure 2. Technology Transfer Model: Transformation Mechanisms

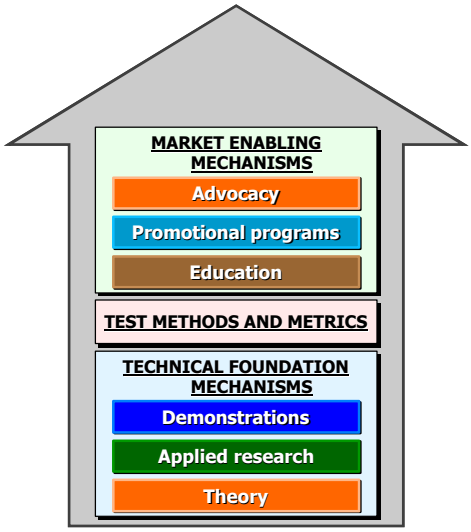


Figure 2, which represents the second phase of the model, outlines the transformation mechanisms in a methodical, step-by-step process. This process addresses the development, demonstration, evaluation, commercialization and, finally, customer acceptance of a technology. The successful achievement of each step's goals is a prerequisite to moving onto the next step. Failure to meet these goals or an attempt to skip a step reduces the chances of the technology being accepted by the *user*. The mechanisms include:

- **Theory** – This mechanism identifies a possible technology to satisfy an unfulfilled customer or *user* need. The technology gets defined and researchers determine if the technology is achievable at some reasonable cost to the *user*. While research organizations like the LRC and other *producers* are the primary players for this mechanism, input from and funding to the other key players is mandatory.
- **Applied Research** – This mechanism must prove the technical and economic concepts of the technology through technical and market research. Prototypes are developed as part of meeting this step's goals. Again, close collaboration with all key players is necessary as the research or manufacturing organizations endeavor to meet the goals of this mechanism. As one of its goals, the applied research mechanism identifies manufacturers willing to commercialize the technology and begin performing the necessary engineering for manufacturing.
- **Demonstrations** – Full-scale demonstrations are necessary to "show the world" the technology works and delivers the promised benefits. The demonstrations must answer any questions or concerns raised by *users* or *spenders* during the market research phase. The

proof must be of the technology and its economics as applied to an actual, rather than laboratory, situation. Successful demonstrations with multiple locations or situations increase the acceptance of the technology. Funding and defining the measured metrics for this phase must come from other key players.

- **Test Methods and Metrics** – The method and metrics on which the evaluation is conducted of a technology, especially during the demonstration step, must be acceptable and agreed to by the research community as well as all the key players. Test results must withstand the rigors of review. While this mechanism may seem intuitive, it may be the most important step of all transformation mechanisms. It sets the stage as to how believable the claims made by the technology will be to the *spenders, users, doers, producers* and *enablers* and, ultimately, how successful the technology will be in the marketplace. Also, it provides a uniform means to measure results utilizing the same technology in different labs and facilities.
- **Education** – The education mechanism is meant to be broad in scope to include the necessity to educate all the key players about the benefits, abilities and limitations of the technology and why it should be adopted in the marketplace, i.e. what it will do to help society. This is the first step in bringing the technology to the market. Yet, many times organizations responsible for technology development do not view the educational function as part of their responsibilities. Funding for education should be included as part of any technology development or else the technology may never advance to the market.
- **Promotional Programs** – If the rigors of the test methods and metrics are met and if a successful education program is funded and executed, then, and only then, will the *producers*, *enablers*, utilities and state/regional agencies charged with the conduct of energy efficiency programs promote the use of the technology to the *spenders*, *doers* and other *users*. Promotional programs can take many forms such as utility incentive programs or endorsements.
- **Advocacy** – This is the final step in the technology transfer model but does not occur until after the technology has reached some level of acceptance within the marketplace. It only occurs when there is public consensus of the use and benefits of the technology. Advocates then request that the benefits of the technology are included in regulations, codes and/or standards.

DELIVERABLES

Automatic Shut-off

	Status	Key Players				
		Spenders	Users	Doers	Producers	Enablers
Advocacy	Ongoing			AESP		ACEEE CEE
Promotional Programs	Ongoing					Utilities,
Education	Ongoing	BOMA	BOMA	ASHRAE, IESNA	NEMA	LRC Utilities, NYSERDA,
Test Methods & Metrics	Complete					
Demonstrations	Complete					
Applied Research	Complete					
Theory	Complete					

Actions:

- Presentation regarding automatic shut-off conducted for the Association of Energy Service Professionals (AESP). See Appendix B.
- Published a paper on findings about automatic shut-off in the conference proceedings of the AESP Meeting. See Appendix C.
- Presented information about automatic shut-off to the American Council for an Energy-efficient Environment (ACEEE) and discussed the possibility of including materials in standards.
- Participated in ASHRAE 90.1 – Lighting Sub-committee meeting – advocated for inclusion of automatic shut-off in standards. See Appendix D.
- Published article on occupancy sensors in Lighting Design and Application (LD&A), a magazine published by the Illuminating Engineering Society of North America (IESNA). See Appendix E.
- Participated and made a presentation on lighting controls at the Illuminating Engineering Society of North America (IESNA) Lighting Controls Protocol Sub-committee. See Appendix F.
- Presented “Best Practices” brochure to Utilities, System Benefit Charges organizations, and Consortium for Energy Efficiency (CEE) and advocated for them to place the document in their web site.

Daylight Dimming

	Status	Key Players				
		Spenders	Users	Doers	Producers	Enablers
Advocacy	Not started					
Promotional Programs	Not started					
Education	Ongoing			AESP,		CEE, NEEA
Test Methods & Metrics	Ongoing					
Demonstrations	Ongoing					
Applied Research	Complete					
Theory	Complete					

Actions:

- Presentation regarding the self-commissioning photosensor and daylight dimming conducted at the Association of Energy Service Professionals (AESP) Meeting. See Appendix B.
- Published a paper in the conference proceedings of the AESP Meeting. See Appendix C.
- Presented information on lighting controls at a Controls Summit organized by the Northwest Energy Efficiency Alliance (NEEA) and Seattle Design Lab.
- Presented information about the self-commissioning photosensor at the Consortium for Energy Efficiency (CEE) 2003 meeting.

Load Management

	Status	Key Players				
		Spenders	Users	Doers	Producers	Enablers
Advocacy	Not started					
Promotional Programs	Not started					
Education	Preliminary activities			IESNA, AESP		PLMA, IEA,
Test Methods & Metrics	Ongoing					
Demonstrations	Proposed					LRC
Applied Research	Ongoing					LRC
Theory	Complete					

Actions:

- Presented load management activities update at the Peak Load Management Alliance (PLMA), September 2003. See Appendix G.
- Presented findings on human factors research and dimming at the IESNA Annual Conference. See Appendix H.
- Published a paper on human factors research and dimming in the Journal of the Illuminating Society of North America (JIES). See Appendix I.
- Published article on human factors research and dimming in Lighting Design and Application (LD&A), a magazine published by the Illuminating Engineering Society of North America (IESNA). See Appendix J.
- Presented load management activities update, and hosted dinner for the International Energy Agency - Demand Response subcommittee.
- Presented load management activities update at the National Energy Service Conference and Exposition.
- Published a paper on the proceedings of the National Energy Service Conference and Exposition.