Streetlighting Research Needs of U.S. Utilities

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This paper describes the results of a survey to determine the streetlighting research needs of U.S. utilities. The survey involved 163 utilities belonging to the Edison Electric Institute and the American Public Power Association. The results of the survey were divided into three areas, covering theoretical research, equipment/product development, and information and technology transfer. Analysis of the responses indicated a substantial need for theoretical research in the areas of glare, driver visual requirements, and night accidents versus lighting studies to establish a firm basis for design standards. Equipment needs were many, beginning with operation of the high pressure sodium lighting system and covering a multiplicity of equipment problems. The area of information and technology transfer covered training and maintenance procedures as well as a variety of legal and other complaints regarding streetlighting. A great need for information transfer between companies is evident.

In September 1986, the Lighting Research Institute (LRI) completed a study for the Electric Power Research Institute (EPRI) to determine the streetlighting research needs of U.S. utilities. LRI used a questionnaire approach to gain insight into the utilities' research needs. The questionnaire highlighted known problem areas and directed questions at specific needs as well as general concepts. One hundred sixty-three utilities belonging to the Edison Electric Institute (EEI) and the American Public Power Association (APPA) responded to the questionnaire. These responses produced a substantial amount of material regarding research needs. While there were some differences of approach between the two associations, the general trend was similar. This paper presents the totals of the associations' responses. An individual breakdown of the results can be obtained by contacting EPRI for a copy of the entire study (*1*).

The questionnaire covered four basic areas relating to utility research needs. It included internal concerns, external or outside influences, equipment, and certain specialty areas. Some questions addressed the technical depth of utility design techniques to determine if development of new techniques might be appropriate. Others were directed toward the research needed for product improvement.

Some overall conclusions can be drawn from this study that are not related to the detailed questions but are significant in terms of the utilities' needs. One of the greatest needs is better communication among the utilities. Many of the comments indicated a concern over problems that have already been solved by other companies or agencies in the streetlighting field. For example, some would like a simple computer program for design. These are available and are being used by various agencies. An interutility letter covering these and other questions would be a viable means of communicating those needs and solutions. A second area involves the inability to obtain quality equipment. Many utilities have similar operating problems, and a combined approach would strongly encourage the lighting industry to rectify these equipment problems. A third area is the almost total lack of research being conducted by utilities in the streetlighting field.

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ANALYSIS OF QUESTION RESPONSES

Internal

The internal area related to the utilities' administrative handling of streetlighting. It covered organization, training, maintenance, and design standards.

Organization

Figure 1 indicates that distribution engineers and district (or area) engineers handle the majority of utility streetlighting design. Marketing personnel (21 percent) are a significant factor, especially in EEI companies.

Approximately 30 percent of the utilities employ lighting specialists for streetlighting design. In 25 percent of those utility companies, the specialists set company-wide standards.

Training

The need for roadway lighting training is evident despite the fact that 26 percent of the utilities believe they have adequate programs. A need for better programs was expressed by 69 percent of the respondents. Of these, the preferred teaching methods were video cassettes (29 percent), text and visuals (28 percent), and a course conducted by lighting consultants (23 percent). Some suggested organizing low-cost seminars, both with and without manufacturer assistance.

Maintenance

Maintenance needs involve equipment as well as internal practices. Utilities generally want to know quickly when field equipment has failed. Figure 2a indicates that immediate or same-day knowledge of luminaire failure would be desired by over 40 percent of the utilities responding. It is evident (see

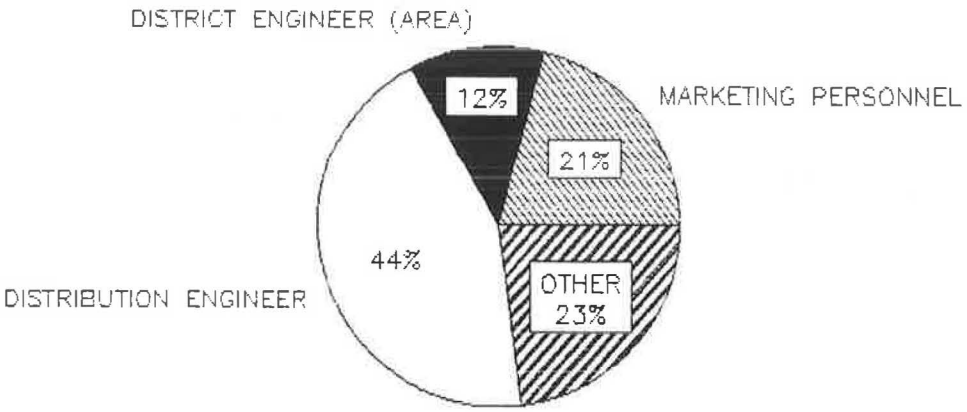


FIGURE 1 Personnel involved in streetlighting design.

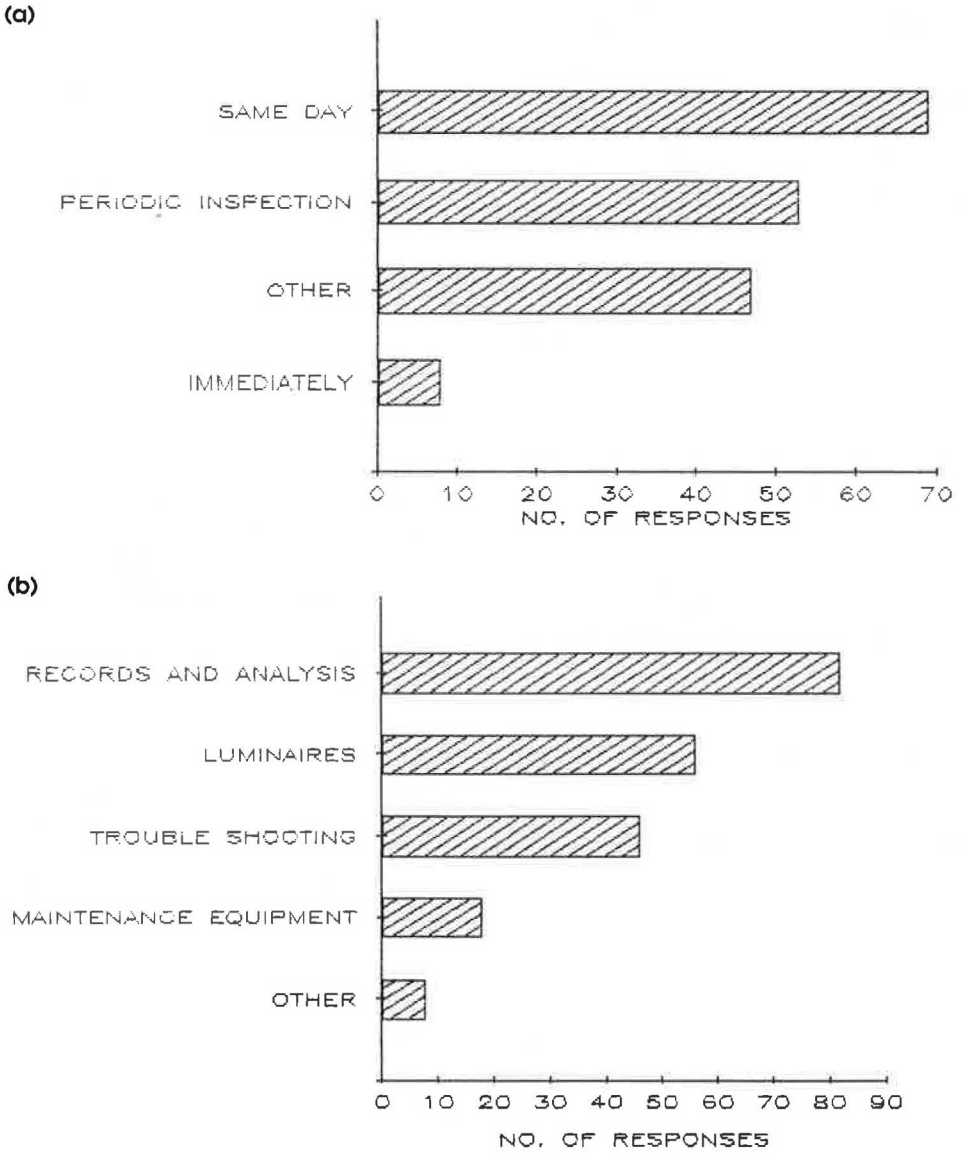


FIGURE 2 Maintenance-related responses: a, need to know when luminaires have failed; b, utility needs in maintenance areas.

Figure 2b) that a great need exists in maintenance of records and their analysis.

Design

Utility streetlighting designers use a variety of standards (see Figure 3). Use of the utility's own standard predominates, followed by government requirements. The American National Standards Institute (ANSI) usage is shown in Figure 4.

Utilities generally feel that no research is needed to support their own standards. However, if a simplified standard could be devised that was applicable at a majority of installations and had a firm research base, the utilities would likely be anxious to use it.

External—Astronomical Interference

The utilities were questioned about their research needs from the standpoint of external influences. One problem, which affects some utilities quite severely, is that of astronomical interference. This is the difficulty that arises when uplight from streetlights causes sky glow and degrades the ability of astronomers to perform their space observations.

Thirty-seven percent of the utilities responding have observatories in their service areas, and 23 percent have received complaints of astronomical interference. The majority of complaints have been resolved by installing cut-off luminaires, physically shielding the luminaires, installing low pressure sodium luminaires, turning off or removing luminaires, and filtering.

Suggestions by utilities for research into astronomical interference could be grouped into the following categories:

- Study of the relative contribution of streetlighting, especially high pressure sodium, to astronomical interference;
- Study of the impact of reflected light in relation to direct uplight;
- Research regarding better optical systems;
- Study of sky glow; and
- Comprehensive study of the financial impact of providing systems with little or no uplight, the possible compromises or negotiable resolutions of this problem, existing research, and adequate roadway lighting levels that would reduce astronomical interference.

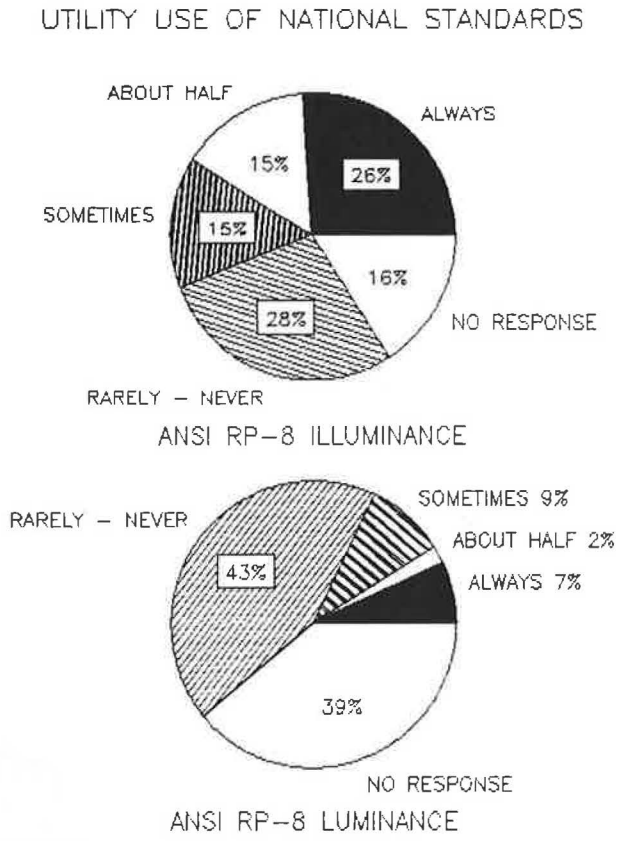


FIGURE 4 Frequency of use of national standards.

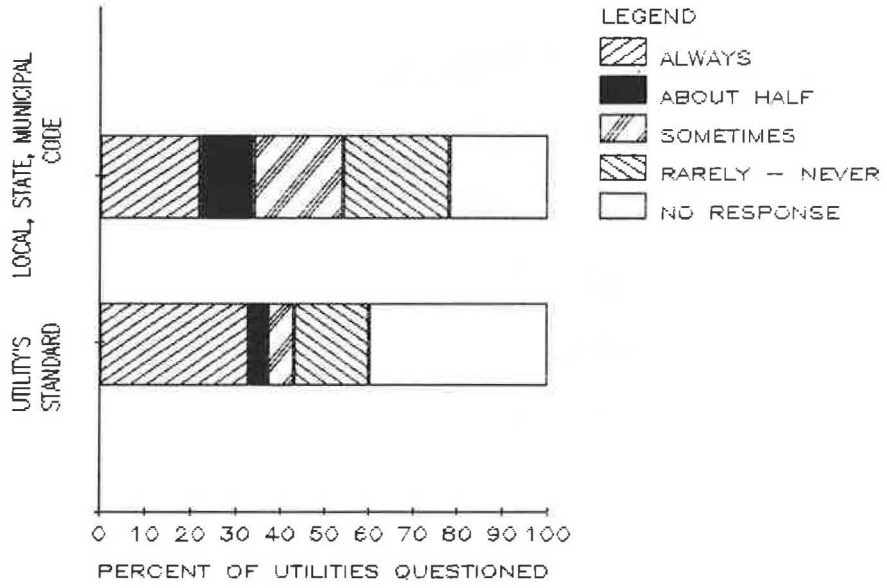


FIGURE 3 Frequency of usage—two most-used standards.

A number of other utilities are aware of this interference through various agencies; however, only 8 percent feel that astronomical interference is a problem and, in general, they give it a low priority for research.

Equipment

Photo Controls

The questionnaire investigated the concerns of utilities regarding the operation and reliability of lighting equipment and where they felt research was needed. One area explored was the need for research into photo controls. The utilities were asked whether there was a need for a more sophisticated control (one that could respond to visibility levels) or simply for improvement of the existing product. Interest in improving the existing control was substantially higher than concern for relating turn-on time to visibility or devising other methods of control. Figures 5a and 5b indicate the importance placed on the various control functions.

High Pressure Sodium Lighting

One of the most significant concerns involved the use of high pressure sodium lighting. Fifty-three percent of the utilities found difficulty with this equipment. A breakdown of the responses by component is shown in Figures 6a and 6b. Starters and lamps obviously require the greatest research effort.

Low Pressure Sodium Lighting

Only the APPA companies were questioned regarding the use of low pressure sodium lighting equipment. Forty-four percent of these companies have tested this equipment, and 26 percent have acquired it. Their evaluation of the factors influencing the use of low pressure sodium indicates that color is the most objectionable feature, followed by maintenance cost, expected life, and availability.

New Lamps

The survey asked about the need for new light sources. The response did not indicate the need for a new type of lamp, but over 60 percent of the respondents desired field data on lamps as well as the current laboratory information. Seventy percent of the respondents felt that color was important.

Research suggestions on lamps were aimed at improving existing lamps in terms of life, color, starting, lumen maintenance, and so forth. There were some suggestions regarding

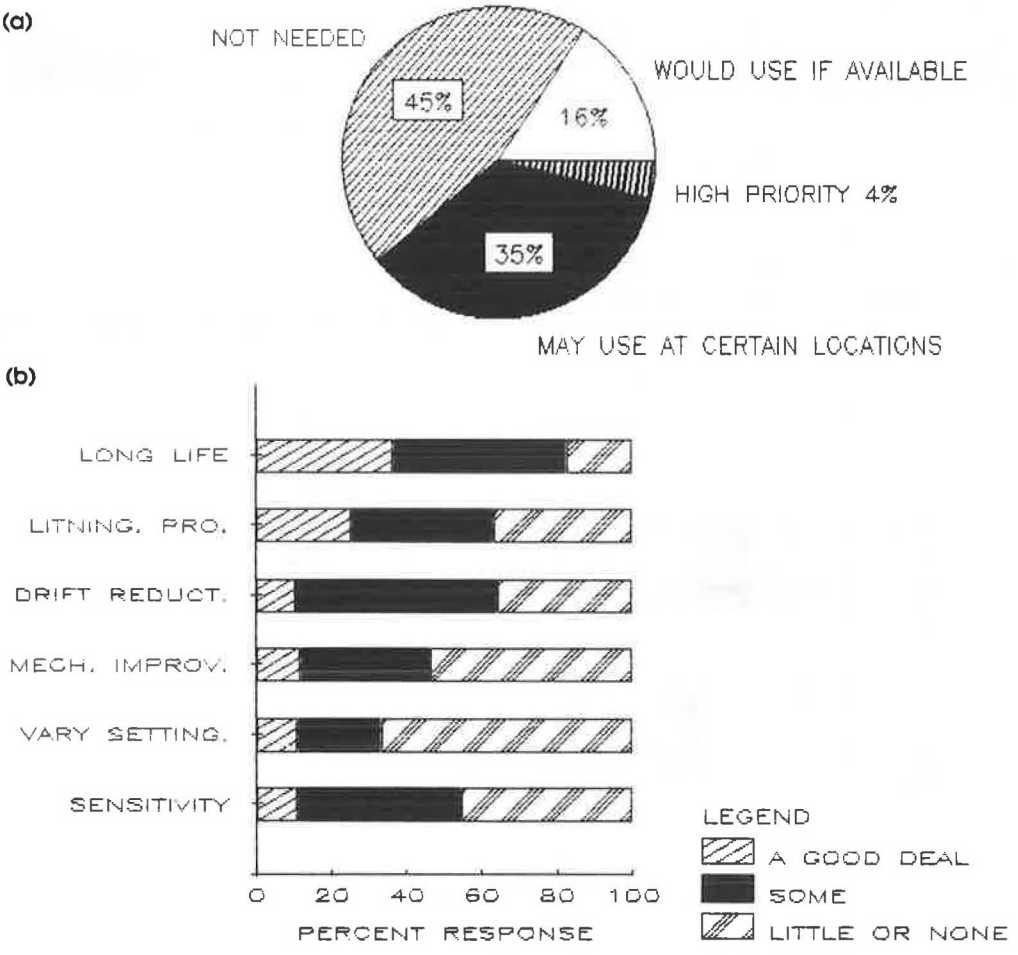


FIGURE 5 Photo control needs: a, need for exact turn-on turn-off; b, amount of improvement needed for each function.

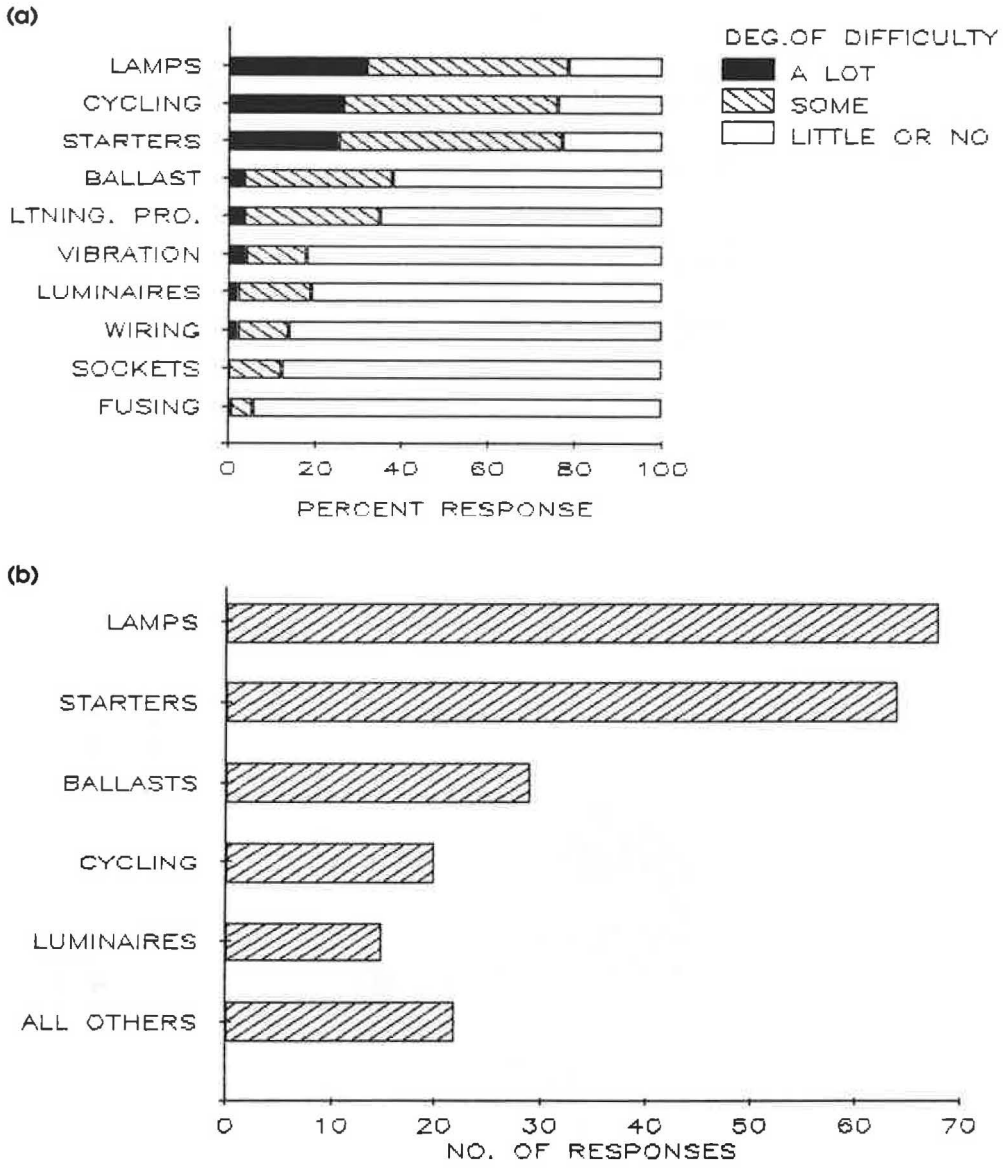


FIGURE 6 High pressure sodium lighting: a, amount of difficulty for each component; b, components requiring greatest research effort.

development of different wattages, such as a 600-watt or 750-watt high pressure sodium lamp to replace the 1,000-watt lamp.

Intersection, Residential, and Arterial Lighting

Utility companies are substantially involved in the lighting of rural and suburban intersections as well as urban streets. Figure 7 shows that customer requirements are the most common method for determining design layout, although a variety of methods are utilized. As there are few computer programs available for this application, utilities have indicated a substantial need in this area.

Results for residential and arterial streetlighting were similar. Two factors weigh almost equally in the application of streetlighting to these areas: (a) the requirement of the residents (customers), and (b) the types of equipment available.

Figure 8 indicates the underlying reasons for the installation of streetlighting. These categories reflect the customers' needs in bringing their requests to the companies.

Light Trespass

An area of growing concern for all street or roadway lighting agencies is that of light trespass (unwanted stray light). The number of complaints received by utility companies over a 5-year period are indicated in Figure 9. One company reported over 100 complaints during this time.

Not all of the complaints were due to streetlight equipment. Equipment represents only 20 percent of the cause of stray

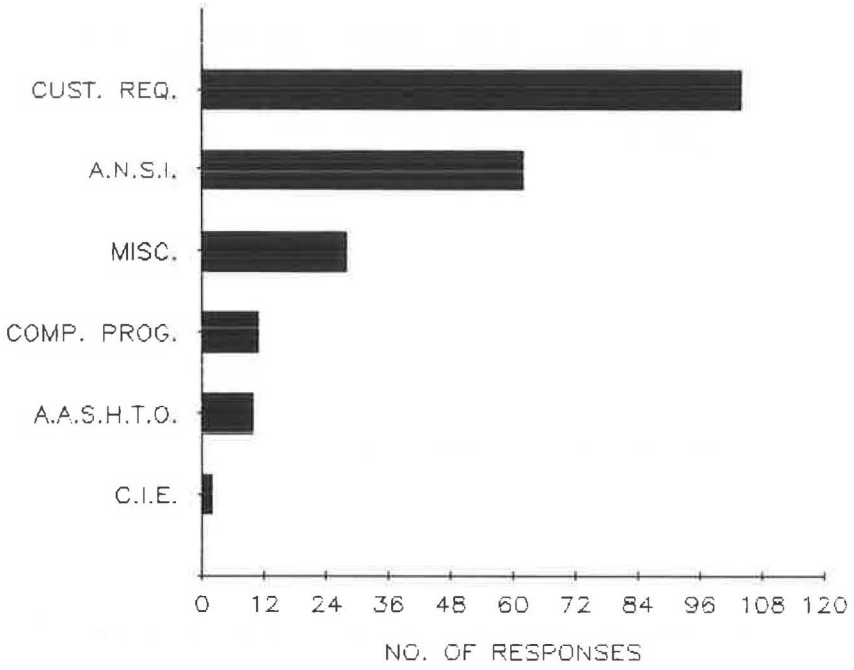


FIGURE 7 Techniques currently used for intersection lighting design.

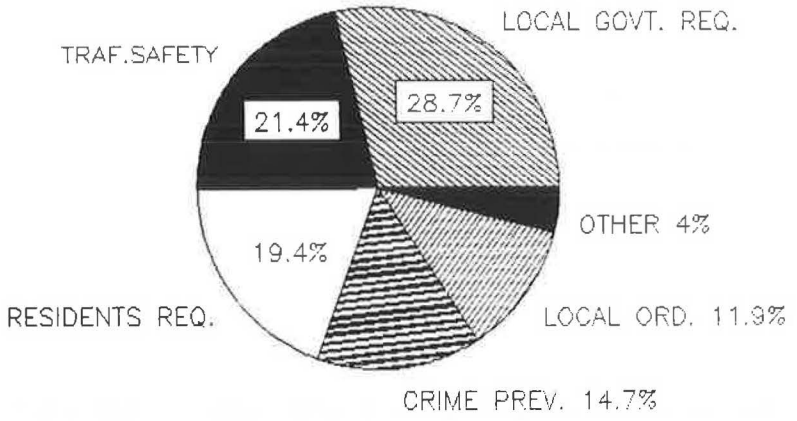


FIGURE 8 Items influencing the installation of streetlighting.

light problems but is involved in about 50 percent of all complaints.

The utilities have been diligent in responding with positive action in more than 90 percent of the light trespass complaints. The types of corrective actions are indicated in Figure 10.

Vandalism

While light trespass concerns required the utilities to respond to public complaints, the problem of vandalism requires the utilities to respond to irresponsible public damage. For some utilities, vandalism is severe; for others, it is relatively minor. Figure 11 indicates that there are three peak areas in the percentage of system vandalized. The largest number of companies have between 0 percent and 2 percent vandalism, the second highest group between 4 percent and 6 percent, and the third between 8 percent and 13 percent.

Several methods were proposed to deal with this problem. While a number of suggestions involved new or different products, improved material, and a more sophisticated psychological approach, it is important to note that many felt the problem of vandalism is unsolvable. Some offered excellent suggestions; others asked for help. This indicates a strong need for interchange on the part of the utilities.

Legal Involvements

Legal involvements have become increasingly significant over the past several years. Of the utilities that responded, 35 percent to 43 percent experienced streetlighting legal prob-

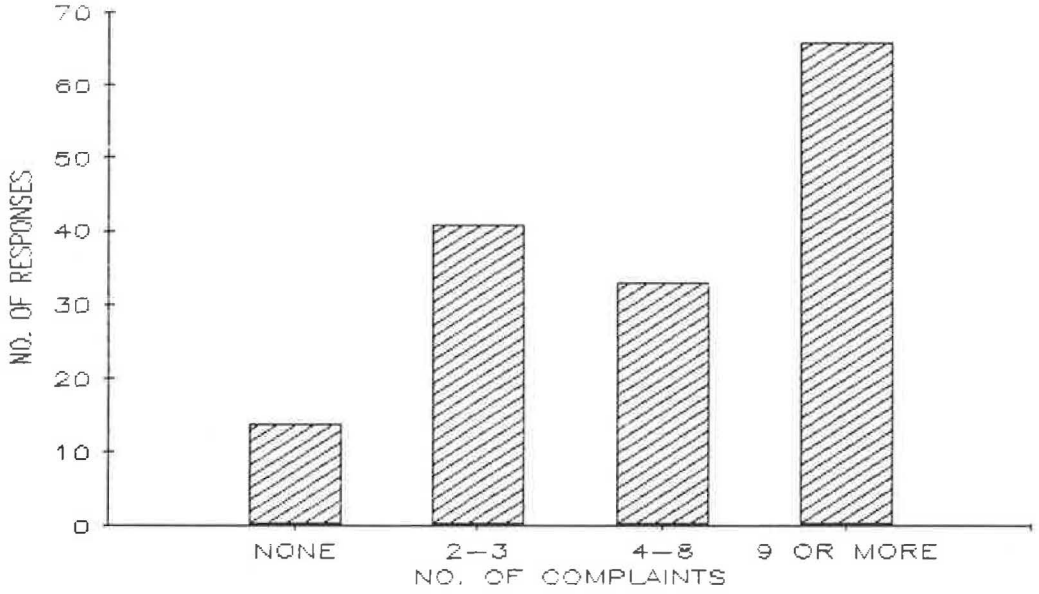


FIGURE 9 Light trespass complaints over past 5 years.

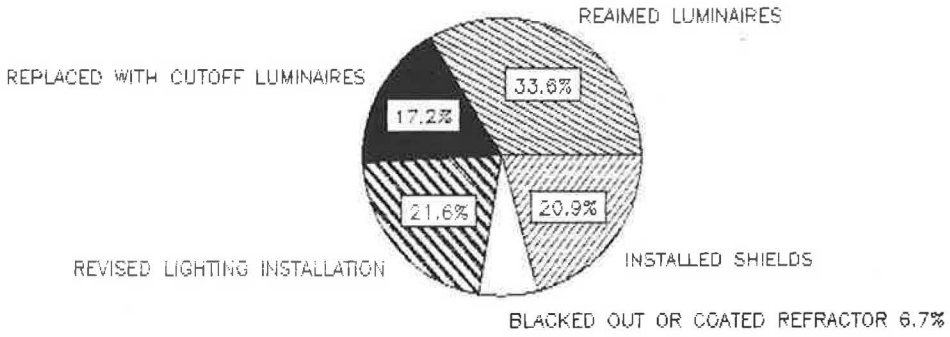


FIGURE 10 Actions taken on light trespass complaints.

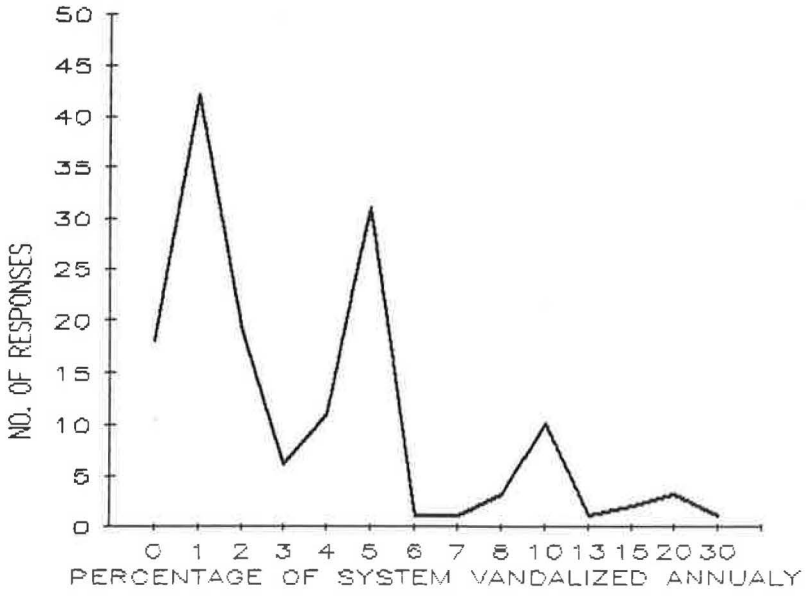


FIGURE 11 Percentage of roadway lighting system vandalized.

lems over the past 5 years, and about one-fourth of these involved design standards.

Approximately 24 percent of the utilities need expert testimony in lawsuits. The research requests urge the adoption of a better communication system among utilities regarding streetlighting legal matters.

Two other research areas suggested were the effectiveness of standards and the utility's liability when installing according to the design of others. A number of other legal responsibility questions need to be researched and solved.

Reduced Lighting

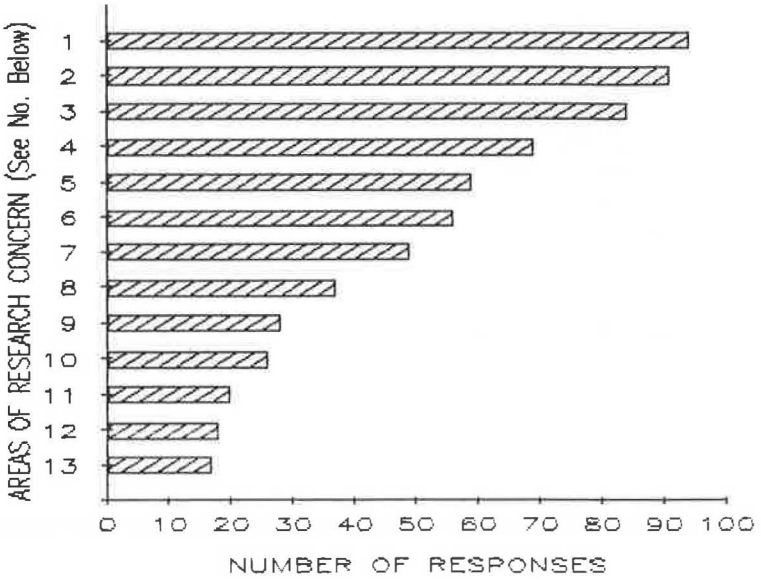
Another area of concern is reduced lighting during specific hours. The response indicated that less than 15 percent of the utilities provide other than dusk to dawn lighting, and most of that involves 24-hr lighting for underpasses and tunnels. Less than 5 percent provide reduced lighting or turn-off situations. About 20 percent of the utilities have received requests from various governmental agencies to reduce lighting during specific hours. While these requests may be based on the governments' need to cut costs, they do raise an important question. How far should the utilities reduce visibility, and its safety benefits, for the purpose of energy conservation or cost reduction? Research is needed to answer this and many other questions on reduced lighting.

Theoretical Lighting Research

Figure 12 gives responses to the survey question devoted solely to the various areas of theoretical lighting research. Discomfort glare is emphasized, as it was throughout the survey wherever the matter of glare was addressed. The second and third preferences—driver visual requirements and night accidents versus lighting studies—indicate a desire to justify lighting standards. Results of these types of studies should resolve levels of lighting as well as some of the legal problems.

Specialty Areas

The questionnaire covered items such as high mast lighting, tunnel lighting, breakaway devices for light poles, and other components of lighting systems that are not common to most



Area Number	Area of Research Concern
1.	Discomfort glare
2.	Driver visual requirements
3.	Night accident versus lighting studies
4.	Pavement reflectance
5.	Interaction of vehicle and fixed lighting
6.	Color rendition necessary for peace officer (police identification)
7.	Visibility contrast method C.I.E. 19/2
8.	Transient adaptation
9.	Dark focus - Night Myopia
10.	Determine critical visual elements by studying near accidents
11.	Driver decision making process
12.	Who is the night driver?
13.	Use of parking lights for urban environment

FIGURE 12 Theoretical lighting research survey responses.

of the utility companies. In general, the utilities were involved through maintenance agreements with other agencies.

High Mast

Of the utilities responding, 29 percent indicated that they install or maintain high mast lighting. Of those, 31 percent cited a need for better overall component design, and 33 percent indicated a specific need for improved lowering or mechanical support systems.

Tunnel Lighting

Tunnel lighting is installed or maintained by less than 16 percent of the respondents. Only 10 percent are involved in the design process. Of those polled, 20 percent agreed that there is a need for new tunnel lighting criteria, but there was no strong preference as to what areas needed improvement. Research suggestions concentrated on the need for better maintenance techniques and worker-safety provisions.

Luminaire Supports

Information gathered regarding problems with luminaire supports is valuable and should be considered by the utilities. The need for research into breakaway devices is strong. A number of research suggestions involving product improvements in such areas as strength, durability, vibration resistance, and liability need to be considered to improve the design of luminaire supports and their application to streetlighting projects.

CONCLUSIONS

The findings of this survey can be divided into three basic categories:

1. Theoretical research,
2. Equipment/product development, and
3. Information and technology transfer.

The particular areas that fall into the above categories can be given a high, medium, or low priority, depending on the utility response.

Theoretical Research

Theoretical research needs in streetlighting are best documented by Figure 12. There are, however, many places in the survey where specific needs were suggested. The four areas of high response were

1. Discomfort glare,
2. Driver visual requirements,
3. Night accident versus lighting studies, and
4. Pavement reflectance.

Theoretical research needs also include the special visibility requirements of intersection lighting involving complex dynamic movement of objects in the visual scene. This area rated a medium priority, as did the daylight entrance zone visibility requirements of tunnel lighting. Reduced lighting during off-peak or other hours also rated medium priority. The nature of astronomical interference requires major investigation and appears to be a serious problem for astronomers. This area does not affect the majority of utility companies and therefore received a low priority rating.

Equipment/Product Development

High priority must be given to the operation of high pressure sodium lamps. Lamp field data to compare with published laboratory results and research to improve lamp auxiliary operating components received a strong response. Interchangeability of starters and lamp cycling were frequently mentioned as needed improvements. The entire high pressure sodium system is a high priority in terms of equipment improvement.

Luminaire supports using breakaway devices are also a high priority area. There is considerable controversy over the use of the equipment and problems with the failure mode. A more reasonable and definite standard is required.

Research to improve life and color of the high pressure sodium lamp was requested wherever there was discussion on lamps. It was classified as a medium priority based on the responses received, as was luminaire optical control. A luminaire is needed that will distribute light to avoid glare and still provide economical unit spacing.

Vandal-proof equipment was a medium priority item in terms of the number of companies involved; however, with some companies it is a serious problem.

Photo control component improvements, such as longer life, received a good response, but a more sophisticated visibility-related control was given low priority. Alternative control methods were shown to have some, but little, need.

Information and Technology Transfer

Highest priority ratings were given to updating maintenance procedures and roadway lighting training. This is despite the fact that many companies had updated maintenance procedures and conducted training in roadway lighting. The area of greatest concern for maintenance is that of records and system analysis. Personnel training in all aspects of roadway lighting was given a strong response.

Legal responsibility was also a high priority, especially in the area of information transfer, which was suggested by respondents several times. The number of lawsuits is growing, and the utility liability responsibility must be defined. There is a need to know what other companies are doing or have done in regard to these legal matters. Reduced lighting also has some legal ramifications.

Design aids are on the high priority list both by response to questions and by inclusion in the general category of suggested research responses. A simplified research-backed method of designing lighting is needed.

TABLE 1 RESEARCH PRIORITIES

Priority	Item	Research Areas
Theoretical Research		
H	Theoretical lighting research	Discomfort glare, night accident studies, driver visual requirements, pavement reflectance
M	Reduced lighting implications	Effects of reduced lighting on visibility and accidents
M	Intersection lighting	Study of complex movements to determine best visual scene
M	Tunnel	Daylight entrance zone
L	Astronomical interference	Define and recommend solutions
Equipment/Product Development		
H	High pressure sodium lamp operation	Research to improve starters and ballasts and eliminate cycling
H	Lamp field factors	Comparison of field operation with published laboratory results
H	Luminaire supports	Breakaway or slip base research
H	High mast	Lighting design criteria; lowering equipment
M	Luminaire optical control	Research to reduce glare and improve beam pattern and efficiency to obtain better spacing-to-mounting-height ratio
M	High pressure sodium lamps	Research to improve life, color, etc.
M	Vandalism	New approaches to deter; tougher equipment
L	Photo controls	Improved quality, reliability, life, and variability of setting
Information and Technology Transfer		
H	Maintenance procedures	Detailed study and procedures update; programs for system analysis, records, etc.
H	Roadway lighting training	Comprehensive training course using text and visuals, video cassette, or lighting consultants
H	Design aids	Computer programs; design standards (intersections, arterials)
H	Legal responsibilities of utility	Liability for design; installation according to others' designs; validity of standards
M	Luminaire maintenance	Techniques
M	Trespass lighting	Solutions to problem caused by roadway or commercial lighting

NOTE: H = high priority; M = medium priority; L = low priority.

A medium priority status was given to trespass lighting. This problem seems to be resolvable in most instances, although the problem is growing and there is a trend toward ordinances in this area. A study of principles and methods of control is required.

Finally, in Table 1, research priorities are assigned as high, medium, or low based on the responses of the public and private utilities. Some of these needs are being addressed, but a good deal of research must be initiated to find answers to many others.

REFERENCE

1. M. Savitz, R. Stark, and R. Vincent. *Development of Streetlighting Research Plan.* Final Report EPR. Lighting Research Institute, New York City, Feb. 1986.