BUILDING ENERGY MANAGEMENT AND REDESIGN RETROFIT (BEMARR)

ENERGY EFFICIENT LIGHTING

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1. GENERAL

1.01 The lighting systems in many buildings were designed before high-cost electricity, without knowledge of the final space use, and without knowledge of recent developments in new lamp types. Lighting is the most visible energy consumer. Although lamp removal has cut back on energy consumption, there is still a significant potential for lighting system modification. The material used in this section has been extracted from the *Building Energy Management and Redesign Retrofit (BEMARR) Manual* issued with GL 76-10-077 (EL 4857) dated October 7, 1976, and updated to reflect recent experience.

1.02 Whenever this section is reissued, the reason(s) for reissue will be given in this paragraph.

1.03 ***Energy Conservation:*** Although energy can be conserved by reduced lighting, such action should be taken only after the entire system has been analyzed. While conservation of energy is important, it must be achieved in a manner consistent with requirements for comfort and productivity. It is very important to recognize that major alterations to a lighting system can have a significant impact on heating and cooling systems. The losses that result from poor control, system inefficiency, and excessive lighting are direct costs for wasted electrical energy.

1.04 ***Power Demand:*** In office buildings, lighting contributes from 25 to 30 percent of the total demand load and contributes from 25 to 50 percent of the cooling load. Potential for saving is therefore high.

2. TYPES OF LAMPS

2.01 Lamps are the sources of electric light to the system. A wide variety of lamps are available and fall into three basic categories:

(a) Incandescent

(b) Fluorescent

(c) High-Intensity Discharge (HID).

2.02 Despite the energy crunch, it is still necessary to have adequate illumination for the task. The method of lighting is the key to energy conservation. The type of lamp to be used is one of the main considerations. Table A shows efficacy (the number of lumens per watt) that different lamps produce.

3. ILLUMINATION LEVEL

3.01 At least three levels of illumination are required in any building: specific task lighting, general lighting around tasks, and general lighting for support areas. The Bell System recommended footcandle levels are shown in Table B.

3.02 The levels shown in Table B are in footcandles (maintained) ***on the task***, and in the plane of

TABLE A

EFFICACY
(LUMENS PER WATT INCLUDING BALLAST)

LAMP TYPE	SMALL SIZES	MIDDLE SIZES	LARGER SIZES
High-pressure sodium	84	105	126
Metal halide	67	75	93
Fluorescent	66	74	70
Mercury	44	51	57
Incandescent	14	20	24

the task, eg, horizontal or vertical. If, in the same general area there is space which does not require the listed level, reduced levels should be provided.

3.03 Where a range is given, weighting should be given to the following factor in deciding on a higher or lower level: the ***age*** of the workers. People over 55 require more light, while those under 40 require less. The importance of ***speed*** and/or ***accuracy*** should be considered also. Finally, the ***reflectance*** of the task background has an effect, with darker backgrounds requiring more light.

3.04 Certain tasks may require more lighting than the area in general. For example, the control boards in mechanical and electrical equipment areas require more light than the rest of the room. The problem can be solved by carefully locating the lighting fixtures or by providing extra lighting in those specific spots.

3.05 In areas where difficult and prolonged visual tasks occur, such as in drafting and graphic design areas, additional lighting should be provided. The additional lighting should be provided by supplemental lighting on the task rather than by increasing the overall room lighting level.

3.06 In order to provide more flexibility in the operation of lighting systems, localized switching should be provided in all small areas, rooms, and cubicles. In large areas, such as general office space, provide ample switching so that as much of the lighting as practical can be turned off when not needed. The lights next to a wall with windows should be switched separately so they can be left off on bright days.

3.07 For more detail on levels for specific tasks where it is felt the above general guidelines are not adequate, and for other information helpful in lighting design, see *American National Standard Practice for Office Lighting* (1982 issue) or *The I.E.S. Lighting Handbook* (1981 edition).

4. METHODS OF REDUCING LIGHTING COSTS

4.01 The following is a list of methods used to reduce power consumption for indoor lighting while maintaining the recommended lighting levels.

(a) Remove lamps from fixtures when there is unnecessary light. Disconnect the unused ballasts.

(b) Where the desired lighting reduction is great, and delamping produces a lack of uniformity (ie, dark spots), consider replacement of lamps with PHANTOM* fluorescent tubes. Since this tube does not produce light, it will reduce lighting levels by 50 percent. In addition, the paired fluorescent lamp also reduces its lighting level by 35 percent. The lighting level of both tubes is then reduced by 65 percent.

(c) Replace 40-watt fluorescent lamps with 35-watt lamps. Table C shows the light and wattage reduction that would be provided by replacing 40-watt fluorescent lamps with the 35-watt WATT-MISER† fluorescent lamps.

(d) Provide adequate switching to permit turning off unneeded lights.

(e) Replace failed ballasts with low-loss magnetic or solid-state ballasts, the choice depending on economics.

(f) Keep fixtures clean. Dirt on tubes and fixtures can decrease light output by 30 percent.

(g) Keep walls and ceilings clean and painted with light color paint.

(h) Use light sensitive controls to reduce lighting near windows on bright days. (Cost study should be made.)

*Registered trademark of Developmental Sciences, Inc.

†Registered trademark of General Electric.

TABLE B

FOOTCANDLE LEVEL (MAINTAINED) (SEE NOTE)

AREA	FOOTCANDLE LEVEL	AREA	FOOTCANDLE LEVEL
Assignment Bureaus	70-100	Lobbies	10
Auditoriums	25	Locker Rooms	10
Basements	10	Lounges	10
Boiler Rooms	10	Mail Rooms	30-50
Business Offices	30-50	Mechanical Equip. Room	10
Cable Vaults	5	Medical Rooms	70
Cafeterias	25	Microfiche Readers	
Classrooms	50-70	Keyboards	30
Computer Rooms	30-50*	Screens	5
Keyboards	30	Operating Rooms	30-50
Cathode-Ray Screens	5	Parking Lots	0.5
Conference Rooms	30-50	Power Room (dc)	10*
Corridors	5	Receiving and Shipping Rooms	10
Drafting Rooms	50-100	Repair Service Bureaus	
Duplicating Machine Rooms	30-50	With Line Cards	50-70
Elevators and Escalators	15	With LMOS	30-50
Elevator Machine Rooms	10*	Stairways	10
Emergency Engine Rooms	10*	Storage Areas	5
Employment Offices	30-50	Switchgear Rooms (ac)	10*
Garages	5*	Telephone Directories	70-100
General Offices	30-50	Toilets	10
Janitors' Closets	15	Training Rooms	30-50
Kitchens	70	Transformer Vaults	10

Note: "Maintained" means the level that will result after the normal unavoidable drop in light output due to lamp deterioration and dirt accumulation.

*For equipment repairs or service, provide 70 footcandles, usually by localized or portable lighting.

TABLE C

LIGHT AND WATTAGE REDUCTION

FLUORESCENT LAMP	F-40	WATT-MISER* LAMP	WATT-MISER II* LAMP	"U" LAMP	WATT-MISER II U LAMP
Watts	40	35	35	40	35
Lumens	3150	2850	3050	2900	2600
Lumens/Watt	78.7	81.4	87.1	72.5	74.1
2-Lamp Fixture (watts include ballast)	100	86	86	100	86

* Registered trademark of General Electric.

(i) Use motion detectors to turn off lamps in unoccupied locations. (Cost study should be made.)

(j) Use daylight as much as possible. Light from windows must be controlled, however, or it might produce undesirable effects due to glare.

(k) Minimize decorative or display lighting.

5. OUTDOOR AREA LIGHTING

5.01 Many outdoor area lighting systems were designed before the energy shortage and are greatly overdesigned or use inefficient light sources by current standards. For some reason the energy saving possibilities here are often overlooked, possibly because the surveys are usually done in the daytime. Large amounts of power are usually involved and the potential for saving is often high.

5.02 Although a first reaction is often to change the lights to more efficient ones, it is seldom economical to change one high-intensity discharge fixture for another. The best thing to do first is to make sure the lights are on only when needed. Photocells have often been used in the past, but it is usually not necessary to have the lights on all night. An alternative is to install time clocks and establish small parking areas for late or all-night parkers with the bulk of the area left dark when most people have gone home. This might require recircuiting into two or more groups of fixtures. At a work center, for example, the lights on or near the building might be left on for late arrivals and the rest of the lights turned off at 6:00 pm when most people have left. Necessary security lighting can be provided by one or two small lights controlled by a photocell.

5.03 Where there is more than one fixture mounted on one pole, consideration should be given to disconnecting excess fixtures. If this causes the light level to drop too much, it might be feasible to replace the existing lamps, usually mercury, with more efficient metal halide lamps designed to work with existing mercury ballasts. There are also high-pressure sodium lamps which can be used with some mercury ballasts to provide even more light with even less wattage. Some fixture manufacturers have kits available for economical replacement of mercury ballasts with high-pressure sodium ballasts. This will produce still greater light output for the same wattage.

5.04 To make any of these changes, it is only necessary to obtain details on the existing ballasts and then consult with the fixture and lamp manufacturers to determine what changes can be made. In all cases, be aware of "fine print" limitations on these newer lamps, such as burning position, ambient temperature, lumen depreciation, and life.

5.05 If there are any outdoor areas still lighted by incandescent lamps, and if it is necessary for these lamps to be left on over 2500 hours per year, it might be economical to replace them with small high-pressure sodium or mercury lamps. The power saving, together with the much longer lamp life, can often justify this replacement.

6. REFERENCES

6.01 The information in this section is based on the following references:

- *American National Standard Practice for Office Lighting* 1982
- *Illuminating Engineering Society (IES) Lighting Handbook* 1981
- General Letter GL 77-02-154 (EL 4626) dated February 22, 1977—*Central Office Lighting Systems*
- General Letter GL 78-01-055 dated January 6, 1978—*PHANTOM Fluorescent Tube*
- General Letter GL 78-07-093 dated July 19, 1978—*Equipment Lighting System*
- System Letter IL 78-11-065 dated November 13, 1978—*New Higher Efficiency Fluorescent Lamps and Ballasts*
- System Letter IL 78-12-090 dated December 15, 1978—*Outdoor Area Lighting—Retrofit for Energy Conservation*
- System Letter IL 79-08-307 dated August 21, 1979—*Outdoor Area Lighting*
- System Letter RL 79-08-366 dated August 29, 1979—*New Lighting Levels*
- System Letter RL 79-11-328 dated November 26, 1979—*New Lighting Levels*
- System Letter RL 79-12-045 dated December 6, 1979—*Classroom Lighting*
- System Letter IL 80-06-046 dated June 9, 1980—*Automatic Control of Lighting by Motion Detectors*
- System Letter RL 80-09-387 dated September 30, 1980—*Lighting of Cosmic Distribution Frames and Modular Protector Frames*
- System Letter RL 80-10-265 dated October 27, 1980—*Building Electrical Systems Design Guide.*