



**LIGHTING PRACTICE:
UPGRADING LIGHTING SYSTEMS IN
COMMERCIAL AND INSTITUTIONAL SPACES
AN AMERICAN NATIONAL STANDARD**



ANSI/IES LP-9-20

**LIGHTING PRACTICE:
UPGRADING LIGHTING SYSTEMS IN
COMMERCIAL AND INSTITUTIONAL SPACES
AN AMERICAN NATIONAL STANDARD**

The content of this Lighting Energy
Management publication
has been approved by the IES.
Suggestions for revisions
should be directed to IES.

**Prepared by the
IES Energy Management Committee**



Copyright 2020 by the Illuminating Engineering Society.

Approved by the IES Standards Committee August 23, 2019 as a Transaction of the Illuminating Engineering Society.

Approved February 7, 2020 as an American National Standard

All rights reserved. No part of this publication may be reproduced in any form, in any electronic retrieval system or otherwise, without prior written permission of the IES.

Published by the Illuminating Engineering Society, 120 Wall Street, New York, New York 10005.

IES Standards and Guides are developed through committee consensus and produced by the IES Office in New York. Careful attention is given to style and accuracy. If any errors are noted in this document, they should be forwarded to Brian Liebel, Director Standards, at standards@ies.org or the above address for verification and correction. The IES welcomes and urges feedback and comments.

Printed in the United States of America.

ISBN# 978-0-87995-277-8

DISCLAIMER

IES publications are developed through the consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on lighting recommendations. While the IES administers the process and establishes policies and procedures to promote fairness in the development of consensus, it makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

The IES disclaims liability for any injury to persons or property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this document.

In issuing and making this document available, the IES is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the IES undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The IES has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the IES list, certify, test or inspect products, designs, or installations for compliance with this document. Any certification or statement of compliance with the requirements of this document shall not be attributable to the IES and is solely the responsibility of the certifier or maker of the statement.

AMERICAN NATIONAL STANDARD

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether that person has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation to any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

CAUTION NOTICE: This American National Standard may be revised at any time. The procedures of the American National Standards Institute require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of approval. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Prepared by the IES Energy Management Committee

Rodney Heller, *Chair*

Allyn E. Hetzke, *Vice Chair*

Members

M. L. Carter

J. G. Howley

C. Neely

K. J. Hemmi

M. A. Myer

D. K. Whitley

Advisory Members

J. Amann

A. B. Mor

H. L. Wolfman

A. J. DeMarte

P. G. Spurley

J. M. Yorgey

CONTENTS

1.0	Introduction and Scope	1
1.1	Introduction	1
1.1.1	Audience	1
1.2	Scope	1
2.0	Lighting Upgrades: The Fundamentals	1
2.1	Lighting Upgrade: Retrofit, Redesign, or Both?	1
2.2	The Upgrade Process	3
2.2.1	Simple Walk-Through Assessment (ASHRAE Level 1 Lighting Analysis)	3
2.2.2	Initial Determination	3
2.2.3	Funding	3
2.2.4	Comprehensive Assessment	3
2.2.5	System Design	4
2.2.6	Cost Analysis	4
2.2.7	Specifications	4
2.2.8	Mockup	4
2.2.9	Acceptance	4
2.2.10	Pre-installation Walkthrough	4
2.2.11	Installation	4
2.2.12	Commissioning	4
2.2.13	Post-installation Walkthrough	4
2.2.14	Operation and Maintenance Manuals and As-Built Documents	4
2.2.15	Energy Verification	5
2.2.16	Occupant Satisfaction	5
2.3	Common Practice	5
2.4	Generic Issues for Upgrade Projects	5
2.5	Equipment Alternatives for Upgrade Projects	6
2.6	Energy-Saving Upgrades	6
3.0	General Upgrade Considerations	6
3.1	Lighting Assessment	6
3.1.1	Performing the Assessment	7
3.1.2	Project Checklist	7
3.1.3	Lighting Assessment Survey Form	8
3.2	Economic Issues	8
3.2.1	Introduction	8
3.2.2	Assessment and Initial Determination	9
3.2.3	Gaining the Expertise to Realize Economic Gains	10
3.2.4	Economic Considerations That May Be Overlooked	11

3.3	Lighting Quality and Quantity	11
3.3.1	Redesign vs. Retrofit	11
3.3.2	Uniformity	11
3.3.3	Lighting Walls and Ceilings	12
3.3.4	Glare	13
3.3.5	Color	13
3.3.6	Task Lighting	13
3.4	Codes and Standards	14
3.4.1	Building Permits	14
3.4.2	Energy Standards and Codes	15
3.4.3	Electrical Codes	16
3.4.4	Electromagnetic and Radio Interference	17
3.4.5	Health and Safety	17
3.4.6	Hazardous Material	18
3.4.7	Emergency Lighting	18
3.4.8	Exit Signs	18
3.4.9	Vandalism	18
3.4.10	Manufacturer Warranties	19
3.5	Commissioning	19
3.5.1	Luminaire Replacements and Upgrades	19
3.5.2	Lighting Controls	19
3.5.3	Project Training and Documentation	21
3.6	Service and Maintenance Issues	22
3.6.1	Minimize Lamp Types Deployed	22
3.6.2	Reduce Lamp Quantities	22
3.6.3	Maintenance and Warranty Issues	22
3.6.4	Facility Management Education	22
3.6.5	Luminaire Dirt Depreciation (LDD)	22
3.6.6	Relamping	22
3.7	Lamp and Ballast Disposal	23
3.7.1	Introduction	23
3.7.2	Lamp Mercury Content	23
3.7.3	Lamp Disposal	23
3.7.4	Lamp Recycling	24
3.7.5	Lamp Breakage	24
3.7.6	PCBs in Ballasts	24
3.7.7	Conclusion	25
4.0	Technology and Equipment Overview	25
4.1	Fluorescent Lamps	25
4.2	Compact Fluorescent Lamps (CFLs)	26
4.2.1	Compact Fluorescent Lamps Installed in Existing Applications	27
4.3	LED Technology	27
4.3.1	LED Technology Background	27
4.3.2	LED Performance	28
4.3.3	LED Rated Life	29

4.4	LED Equipment Options	30
4.4.1	Screw-Based LED Replacement Lamps	30
4.4.2	TLEDs: Fluorescent Lamp Replacement Options for Fluorescent Troffers	30
4.4.3	TYPE A TLEDs	31
4.4.4	TYPE B TLEDs	32
4.4.5	TYPE C TLEDs	33
4.4.6	Hybrid TLED Lamps	33
4.4.7	Ballasts for TLED Lamps: Types and Considerations	33
4.4.8	LED Retrofit Kits and LED Luminaires	34
4.5	Considerations When Using TLED Lamps in a Retrofit Project	35
4.5.1	Considerations When Retrofitting with TLEDs	35
4.5.2	Considerations for Ballast or Drivers When Upgrading with TLEDs	36
4.5.3	Considerations When Not Using an External Driver or Ballast (Direct Wire)	37
4.5.4	Additional General Information Regarding TLEDs	37
4.6	LED Applications	40
4.7	Additional Resources for LED Evaluation and Selection	41
4.8	Lenses and Louvers	41
4.8.1	Lenses	41
4.8.2	Louvers	41
4.8.3	Words of Caution	41
4.9	Reflectors	42
4.9.1	Words of Caution	42
5.0	Specific Technology Upgrades	42
5.1	Upgrading Troffer Luminaires	42
5.1.1	Upgrading 2 × 4 Troffers	42
5.1.2	Upgrading 2 × 2 Troffers	43
5.2	Upgrading Fluorescent Strip or Industrial Reflector (Hooded) Luminaires	43
5.3	Upgrading Wraparound Luminaires	44
5.4	Upgrading Recessed Downlights	44
5.4.1	Types of Recessed Downlights	44
5.4.2	Basic Upgrade Strategies	44
5.4.3	Other Downlight Upgrades	45
5.5	Upgrading High-Bay and Low-Bay Luminaires	45
5.6	Upgrading Lighting Control Systems	46
5.6.1	Codes and Standards for Lighting Controls	46
5.6.2	Confirm Space Usage Patterns	46
5.6.3	Control Strategies	47
5.6.4	Wiring Accessibility	49
5.7	Upgrading Exit Signs	50
5.7.1	Energy and Maintenance Considerations	50
5.7.2	Exit Types and Preferences	50
5.7.3	Codes	50
5.7.4	The “Retrofit or Replace” Decision	50
5.7.5	Exit Sign Battery Back-up and Flood Heads	51

5.8	Upgrading Task Lighting	51
5.8.1	Typical Light Sources for Task Lighting	52
5.8.2	Upgrading Existing Task Lights	52
5.8.3	Relying More on Task Lighting	52
6.0	Energy Reduction Strategies	52
6.1	Daylight Harvesting	52
6.1.1	Daylighting Considerations	53
6.1.2	Harvesting Daylight to Reduce Electric Light	53
6.2	Peak Load Reduction	54
6.2.1	Basic Strategies in Reducing Peak-Load	54
6.2.2	Load Reduction Trade-offs	55
6.2.3	Rebates and Utility Load Curtailment Programs	55
7.0	Current Research	56
7.1	Scotopically Rich Lighting and Visual Performance	56
7.2	Lighting Quality Research	56
8.0	Specific Application Considerations	56
8.1	Office Lighting Upgrades	56
8.1.1	Upgrading General Lighting Systems in Offices	56
8.1.2	Upgrading Other Lighting in Offices	57
8.1.3	Controls in Office Environments	57
8.2	School Lighting Upgrades	57
8.2.1	Upgrading Lighting Systems in Schools	57
8.2.2	Lighting and Controls Design Guidelines	57
8.3	Retail Lighting Upgrades	58
8.3.1	Overview	58
8.3.2	General Lighting for Retail	59
8.3.3	Supplemental Lighting Systems for Retail	59
8.3.4	Controls	59
8.4	Healthcare Facility Lighting Upgrades	60
8.4.1	Overview	60
8.4.2	General Lighting for Healthcare Facilities	60
8.4.3	Supplemental Lighting Systems with Healthcare Concerns	61
8.4.4	Controls	61
8.5	Summary	61
	Annex A – Field Measurements	61
	Annex B – Illuminance Meters	64
	Annex C – Example Checklists and Forms	66
	References	70

1.0 Introduction and Scope

1.1 Introduction

Increasing lighting efficiency is often the most cost effective energy efficiency improvement that can be made to an existing building. There are three basic approaches for improving the energy efficiency of an existing lighting system: retrofit, redesign or a combination of both. Retrofitting the existing luminaires is the more common approach. However, depending on a variety of factors, redesign may be the better choice. A thorough assessment is necessary to determine which of these methods is advantageous.

When upgrading lighting in any space, it is important to know the recommended practice and illumination levels for the occupant and task. The IES publishes many standards on lighting applications, and a competent lighting practitioner or designer should be able to help with specifying accepted illumination levels in the building. There may be a nominal cost, but it is a sound investment to get the lighting upgrade project right. When working on a lighting upgrade project, one should always be aware of the delicate balance between quality lighting and energy savings. If too much focus is placed on energy savings, quality may suffer, and vice-versa.

1.1.1 Audience, This document is intended for commercial and institutional building owners, lighting practitioners, facility managers and engineers, energy service companies, retrofitters, and utility representatives considering a lighting upgrade.

This document is written in general terms; every lighting project is different because of a wide variety of factors (e.g., architectural and luminaire styles, age of the building and its lighting systems, tasks performed, age of occupants).

According to the U.S. Department of Energy Buildings Energy Databook, 2010, Chapter 3, Table 3.1.4,¹ lighting systems often consume up to 26% of the electrical energy used by the building, depending on the type of building, location, age and other factors. A lighting upgrade generally offers one of the most cost-effective

and easiest means to reduce operating costs, with a return on investment that is acceptable to the financial managers of the facility. However, appropriate illumination levels and light quality also need to be achieved along with the energy savings. **Figure 1-1** illustrates the large portion of office costs that are due to employees. If those employees are less productive, the company is not getting “its money’s worth.” This is why it is imperative to not lose employee productivity in the name of energy savings. According to *Lighting Europe*, April 2015, Quantified Benefits of Human Centric Lighting, if completed properly, a lighting upgrade can actually increase occupant productivity²!

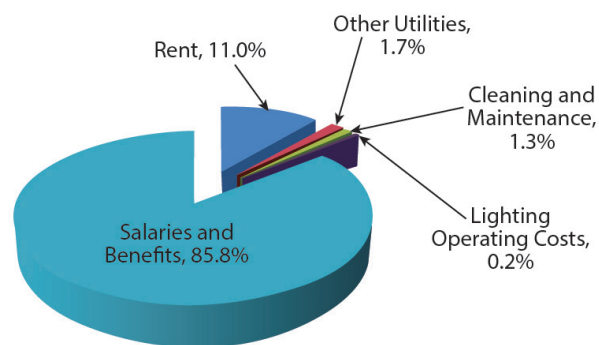


Figure 1-1. Average office costs show the importance of maintaining employee productivity.¹ (Graphic redrawn based on original by Elizabeth Gillmor)

1.2 Scope

This document addresses the general methods of performing a successful lighting upgrade. The designer should consult the latest product information obtained directly from lighting manufacturers for the most current data.

2.0 Lighting Upgrades: The Fundamentals

2.1 Lighting Upgrade: Retrofit, Redesign, or Both?

As mentioned above, the basic ways to improve energy efficiency for an existing lighting system are retrofit, redesign, or a combination of both. A retrofit, largely due to financial considerations, is the most common type of upgrade. Sometimes, however, it may make