General Lighting Recommendations

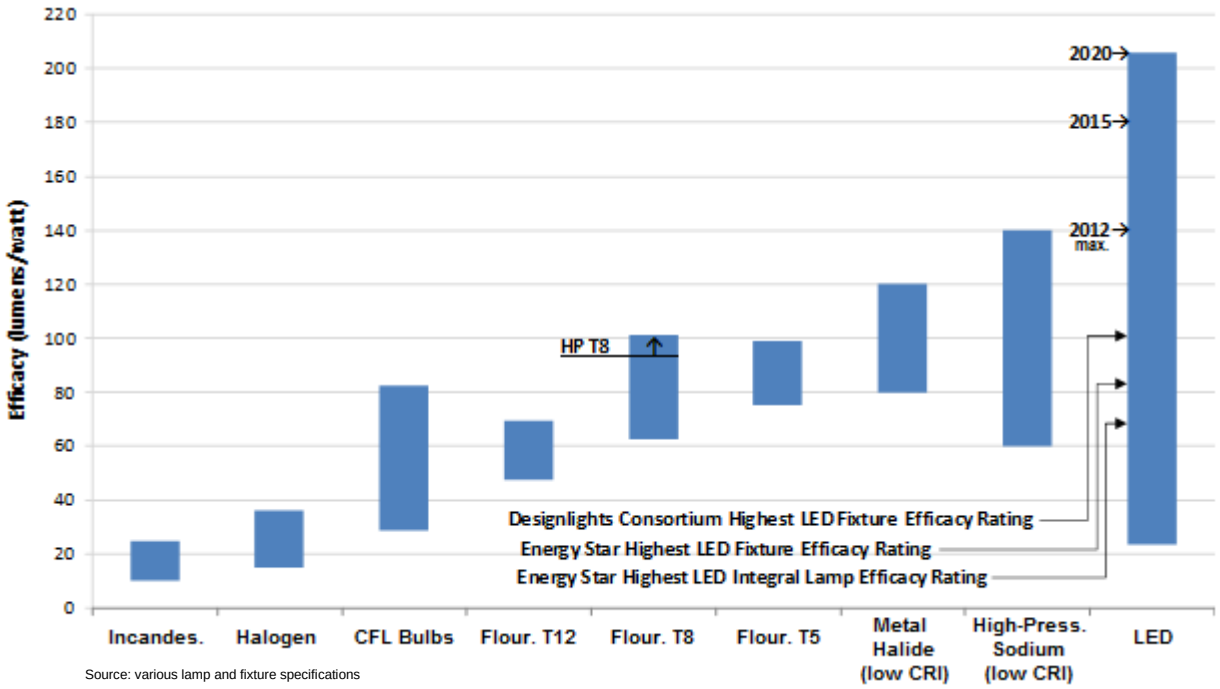
DESIGN GUIDELINES FOR ENERGY EFFICIENT LIGHTING SYSTEMS

According to the US Department of Energy, 51 percent of the energy used in commercial buildings is consumed by lighting systems, meaning there's significant savings to be had through energy-efficient lighting measures. The guidelines presented here are designed to support building designers and owners selecting efficient lighting technologies and practices. This document provides both general technology recommendations as well as example specifications that can be copied and pasted into project specifications. These recommendations are based on those of the Illumination Engineering Society of North America (IESNA), the Consortium for Energy Efficiency (CEE) and other non-profit third-party industry groups that promote cost-effective energy efficiency in lighting. The most current IESNA Handbook should be consulted for more specific design recommendations.

Through your electric utility's energy efficiency programs, CLEAResult helps building owners, architects and engineers realize the benefits of energy efficiency. Building owners are encouraged to assess and address their energy use through a variety of program-related services, including energy performance benchmarking, energy master planning, technical assistance and even public relations support. These third-party recommendations are provided free of charge through your electric utility and are not meant to substitute for the services of paid professionals.

Lighting Technologies

Lighting technologies have various ranges of efficacies, which is rated by light output per watt input. Incandescent lamps being the least efficacious lighting technology, while LED efficacies are improving every year. The graph below, created from IESNA reports, illustrates the different light efficiencies for various technologies. For indoor lighting, both high- and low-bay, we recommend high performance fluorescent fixtures and ENERGY STAR® or DesignLights qualified LED fixtures.



Source: various lamp and fixture specifications

ENERGY STAR AND DESIGNLIGHTS LED FIXTURES

LEDs are quickly becoming the premier lighting technology and have the potential to save significant energy and maintenance costs. We recommend that any LED fixture purchased be qualified under ENERGY STAR or DesignLights Consortium (DLC). These industry groups rate the best and most reliable LED products on the market. This is the easiest way to choose an LED product that will not fade out or change color before its time. In order to receive an incentive for LED installation in many energy efficiency incentive programs, the LED product MUST be qualified by ENERGY STAR or DLC. For more information, see the following websites:

https://www.designlights.org/QPL
http://www.energystar.gov/products/certified-products/detail/light-fixtures
http://www.energystar.gov/products/certified-products/detail/light-bulbs

HIGH PERFORMANCE T8 FIXTURES

For many indoor new construction and retrofit applications, we recommend high performance T8 lamp and ballast systems. High performance T8s provide increased light output along with longer lamp-life and lumen maintenance at the same wattage as traditional T8s. Improvements to traditional T8s enable superb color quality (CRI ≥80) at any color temperature. Premium-efficiency ballasts save energy compared to standard ballasts. The Consortium for Energy Efficiency (CEE) is a non-profit industry group that qualifies high-performance T8 and reduced-wattage T8 lamp and ballast systems. Some energy efficiency incentive programs require CEE-qualification for any four-foot T8 lamps. For more information, visit the following website:
http://library.cee1.org/content/commercial-lightingqualifying-products-lists

An important thing to consider when choosing a T8 lamp and ballast system is the ballast factor (BF). This factor is a measure of the lumen output of a ballast relative to a reference ballast. High, low and normal ballast factors are all available as premium ballasts for every type of T8 lamp. This way, you can modify the power input and light output of a T8 fixture by changing the ballast factor in new designs and retrofits. The following chart gives a few examples for a high performance T8 system.

COMPARISON OF TYPICAL INDOOR FIXTURES

Typical 2x4 Fixture Type	Lumens /Lamp	Lumen Maint.	CRI	Rated Life (hrs)	System Wattage	Lumen Output
ENERGY STAR LED 2x4 Fixture	N/A	≥70%	≥80	≥25000	50	3,600
2-Lamp High Performance T8 (F32T8)	3100	95%	≥80	≥24000	54	6,200
2-Lamp Reduced Wattage T8 (F25T8)	2400	95%	≥80	≥24000	48	4,300
2-Lamp Standard T8 (F32T8)	2850	90%	75	20,000	58	5,700

Source: various lamp and fixture specifications

OUTDOOR LIGHTING

Because LED lamps tend to provide directional light in a more even spread than other technologies, we recommend ENERGY STAR or DesignLights qualified LED fixtures for outdoor illumination. The directional quality of LEDs means that outdoor areas can be adequately lit using less light output, and therefore less energy. In addition, LED fixtures can last up to ten years and require far less maintenance than conventional outdoor lighting. In areas where maintenance is a challenge, such as pole lights, the reduced maintenance for the LED fixtures helps balance the up-front cost. Make sure that the LED product is rated for high temperatures if the fixture is to be installed in a warm climate.

Lighting Power Density (LPD)

LPD is the power used by luminaires (including lamps, ballasts, transformers and control devices) per unit area of a building in watts per square foot. For new construction buildings, local building codes dictate the maximum allowed LPD. Energy efficiency incentives for new construction lighting are paid based on comparing the project's actual LPD with the code requirement.

The following table lists the current maximum allowed LPD for various building types according to International Energy Conservation Code 2012 (IECC 2012), along with maximum LPD levels we recommend.

RECOMMENDED LIGHTING POWER DENSITIES		
Facility Type	**IECC 2012 Allowed LPD**	**Recommended LPD (30% Savings)**
Automotive Facility	0.90	0.63
Convention Center	1.20	0.84
Courthouse	1.20	0.84
Dining: Bar/Lounge/Leisure	1.30	0.91
Dining: Cafeteria	1.40	0.98
Dining: Family	1.60	1.12
Dormitory	1.00	0.70
Exercise Center	1.00	0.70
Gymnasium	1.10	0.77
Health Care - Clinic	1.00	0.70
Hospital	1.20	0.84
Hotel	1.00	0.70
Library	1.30	0.91
Manufacturing	1.30	0.91
Motel	1.00	0.70
Motion Picture	1.20	0.84
Multi-Family	0.70	0.49
Museum	1.10	0.77
Office	1.00	0.70
Parking Garage	0.30	0.21
Penitentiary	1.00	0.70
Performing Arts	1.60	1.12
Police/Fire Stations	1.00	0.70
Post Office	1.10	0.77
Religious Buildings	1.30	0.91
Retail	1.50	1.05
School/University	1.20	0.84
Sports Arena	1.10	0.77
Town Hall	1.10	0.77
Transportation	1.00	0.70
Warehouse	0.80	0.56
Workshop	1.40	0.98

The following table lists the current maximum allowed lighting energy for outdoor lighting areas according to International Energy Conservation Code 2012 (IECC 2012).

ALLOWED OUTDOOR LIGHTING POWER DENSITIES				
Facility Type	**Zone 1 W/SF**	**Zone 2 W/SF**	**Zone 3 W/SF**	**Zone 4 W/SF**
Uncovered Parking: Parking Areas and Drives	0.04	0.06	0.1	0.13
Building Grounds: Walkways ≥ 10 ft wide, Plaza Areas, and Special Feature Areas	0.14	0.14	0.16	0.2
Building Grounds: Stairways	0.75	1	1	1
Building Grounds: Pedestrian Tunnels	0.15	0.15	0.2	0.3
Building Entrances and Exits: Entry Canopies	0.25	0.25	0.4	0.4
Sales Canopies: Free-standing and Attached	0.6	0.6	0.8	1
Outdoor Sales: Open Areas	0.25	0.25	0.5	0.7
Building Facades	--	0.1	0.15	0.2
Entrances and Gatehouse Inspection Stations	0.75	0.75	0.75	0.75
Loading Areas for Emergency Vehicles	0.5	0.5	0.5	0.5

Source: International Energy Conservation Code 2012

Lighting Controls

Lighting controls reduce energy use from lighting by dimming or turning off luminaires in day lit or unoccupied spaces. Lighting controls include dimming controls, daylight controls and occupancy controls. Multiple controls may be appropriate for a single building space. We recommend installing lighting controls wherever appropriate. See the table below for a more detailed description of each control type.

LIGHTING CONTROL TYPES	
Dimming Controls	Dimming controls lower light levels in order to reduce the energy consumed. Dimming can be continuous or involve step controls.
Daylight Controls	Daylight controls dim or turn off lights when ambient light is sufficient. Daylight sensors can be indoor or outdoor.
Occupancy Controls	Occupancy controls sense occupancy or vacancy in order to turn lights on or off. There are two main types: infrared and ultrasonic. Controls that use both technologies are the most reliable.
Personal Tuning	Includes personal computer-based controls, wireless on/off controls and dimmers, as well as pre-set scene selection programming. All adjust individual light levels by occupants according to their personal preference, typically in offices and classrooms.
Institutional Tuning	Adjusts light levels through commissioning or provision of switches or controls for areas or groups of occupants. Examples include dimmable ballasts and on/off or dimmer switches for non-personal tuning.

Light Quality Concerns

COLOR RENDERING INDEX (CRI)

CRI is a quantitative measure of a light source's ability to reproduce colors of various objects in comparison to an ideal or natural light source. Simply put, it determines how "true" colors appear. Higher CRI lamps can better reproduce the visible light spectrum and can potentially reduce needed footcandle levels. With natural light having a CRI of 100, we recommend a lamp with a CRI greater than 80 ***(***a lamp's CRI will be listed in its product specifications document)***.***

Note: Lamp sources of different color temperatures can all have a CRI greater than 80. Color temperature is a measure of the color of a light source in degrees Kelvin. Lower color temperatures (~3000K) are more golden, while higher color temperatures (~6000K) have more of a blue tint. Choice of color temperature depends on individual preferences, but we recommend that all light sources in a facility utilize the same color temperature.

ILLUMINATION LEVELS

IESNA provides detailed horizontal and vertical illumination level recommendations for thousands of specific space types in their Handbook. These light levels are most commonly expressed in "footcandles" (fc). Lighting designers should reference the IESNA Handbook as the authority for maximum and minimum footcandle levels in each applicable space type. This ensures appropriate light levels will be maintained while also minimizing energy consumption.

Many existing facilities have much higher than recommended footcandle levels, and this problem is amplified when combined with the visual discomfort of “glare” (often experienced when working on computers). Glare from overhead lights can actually make it difficult to read most computer screens or monitors since those devices are already backlit. In cases where higher light levels are needed or desired for a specific task or usage type, appropriate illumination is better achieved by moving the light source closer to the task or through supplementary task lighting, as opposed to simply increasing the light output from an overhead fixture.

RECOMMENDED LIGHT LEVELS		
Orientation and Simple Tasks These tasks occur in public spaces where reading and visual inspection are only occasionally performed. Visual performance is largely unimportant.		
Public Spaces	Atriums	3 fc
Simple Orientation for Short Visits	Hallways	5 fc
Working Spaces for Simple Visual Tasks	Kiosks	10 fc
Common Visual Tasks Visual performance is important for these. Higher light levels are recommended for visual tasks involving low contrast or small size.		
Tasks with High Contrast and Large Size	Classrooms & Offices	30 fc
Tasks with High Contrast and Small Size OR Low Contrast and Large Size	Assembly Line	50 fc
Tasks with Low Contrast and Small Size	Operating Room	100 fc

Source: IESNA Handbook

Example Lighting Specifications

NEW CONSTRUCTION AND RETROFITS

A. Average lighting levels and measurements must comply with the most current Illuminating Engineering Society of North America (IESNA) recommended practices.
B. Final light levels must meet the requirements of the end user and meet the satisfaction of all approving authorities having jurisdiction for specific applications.
C. The Engineer, Contractor or Supplier must confirm that the lighting levels will meet the illumination range stated in this document, or most current IESNA recommendations, for the applicable space type.
D. Retrofit designs should consider the recommended practice of:
    a. Reducing the number of lamps in the retrofit fixture.
    b. Reducing the number of fixtures in a room or space.
    c. Converting from 2-lamp, 8’ T12 high output lamps to 2-lamp and 4’ high performance (or “super”) T8 lamps with low ballast factor ballasts.
    d. Uniform lamp and ballast types to facilitate a consistent and economical equipment stock.

LED LIGHTING SYSTEMS

A. LED Lighting Systems—
    a. All screw-in lamps will be LED

b. LED lamps and fixtures must be certified and listed by at least one of the following organizations:
    1. *DesignLights Consortium (DLC)*
    2. *ENERGY STAR*

LINEAR FLUORESCENT T8 LIGHTING SYSTEMS

A. 4-FT LAMPS

a. For all possible fluorescent lighting applications, 4-ft high-performance T8 fixtures should be chosen for maximum efficiency. T8 lamps and ballasts should meet the Consortium for Energy Efficiency (CEE) High Performance criteria (www.cee1.org). High-performance lamps should be chosen as one of the following wattage levels: 32W, 28W, or 25W.

b. 32W lamps should be CEE-Qualifying High-Performance 4-ft T8 lamps, installed in conjunction with CEE-Qualifying High-Performance ballasts. A qualifying 32W lamp should be rated at ≥ 3,100 initial lumens, ≥ 80 CRI, ≥ 24,000-hour life (at 3 hours per start) and ≥ 94 percent lumen maintenance.

c. 28W lamps should be CEE-Qualifying Reduced-Wattage 4-ft T8 lamps and installed in conjunction with CEE-Qualifying Reduced-Wattage ballasts. A qualifying 28W lamp is rated at ≥ 2,585 initial lumens, ≥ 80 CRI, ≥ 20,000-hour life (at 3 hours per start) and ≥ 94 percent lumen maintenance.

d. 25W lamps should be CEE-Qualifying Reduced-Wattage 4-ft T8 lamps, installed in conjunction with CEE-Qualifying Reduced-Wattage ballasts. A qualifying 25W lamp should be rated at ≥ 2,400 initial lumens, ≥ 80 CRI, ≥ 20,000-hour life (at 3 hours per start) and ≥ 94 percent lumen maintenance.

e. Ballasts for all 4-ft T8 fluorescent lighting should be CEE-Qualifying High Performance and/or Reduced-Wattage Ballasts (www.cee1.org).

B. LAMPS (all other types) – Prior written approval must be obtained from the owner for use/specification of any lamp type other than 4-ft. T8 as listed above.

a. 2’ lamps should be F17T8, nominal lamps of 17 watts or lower (high efficiency, premium lamps).

b. 3’ lamps should be F25T8, nominal lamps of 25 watts or lower (high efficiency, premium lamps).

c. Color Rendering Index (CRI) should be a minimum of 80. For color critical applications, Color Rendering Index (CRI) should be a minimum of 86.

d. Minimum lamp life for all 2ft, 3ft and 4ft T8 lamps should be a minimum of 20,000 hours, at 3 hours per start. They are also recommended to be 24,000 hours or more at 12 hours per start regardless of the type of electronic ballast.

LINEAR FLUORESCENT T5 AND T5HO LIGHTING SYSTEMS

A. T5HO LAMPS – use 49W T5HO lamps in fluorescent high bay applications for increased energy savings with comparable lumen output.

HIGH BAY AND OUTDOOR FIXTURES

LED fixtures should be installed in areas with high ceilings or in outdoor areas. All LED fixtures must be on the qualified products list of either ENERGY STAR or DesignLights Consortium (DLC).

LIGHTING LEVEL REQUIREMENTS

Lighting systems are to be designed such that illumination levels fall within a given range, according to the space type. Average lighting levels are not to fall below the range’s lower limit and not to exceed the range’s upper limit. This is to assure all spaces are adequately lit but are not over-lit. The ranges

apply to all working areas in a space, and should be sustained throughout lamp life. The following footcandle (fc) ranges are derived primarily from IESNA recommended levels and NCAA gymnasium lighting best practices.

Space Type *	Lighting Level Range (fc)
Classroom	30 – 50
Science Lab	50 – 70
Library	30 – 50
Office	30 – 50
Computer Lab	3 – 30
Corridor / Common Space	10 – 20
Gym (recreational)**	30 – 50
Gym (competition)**	50 – 100
Gym (NCAA broadcasting)**	100 – 150
Cafeteria	10 – 20
Kitchen	30 – 50
Pool	5 – 50
Parking Garage	10 – 20
Restroom	5 – 15
Mechanical Room	20 – 50

* IESNA recommended lighting levels should be used for other space-types not listed above.
** “Gym” refers only to the lighting levels on the actual court, not the adjacent general circulation and seating.

LIGHTING CONTROLS

A. INTERIOR – All interior spaces must be controlled via occupancy sensors; infrared, ultrasonic, or dual technology, as applicable to the space.
B. INTERIOR – where possible, interior lighting fixtures should be equipped with photocells to dim or turn off fixtures when lighting levels reach desired brightness with ambient light alone.
C. EXTERIOR – Exterior light fixtures should be controlled via photocell or time-clock for energy conservation.