Photo courtesy of Cree

UPGRADING HIGH BAY AND LOW BAY LIGHTING TO LED

ENERGY SAVING FACT SHEET

WHY UPGRADE TO LED

LED equipment for lighting high ceiling environments has advantages over metal halide and linear fluorescent including:

- Reduce electric bill
- More precise distribution of light output reduces lumens required per fixture
- Can readily be combined with dimmers and occupancy sensors to further reduce energy consumption
- Simple payback time is frequently reduced by rebates and incentives
- Reduced air conditioning load (heating load increases)
- Better color rendering index
- System maintenance labor is reduced by longer life (>50,000 hours)
- Disposal issue with mercury is eliminated

There are additional advantages specific to the current system.

Current System	Specific Advantages of Upgrading to LED
T12 with magnetic ballast	• Current equipment has degraded output and reaching end of useful life. • Production of most T12 lamps was discontinued in 2012 and T12 lamps will become more difficult to obtain. • Energy savings—50 to 85% (with controls).
Metal halide	• Eliminate long start up and hot restrike times. • Better lumen maintenance. • Minimal color shift.
T5 and T8	• Better color rendering for retail and other color critical spaces.

High bay lighting is installed at 25 feet or greater above the floor and can be found in manufacturing, warehouses, convention centers, sport facilities, and big box retail. Traditional high bay luminaries are metal halide and linear fluorescent (T12, T8 or T5).

Low bay lighting is installed at less than 25 feet above the floor can be found in retail, assembly and warehouse. Traditional low bay luminaries include metal halide with prismatic lenses or reflectors and linear fluorescent.

This fact sheet focuses on indoor luminaires, but much of the information is pertinent to outdoor lighting.

NINE STEPS TO EVALUATE LED UPGRADE OPPORTUNITIES

1. Get the right quantity of light. The goal is to provide sufficient illumination for people to do their activities comfortably and in a pleasing environment.

The output of current fixtures may have degraded by 20 to 40% over their life. New LED fixtures can be purchased with lumen outputs from 10,000 to 60,000 lumens. How do you determine the correct amount of lumens?

Programs are available to use the fixture spacing and celling height to determine how many lumens are needed to achieve the target illumination at the work surface. Work with your lighting supplier or go the manufacturers web sites.

Uniformity of illumination is as important as amount of light. The darkest areas should have at least 1/3 the illumination as brightest.

2. Get the right quality of light. Determine the color temperature and Color Rendering Index (CRI) needed for the location.

Color temperature is typically specified as 3000 K or less for hospitality, 3000 to 4000 K for indoor, and 4000 K or more for outdoor.

We have grown accustomed to incandescent lighting which has been defined as a color rendering index of 100. Other light sources differ in their distribution of light through the spectrum and this affects the perceived color of objects. Specify a CRI of at least 80 for retail or other locations where color is a critical consideration. This information is available on most LED specification sheets.

Evaluate color temperature and CRI of samples before committing to a large-scale replacement.

3. Use Design Lights Consortium (DLC) qualified products. Energy Star® does not rate linear fluorescent lamps and their LED replacements, nor does it rate high/low bay fixtures. The Design Lights Consortium rates these products and establishes minimums for a wide range of performance parameters simplifying procurement specifications. http://www.designlights.org/content/qpl/productsubmit/categoryspecifications
DLC maintains a searchable qualified products list including over 10,000 LED products for high and low bay applications. http://www.designlights.org/qpl

If a candidate product is not DLC listed, then verify performance is validated with independent testing.

How much light is enough?

Illuminating Engineering Society of North America sets officially recognized standards measured in foot candles (or lux). www.ies.org

Typical Illumination Levels

Illumination Level for Space / Task	Foot candles, fc
Corridors, Stairs	5 min.
Parking Garage	10
Warehouses, Material Handling	10 to 30
Industrial (machining and assembly of medium to large items)	30 to 50
Retail, Inspection, Detail Work	50 to 100

4. Rank efficacy (efficiency) in lumens per watt. For LED products with similar light output, the wattage varies significantly. Therefore, it is important to compare products on their efficiency measured in lumens per watt. DLC listed products are available with efficacy better than DLC minimums as illustrated in the accompanying table.

LED Light Output Efficiency Varies Significantly

Design Lights Consortium Listed Products			Output Lumens per Watt		Best Increase Over Avg.
Category	Minimum				
	Lumens	lm/W	Average	Best	
High Bay	10,000	80	95	144	51%
High Bay Retrofit	10,000	80	89	123	38%
Low Bay	5,000	80	95	132	39%

To maximize the benefits of an upgrade, it is imperative to obtain the highest lumens per watt in relation to cost. Suggestions for specifying the efficiency are listed below. Seek guidance from your lighting suppler.

Recommended Efficiency to Specify

Category	Design Lights Efficiency Min. Lumens/Watt	Specify Efficiency Lumens/Watt
High Bay	80	100
High Bay Retrofit	80	90
Low Bay	80	100

5. Special requirements checklist.

Is illumination level appropriate? If not, can it be corrected by modifying lumens per fixture or does the fixture spacing need to be modified?

Spacing criteria. Fixtures are designed to produce relatively uniform illumination when centerline spacing and mounting height meets a spacing criteria. Check that the proposed upgrade fixtures have similar spacing criteria as existing equipment.

Check the condition of existing fixtures. Worn wiring, damaged sockets, degraded reflective surfaces, or discolored lenses are justification for replacing the entire fixture.

Consider adding controls. Occupancy sensors or harvesting daylight with sensors can be combined with new fixtures to potentially reduce energy consumption by 50%. Make sure proposed equipment interfaces with appropriate controls.

Check for glare. How the light is diffused varies significantly between products. If the light source is visible in the fixture, then evaluate sample parts or fixtures in proposed setting. Lens selection is critical to eliminating glare**.**

Identify maintenance action and cost. At the end of life is a module replaced or complete fixture? Is an electrician required to do the service? What are the material costs? What parts need to be stocked?

Compatibility with other building systems. Verify proposed equipment will function with all systems that interact with it (dimmers, safety hardware, building automation, etc.).

6. Special considerations for linear fluorescent upgrades.
LED upgrades can be done with replacement lamps, upgrade kits or luminaire replacement. Selecting the best approach requires consideration of the following aspects (see table below). Appropriate safety certification (listed by Underwriter Laboratory, etc.) may be critical to insurance coverage and passing local inspection. A comprehensive review of terminology and certification requirements can be found in "Upgrading Troffer Luminaire with LED" published by the Department of Energy and available at: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led_troffer-upgrades_fs.pdf

Comparison of Upgrade Approaches For Linear Fluorescent Fixtures

LED Upgrade Type	Advantage	Disadvantage
Replacement Lamps	• Lowest initial cost with least labor. • Can be used where fixture would be difficult to work on.	• Light output from fixture difficult to estimate. • Safety certification may not apply to combination of old and new. • Not suitable for fixtures with discolored lenses, or degraded reflective surfaces.
Replacement Kits	• Typically intermediate initial costs; however, accurate labor estimate needed for decision making.	• Light output from fixture difficult to estimate. • Safety certification may not apply to combination of old and new. • Not suitable for fixtures with discolored lenses, or degraded reflective surfaces. • Not suitable if ceiling plenum restricted due to space or disturbance of existing materials.
Replace Luminaire	• Lowest operating cost for equivalent light output. • Safety certification for unit. • Connection for dimming controls, daylight harvesting controls, etc.	• Higher initial cost. • Not suitable for recessed fixtures if ceiling plenum restricted due to space or disturbance of existing materials.

7. Determine annual energy costs. Start with an estimate of the hours a fixture is operated per year and the electric rate.

[Annual operating cost] = [Wattage] x [Hours per year] x [Cost per kWh] x [.001 kW per Watt]

As an example, consider a 440 W metal halide fixture operating 5,000 hours per year and billed at a rate of $0.0844 per kWh. The annual electric cost per fixture is compared to a 240 W LED fixture below.

Example of Operating Cost for 5,000 hours per year

Metal Halide	LED
440 W	240 W
$186	$101

8. Determine payback. For fixtures operating more than 40 hours per week, the annual energy cost saving may be sufficient to justify upgrading a fixture to LED. In other situations, the higher cost of LED upgrade may appear to be a barrier. For these cases, a more detailed cost analysis is required and should include initial cost and rebates, labor, and maintenance cost and labor.

The following worksheet allows the current fixture to be compared to an upgrade by prorating the cost of operation on an annual basis. This method allows a direct comparison of options with differing initial costs. Basic information about the before and after cases is entered in the white cells. Calculate values in gray cells using formulas on left. An Excel version of the work sheet which performs the calculations is available at
http://www.wastereductionpartners.org/phocadownload/Energy/led_worksheet_pro.xlsx

The individual fixture costs can be scaled by the quantity of fixtures to determine project costs.

For T8 and T5 systems, consider how other improvements (delamping, longer life lamps, lower wattage, etc.) compare in financial benefit to the proposed LED upgrade.

Note: Using a life cycle cost is not recommended when the usage would be spread across more than six years. The savings may appear large but depend strongly on the validity of the assumption about the life of the product. The benefit of a large initial cost may or may not be realized over time.

What Electric Rate Should You Use?

For a rough estimate, use the average North Carolina commercial sector rate of $0.0844/kWh or use the average rate (total cost for usage and demand divided by total kilowatt hours) from a recent electric bill.

CAUTION: The average rate may overestimate the savings because the actual saving depends on the incremental rate for the usage and demand reductions. The increment rate can vary from more than $.116 to less than $.050 per kilowatt hour depending on the rate schedule, amount of use, and/or time of use. See the worksheet for a more detailed analysis.

ENERGY SAVING FACT SHEET

WORKSHEET FOR COST COMPARISON AND PAYBACK OF LED LIGHTING UPGRADES

Excel version available at Waste Reduction Partners: wastereductionpartners.org.

Enter values in white cells

Calculate values in gray cells using formulas on left

	EXAMPLE			COMPARISON		
	Before	After	Saving	Before	After	Saving
Project Parameters						
Type	Metal Halide	LED				
Watts per fixture	400	240	160			
Operating hours per year	5000	5000				
Incremental usage rate per kWh, Note 1	$0.075	$0.075				
Demand rate per kW, Note 1	$3.81	$3.81				
Annual Energy Cost per Fixture						
Kilowatt hours per year, kWh [Watts] x [Operating hours] x [.001 kW/W] =	2000	1200	800			
Electric usage cost per year [kWh per year] x [Incremental usage rate] =	$149.66	$89.80	$59.86			
Electric demand cost per year [Watts] x [.001 kW/W] x [demand rate] x [12 months] =	$18.29	$10.97	$7.31			
Annual Maintenance Cost per Fixture						
Life, hours	20,000	75,000				
Replacements per year [Life] / [Hours on per year] =	0.25	0.07				
Material cost per replacement, Note 2	$41.60	$251.50				
Material cost per year [Material cost] x [Replacements per year] =	$10.40	$16.77				
Labor cost per replacement, Note 3	$20.00	$20.00				
Labor cost per year [Labor cost] x [Replacements per year] =	$5.00	$1.33				
Maintenance cost per year [Material cost per year] + [Labor cost per year] =	$15.40	$18.10	-$2.70			
Annual Saving per Fixture						
Annual Savings [Usage savings] + [Demand savings] + [Maintenance Savings] =			$64.48			
Investment Cost per Fixture						
Material cost of lamp(s), kit or fixture		$503.00				
Rebate		$225.00				
Labor cost for installation		$40.00				
Investment cost per fixture [Cost] - [Rebate] + [Labor] =		$ 318.00				
Payback Period						
Simple Payback, years [Investment cost] / [Annual saving] =			4.9			

Note 1. Refer to an electric bill or utility web site for rate schedules.

The incremental usage rate is the rate that would be applied to the last kWh consumed. For meters on a Time of Use rate, estimate the fraction of on peak and off peak for the lighting involved. Then combine the on peak and off peak rates weighted by these fractions.

The demand rate would apply only if the lighting was turned on during the short period when peak demand occurs. Use zero if lighting upgrade will not change demand charge.

EXAMPLE: Duke Energy Large General Service Rate for over 3000kWh and 30 kW per month

Note 2. Replacement costs may not be well known. EXAMPLE assumes one half of new.

Note 3. Labor cost will vary significantly between projects. EXAMPLE amounts are for illustration only.

Download Excel workbook at http://www.wastereductionpartners.org/phocadownload/Energy/led_worksheet_pro.xlsx

9. Financing Options

DSIRE is a comprehensive database of information on federal, state, local, and utility incentives and policies that support renewable energy and energy efficiency.

http://www.dsireusa.org/

Duke Energy assistance: 866-380-9580. Lighting incentives page:

http://www.duke-energy.com/north-carolina-business/smart-saver/customer/lighting-incentives.asp

Duke Energy Smart Saver® Prescriptive incentives include $40 per for LED panel replacing T12 or T8 4 ft. and 2 ft. lamps and larger rebates for LED fixtures.

http://www.duke-energy.com/pdfs/SS-Comprehensive-Prescriptive-NC.pdf

Duke Energy Progress assistance: 866-326-6059. Energy Efficiency for Business page:

https://www.progress-energy.com/carolinas/business/save-energy-money/energy-efficiency-for-business.page?

Duke Energy Progress Incentive Program including incentive of $.35 per watt reduced by approved replacement

https://www.progress-energy.com/assets/www/docs/business/Progress_Lighting_Application_123113-FINAL.pdf

Duke Small Business Energy Saver Program (Lime Energy): 855-776-4723. Duke Energy will pay up to 80 % of selected energy-efficiency improvements with 50% a typical amount. The program pays the rebate upfront, thereby reducing investment cost without waiting for a rebate. The upgrade is completed by a local contractor who takes care of all necessary material and labor.

www.duke-energy.com/sbes

Additional Resources

More detailed information about LED upgrades for linear fluorescent fixtures can be found in the following:

DOE Adoption of Light-Emitting Diodes in Common Lighting Applications
http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led-adoption-report_2013.pdf

DOE Energy Efficiency & Renewable Energy (EERE) Report on Indoor Luminaires Featuring Downlights, Industrial Luminaires, Track Heads, Troffers and Linear Fixtures.
http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/snapshot2014_indoor-luminaires.pdf

About This Work Sheet

This work sheet is produced by Waste Reduction Partners, a program of the Land of Sky Regional Council and the N.C. Department of Environment and Natural Resources, Division of Environmental Assistance and Customer Service. The work of WRP is sponsored, in part, by the State Energy Program and the U.S. Department of Energy. However, any opinion, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of either the N.C. DENR or the U.S. DOE. An online version of the associated Excel workbook is available at: http://www.wastereductionpartners.org/phocadownload/Energy/led_worksheet_pro.xlsx