guidance

Lighting

A team approach is best used to implement a lighting strategy. This team should consist of the production manager, the maintenance and the utility manager. The team's assignment is to create an action and implementation plan for the complete facility. This plan ensures that energy efficient lighting is provided everywhere in the production, support, offices and logistic areas. This can be accomplished in 5 steps:

Step 1: Assessment of current situation

Make an inventory of the existing lighting situation at all facility areas. Type of lamps, number of fixtures, type of ballast, annual burning hours should be noted. This can be monitored in a spreadsheet with the following setup below:

Step 2: Assess lighting opportunities

The second task of the team is to check or identify lighting upgrade opportunities. The team also needs to identify the required lux levels for a given area. In many cases external suppliers are needed to assist in this identification. It is important that the situation is evaluated per individual location, because the circumstances will be different in every location and local regulations and codes will determine safe operating levels. An example of lighting levels is listed below:

Area	Lux Levels	Foot Candle Levels	Notes:
Open Parking (no special conditions)	20 - 50	2-5	Insurance requirements may dictate higher levels
Building Entrances	200 - 400	20 - 40	
Working Storage Yards	100 - 200	10 – 20	Non work areas would need less lighting levels
Offices Hallways, Corridors & Lobbies	100 - 200	10 - 20	
Office Areas Easy Task	200 - 500	20 - 50	Desk lamps can be used to provide more lighting if needed
Office Areas Detailed Task	500 - 750	50 - 75	Offices with heavy PC use should use a lower rating then stated
Assembly Areas - Non – task locations	200 - 400	20 – 40	Primarily areas not related to production activities
Assembly Areas – Production	500 -1000+	50 – 100 +	Levels will vary depending on task and operation requirements
Warehouse	150 - 300	15 -30	Level will depend on tag and label reading requirements
Rest Room, HR Areas, Locker Rooms	200 - 300	20 - 30	In most cases personal preference dictates lighting levels in these areas

(Chart shown for reference only actual lighting levels will depend on plant preferences and local codes)

For example:

In warehouses with low lux levels compared to production areas, low traffic patterns may want to consider lighting that can employ motion detection and if possible skylights to increase natural lighting during daylight hours.

Production areas will need to address different levels of lighting required for different areas on the production line, sanitation issues, wash down concerns and maintenance conditions. The lighting solution for this area may be different

Location (warehouse, office building, ...)	Type of lighting (TL12, TL8, MHL, ..)	Number of fixtures	Installed power (kW) per fixture	Type	of ballast (electronic,	Installed power (kW) of ballast	Average age of fixtures + ballast	Annual burning hours (estimate)	Annual energy use (kWh)	Annual energy costs	Specific lighting requirements

and in most cases will be different than a warehouse or human resource area.

When considering lighting for an area the team should consider the following options:

- New fixtures and ballast (T8s in place of Metal Halides)
- Optimize control (occupancy sensors in aisles or seldom used areas)
- Employee awareness (shutting down lights when not in use)

Quality of light for warehouses and production facilities can be important for employees. See examples:

HPS (22) **MH (65)** **FL (85)**

In warehouses, visibility is necessary to both ensure smooth process flow and worker safety. In commercial warehouse lighting, brightness should be directly proportional to the activity within an area. Some types of light render color more effectively than others, and operations such as assembly line work often require a color rendering index (CRI) of close to 100 (CRI of daylight). CRI can be defined as how accurately a light source makes an object appear compared to natural or incandescent light. The advantages and drawbacks of warehouse lighting fixture types are itemized below:

- High Pressure Sodium; High Pressure Sodium fixtures were the preferred form of lighting in warehouses for many years. Not only did they offer the highest lumens per watt efficiency, they also featured the longest lamp life (approximately 25,000 hours). Although many people find the yellowish light they produce annoying, they are still used extensively in areas where color rendering is not important.
- Metal Halide; Most people working in warehouses or doing assembly line work prefer to work under the bright white light of Metal Halide lights. The CRI of an MH lamp is much higher than that of high pressure sodium. Lamp life tends to be only 7,500 hours or so, making frequent replacements inevitable. Also, lumens per watt efficiency tended to be significantly lower than HPS fixtures, making MH more costly to operate.
- Fluorescent High Bays; Fluorescent high bay warehouse lights burn significantly cooler than HID fixtures. Florescent warehouse lights can help to lower HVAC costs. Fluorescent fixtures also render colors more effectively than HID light sources, and they use far less power than HID fixtures. For example, a 35 watt fluorescent high bay can produce equivalent lighting levels to a 400 watt HID fixture. Fluorescent warehouse lights are ideal for lighting large areas of floor space where heavy traffic requires clear visibility without glare or shadow.

Step 3: Evaluation of the most optimal situation per location

When the most efficient solution per location is identified, the different solution need to be evaluated (financially and technically) and a prioritization schedule developed.

An evaluation matrix should include the following items:

- Total Cost: includes purchase cost, installation and preparation costs, maintenance etc.
- The total savings for the solution: energy usage and cost of new system vs. current system
- Simple Payback of solution: the amount of time in decimal years that will transpire before a system upgrade option's energy savings reach the net installation cost
- Low cost solution (like awareness or motion detectors, or more advanced, like replacing complete fixtures)?
- Technical evaluation, what are possible technical issues (like heights, hard to reach areas, quality, etc.).

To review, if a lighting retrofit is to be done, careful consideration should be given to the following:

- Identify lighting needs for the area function or process
- Identify lamps to fulfill lighting requirements: Select the lamp that has the desired CRI, lamp life and lumen output
- Discuss with a lighting professional and ask for a demonstration or trial installation
- Identify proper ballasts and fixtures to fulfill lighting needs of plant and warehouse
- Identify the optimal control technology: Decide whether to use infrared, ultrasonic or dual technology occupancy sensors

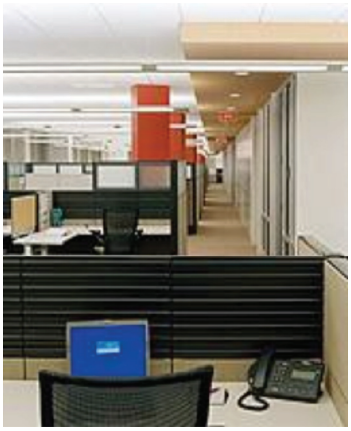
Outlined below is a comparison of a replacing existing HID (metal halide) system with a new fluorescent lighting system.

WAREHOUSE: RETROFIT EXAMPLE		EXISTING SYSTEM 400W high-bay standard metal halide	PROPOSED Fluorescent high-bay w/6- lamp high- lumen T8 lamps
LAYOUT	Fixture Mounting Height	31 ft.	31 ft.
LAMP & FIXTURE DATA	Initial lamp lumens	36000	3100
	Number of lamps	1	6
	Initial fixture lumens	36000	18600
	Ballast factor	1.00	1.18
	Lamp lumen depreciation	0.75	0.95
	Fixture watts	460	222
	Fixture lumens/watt	41	77
FOOTCANDLES	CRI	65	82
	FC Average Maintained	38	34
OPERATING DATA	Number of fixtures	496	496
	Cost/kWh	$0.085	$0.085
SAVINGS ANALYSIS	Annual Energy Costs	$169,888	$81,989
	Annual Energy Savings	Existing	$87,899

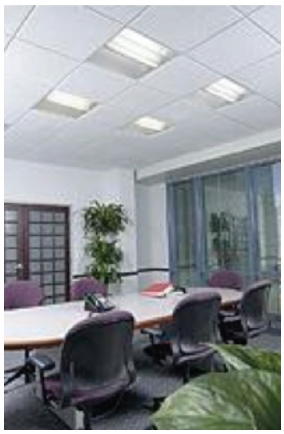
(Please note that this is an example. Actual values will vary depending on location)

For an office example:

T8 Lighting



T5 Lighting



An example of changing from T8 Fixtures to T5 Fixtures in an office environment.

OFFICE INTERIOR: NEW INSTALLATION COMPARISON		3-LAMP T8 PARABOLIC FIXTURES	2-LAMP-T5 FIXTURES
LAYOUT	Fixture Mounting Height	10 ft.	10 ft.
LAMP & FIXTURE DATA	Initial lamp lumens	2800	2800
	Number of lamps	3	2
	Initial fixture lumens	8400	5600
	Ballast factor	0.90	1.15
	Lamp lumen depreciation	0.90	0.95
	Fixture watts	87	66
	Fixture lumens/watt	54	82
FOOTCANDLES	CRI	72	82
	FC Average Maintained	41	40
OPERATING DATA	Number of fixtures	228	198
	Cost/kWh	$0.085	$0.085
	Total wattage	19836	13068
SAVINGS ANALYSIS	Annual Energy Costs	$7,385	$4,865
	Annual Energy Savings	n/a	$2,520

(Please note that this is an example. Actual values will vary depending on location)

Step 4: Communicate to all employees (publicize information at Plant)

Lighting is not only something 'technical', but it has also to do with the comfort feeling of people, with working conditions and atmosphere, the team has to communicate their findings to all employees. Progress should be demonstrated and discussed monthly with plant employees. This should be handled by the plant manager or someone appointed by management. For this, a special meeting needs to be organized with the following agenda:

- Introduction of energy efficiency
- Total costs of lighting in this facility
- Inventory results lighting survey
- Presentation of solutions and planning
- Impact new situation on employees

By making employees aware of the plant's energy efficiency efforts the facility may experience an immediate reduction of 2-5% from this action alone.

Step 5: Implement and check results

After the evaluation and the presentation to all employees the team is responsible for the implementation of all actions outlined. A post startup monitoring plan should be included in the lighting upgrade project. Three (3) months after commissioning the new lighting system an electrical power check should be conducted to determine if the design savings have been achieved. See table below as an example. This will help in identifying actual savings vs. design calculations.

Location	Lighting type	Monthly energy use	Monthly energy costs	# Fixtures	Technical evaluation	Comparison Savings