SAINT MARY'S COLLEGE OF CALIFORNIA

Building Operations Awareness

Lighting

Building Occupant Awareness Manual

Lighting Guide

2008

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Lighting

Introduction

This document is intended to supplement the Lighting training workshop. It contains all the material covered in the workshop as well as additional detail. Those who attended the workshop are encouraged to read this manual afterwards to reinforce the principles that were presented.

Goals

The goals of this section are to:

- elaborate on why conservation, recycling, and energy efficiency are beneficial and important.
- provide basic information on the most common light fixtures, lighting controls and their applications, and
- discuss relevant maintenance issues.

Consequences of Using Energy Efficient Lighting

- Energy and cost savings.
- Improved quality as a result of technology upgrades.
- Decreased maintenance requirements.
- Fewer waste materials to manage.
- Positive impact on climate change issues.

T12 and T8 Fluorescent Lighting

T12 Fluorescent Lighting

The majority of existing fluorescent lighting installed in buildings is known as T12 fluorescent. Each fluorescent lamp is stamped with a model number like, for example F34T12 where…

F = fluorescent
34 = the lamp wattage
T = tubular shape
12 = 12 eighths of an inch (1.5 inches) tube diameter.

The F34T12 model number will usually be appended by the letters ***cw*** (cool white)
or ***ww*** (warm white).

Tubes are usually 4 feet in length but can be 2, 3, 6, or 8 feet long. They are also available in U or circular shapes. Four-foot long tubes normally have a wattage of 34 or 40.

Forty-watt tubes are no longer being manufactured. The 34-watt tube is slightly more efficient than the 40-watt tube, saving about 11 per cent in energy but reducing light output by 7 per cent. Fortunately, this will become an academic question because the 34-watt tube is a transitional technology; new installations and retrofits normally employ T8 lighting systems. The quality of light from a 34-watt tube is lower than that of a 40-watt tube. Some experts have questioned whether the reduction in light quality is worth the energy savings.

T8 Fluorescent Lighting

T8 lighting systems are now standard for both retrofits and new installations. T8 tubes will usually be stamped with a model number like, for example **F32T8** where…

F = fluorescent
32 = the lamp wattage
T = tubular shape
8 = eight eighths of an inch (1 inch) tube diameter.

T8 lamps have been designed to fit into existing fixtures that have the same endpins and sockets as T12 lamps. T8 lamps do require specific ballasts. T12 and T8 ballasts are not interchangeable.

A T8 retrofit lamp (with a full output T8 ballast) will generally produce the same amount of light as the original T12 40-watt lamps. Various shapes and sizes of tube are available as well.

Advantages of T8 Lighting

When used in combination with electronic ballasts, T8 lighting consumes about 30 per cent less electricity than standard T12 lighting. In addition to energy savings, there are several other benefits:

A reduction in light output depreciation… the total light output of any lamp will decline over time. Figure 1 shows how a 40-watt tube will gradually depreciate in light output, about 18 per cent by the end of lamp life. Light or lumen output of T8 lamps will depreciate less than T12 lamps.

1. Improved color rendition… T8 lamps have better a color rendition index than either T12 40-watt or T12 34-watt lamps (Color Rendition is discussed later in this document).

2. Smaller diameter tubes are easier to handle and store.

4. ***More effective when used with specular reflectors…*** because of the way light is reflected inside a fixture, smaller diameter T8 lamps are simply more efficient than T12 lamps in directing light out of the fixture.

5. ***Less hazardous waste to manage…*** due to their smaller size, there is less waste material to dispose of. Furthermore, T8s have been designed with fewer heavy metals such as mercury, lead, and cadmium.

6. ***Should have fewer complaints about lighting quality…*** many past complaints may be due to the lower color rendition of T12 lamps. Color rendition is greatly improved with T8s. Other problems have included flickering and noisy ballasts. This is also minimized or eliminated with the T8 since electronic ballasts are normally installed with T8s.

7. ***Few tubes or ballasts will fail for at least three years after a retrofit…*** this enhances savings and reduces the payback period of the retrofit, This is especially effective if many of the tubes and ballasts are nearing the end of their life. Lighting maintenance can often be avoided just prior to a retrofit.

Color Rendition

The Color Rendition Index (CRI) rates how accurately colors are perceived under various light sources. People are generally very sensitive to color rendition although they may not be aware that they are reacting to it – they just know some types of lighting is more or less comfortable than others. The CRI can be used to compare different types of lights.

A CRI of 100 is considered ideal. It is the color perceived under sunlight. An incandescent bulb has a CRI of 97, which is considered to be excellent color rendition. On the other hand, high pressure sodium lights have a CRI of 32 and are perceived by many people as unattractive and unpleasant making their used limited in many situation.

The CRI is generally divided into subcategories of quality as follows:

CRI	Quality
75 to 100	excellent
60 to 75	good
50 to 60	fair
50 or less	poor

Fluorescent lamps have lower CRI ratings than incandescents. The older standard T12s have a rating of 62 for cool white bulbs and only 52 for warm white. The transitional 34-watt bulbs have an intermediate CRI of 57. New T8s are best of all, at 75 to 85.

Fluorescent Ballasts

All fluorescent lamps require ballasts to operate. The purpose of the ballast is to provide a specific voltage and current to both start and maintain illumination in the lamp.

Electromagnetic Ballasts

The main components of an *electromagnetic ballast* are the iron core and copper windings. These components create a noticeable heaviness. The ballast acts much like a transformer. Electromagnetic ballasts are usually of the rapid start type -- a few seconds are needed for the lamp to start up.

Ballasts include a capacitor, which helps to maintain a constant output current. Prior to 1980, ballasts may contain capacitors with PCBs; PCBs must be disposed of in accordance with government regulations.

Sometimes a very unattractive black tar will be noticed on the ballast and ballast cover or even dripping onto the floor. This occurs when a ballast overheats, causing an asphalt silica compound to boil out. Asphalt silica compound is placed inside the ballast to help dissipate heat. Electromagnetic ballasts have a relatively high output and would fail prematurely without it. The compound also assists in reducing noise. Asphalt silica compound is often mistaken for PCBs.

A more efficient electromagnetic ballast has been on the market for several years and has become the industry standard. This ballast still has the iron core and copper winding construction but has been designed to operate at higher efficiency. For example, a 2-tube, 34-watt fixture with an energy efficient ballast consumes 6 watts compared to 12 watts for the old model. It also generates less waste heat. As old ballasts burn out, they are usually replaced with the energy efficient model.

In most buildings, 40 to 75 per cent of old ballasts have already been replaced. Electronic ballasts (see below) have even greater efficiency but are seldom used as a replacement for burned-out electromagnetic ballasts because of their higher cost.

Electromagnetic ballasts can also generate noise including humming and vibration. Under average usage, they typically have a life span of about 11 calendar years.

Electronic Ballasts

Electronic ballasts have been on the market for at least a decade. Some of the earlier models had various defects. As a result of these defects, many building maintenance supervisors hesitated to adopt this new technology. In recent years, however, the reliability of brand name products has been demonstrated. They are now the standard for T8 installations. Electronic ballasts offer many advantages over electromagnetic ballasts including:

1. ***A 30 per cent or higher energy savings...*** when used in conjunction with a 2 °— 32-watt T8 fixture, they consume only 1 or 2 watts of electricity.

2. ***Less waste heat…*** since an electronic ballast uses little electricity, waste heat is likewise minimal. Waste heat contributes to the cooling load during hot weather. In facilities without mechanical cooling, there will less building overheating. In those facilities with mechanical cooling, reduced load on the cooling system will save electricity.

3. ***High frequency output***… electronic ballasts have an output frequency of 20,000 Hz or higher. This results in quieter operation, lacking the usual humming of 60 Hz electromagnetic ballasts. Another added benefit is the absence of flickering.

4. ***Fewer ballasts needed…*** a single electronic ballast can serve from one to four T8 tubes; leading to lower installation and maintenance costs (In contrast, electromagnetic ballasts are limited to a maximum of two tubes per ballast). A related benefit is that one burned-out tube will not cause a multiple tube fixture to fail. In contrast, if a tube burns out in a 2-tube fixture served by an electromagnetic ballast, the other tube will not work.

5. ***Improved reliability…*** electronic ballasts have a lower failure rate than electromagnetic ballasts.

6. ***Lightweight…*** compared to an electromagnetic ballast, electronic ballasts are relatively light, resulting in easier handling, installation, and disposal.

7. ***Longer life span…*** electronic ballasts are predicted to last up to 25 years – over twice as long as the average electromagnetic ballast.

8. ***Instant start capability…*** both instant start and rapid start capability is available. The instant start option avoids the first few seconds of minor irritation of the flickering characteristic of rapid start ballasts. Instant start ballasts, however, are best suited to applications where there is a minimum of switching. Where there is greater switching, rapid start ballasts will promote longer lamp life.

9. ***Consistent light output…*** solid-state circuitry is better suited to maintaining consistent light output when adapting to minor fluctuations in building voltage.

10. ***High power factor and less harmonic distortion…*** sensitive electronic equipment and computers can be adversely affected by harmonic distortion; a complex subject having to do with electricity quality. The less harmonic distortion the better. Poor power factor can also lead to electricity quality problems as well as higher utility costs.

11. ***No PCBs…*** a complete retrofit where all electromagnetic ballasts are replaced with electronic ballasts eliminates any concerns about PCB ballasts and related handling and disposal questions.

12. ***No asphalt silica compound…*** since electronic ballasts generate comparatively little waste heat, there is no need for enhancing heat dissipation with asphalt silica compound. Hence, there will be no further black tar leaks to be cleaned up.

Specular Reflectors

Conventional fluorescent light fixtures are painted white inside to assist in reflecting light out of the fixture to where it is needed. Any other color would tend to absorb more of the light and be less efficient. Even with white paint, however, about 30 per cent to 40 per cent of the generated light still bounces around within the fixture and ultimately converts into waste heat. Specular reflectors have been developed to more efficiently direct the light out of the fixture and use the 30 per cent to 40 per cent of light that would otherwise be wasted.

A specular reflector is a thin mirror-like component, designed to fit into a new or existing fluorescent fixture and located above the tubes. The reflective film usually consists of polished aluminum or silver. Because of geometry, smaller diameter T8 tubes are more effective than T12 tubes when used with specular reflectors.

With a 30 per cent to 40 per cent efficiency improvement, fewer tubes and ballasts and less electricity will be needed to provide an equivalent level of light. Of course, there is an extra cost for specular reflectors. The economics of each situation has to be evaluated.

In retrofit installations where existing light levels are excessive, they are very effective. In these cases, delamping of up to 50 per cent and using specular reflectors can often supply appropriate light levels. Using a hypothetical example, an existing four-lamp, T12 fixture with two electromagnetic ballasts could be retrofitted with 2 °— T8 tubes, one electronic ballast, and one specular reflector.

Incandescent Lamps

Invented over a century ago by Thomas Edison, incandescent lamps are still very common. The basic design of passing electricity through a tungsten filament enclosed inside a thin glass bulb has changed little. The resistance of the tungsten filament causes it to reach very high temperatures and glow brightly, giving off light similar to electrical resistance heaters.

Fluorescent lamps are about four times as efficient as incandescent bulbs. Figure 2 shows a comparison of efficiency between incandescent lamps and other common light sources. Low efficiency, high heat output, potential fire hazard, a short 1,000-hour life, and extra maintenance to change bulbs frequently are among the disadvantages.

There are two types of incandescent specialty lamps that require further discussion: long life and so-called green lamps.

Long life bulbs may last up to 5,000 hours, but they sacrifice efficiency for longevity and cost more than standard 1,000-hour bulbs. They are intended for use in areas which are difficult to access, not for general-purpose lighting.

Green lamps are sold in green colored cardboard boxes and have a slightly lower wattage rating. For example, a bulb will have a wattage rating of 62 watts instead of the usual 75 watts or 52 watts instead of 60 watts. Use of these bulbs is the same as removing any higher wattage bulb and replacing it with one of lower wattage; such as replacing a 60-watt lamp with a 40-watt. Green bulbs are not any more efficient than standard bulb in terms of lumens of light output per watt of electricity.

The advantages of incandescent bulbs include:

1. ***Instant-on capability***
2. ***Inexpensive bulbs...*** standard bulbs cost less than a dollar. They are ideal for temporary or little used areas such as crawl spaces and storage rooms where a high capital investment is not justified.
3. ***No ballasts...*** they operate directly off 120 volt.
4. ***Color rendition...*** the color rendition index is rated at 97, which is almost equivalent to that of natural sunlight. No other light source is this high. Outdoor use: They are excellent for outdoor use and have no difficulty starting even in the coldest weather.
5. ***Dimmable...*** dimming systems and incandescent bulbs are widely used in recessed pot light applications; often located in board rooms, offices, lobbies, and staff rooms. Until recently, there was no alternative. However, dimmable compact fluorescent lamps have now been introduced.

Quartz Halogen

Quartz halogen lamps are similar to incandescent lamps. A conventional incandescent lamp loses filament material by evaporation; this is deposited on the wall of the bulb causing bulb blackening and lower efficiency. With a quartz lamp, a sealed capsule filled with halogen gas encloses the tungsten filament, which prevents filament evaporation and deposits on the bulb wall. Because of high temperatures, the lamp is made of quartz glass; hence the term quartz halogen. The sealed halogen capsule improves light output by about 50 per cent. Lamp life is about 2,000 hours, twice that of standard incandescent.

Common applications include portable and construction lighting, outdoor building and sign illumination, displays, recessed pot lights, and car headlights. Due to the higher cost of lamps, they are not as common as conventional incandescents.

Compact Fluorescent

Compact fluorescent lamps are small size T4 (4-eighths of an inch diameter) fluorescent lamps and are an ideal replacement for many incandescent lamp applications. As with all fluorescent lamps, a few minutes of warm-up are needed prior to achieving full light output. They are available with both electronic and electromagnetic ballasts. Electronic ballasts are the most common.

Electronic ballasts offer the advantage of instant start and reduced ballast noise. Earlier versions with a separate electromagnetic ballast and replaceable tube have become less widely available; this is unfortunate because the ballast tends to outlast the tube. Lamps with electronic ballasts are generally integrated with the tube. Once the lamp burns out, the entire assembly must be disposed of. Where possible, fixtures with hard-wired ballasts and replaceable tubes are recommended for lower life cycle costs.

As with T8 lamps, compact fluorescent lamps have a high color rendition index of 82 or better; close to that of incandescent. A variety of colors, shapes and sizes are available, some with visible tubes and some enclosed. They commonly range from 7 to 28 watts. Advantages over incandescent lamps include 75 per cent energy savings, less waste heat, and a 10,000 hour average life. The added life results in less maintenance; 10 incandescent bulb changes to one compact fluorescent. Dimmable models have recently been introduced and may be a possible alternative to the numerous incandescent lamp/dimmer switch installations. It is suggested, however, that maintenance staff should proceed with caution until power factor and electricity quality issues have been fully addressed.

High Intensity Discharge Lamps(HID)

The most common HID lamps are:

- Mercury vapor
- Metal halide
- High pressure sodium
- Low pressure sodium

HID lamps have wide applications for both indoor and outdoor use. Due to their high intensity light output, they are ideal for high bay areas, parking lots, arenas, and street lighting. As with fluorescent lighting, all HID lamps require ballasts, some of which are quite noisy. A five to fifteen minute warm-up is usually needed to achieve full light intensity.

> **Important!**
>
> **HID Lamp Safety**
>
> Both MH and MV lamps operate at high pressure in the arc tube. This arc tube can sometimes rupture, discharging extremely hot particles of quartz and glass, which can break the outer bulb creating a risk of injury or fire.
>
> Check manufacturer's recommendations. Also, never operate a lamp without an intact outer bulb.

As with quartz halogen lamps, the filaments of HID lamps are enclosed in a sealed quartz capsule containing gases such as sodium, mercury vapor, and metal halides; hence the various lamp names. Specific gases or mixtures of gases, when heated by electricity passing through lamp filament, possess a characteristic light color. Diversity of light color can be achieved by varying the gas mixture and the temperature of that gas mixture. (The same is true of fluorescent and quartz lighting). All HID lamps consist of a small inner arc tube enclosed in an outer bulb.

Mercury Vapor (MV)

MV fixtures are based on older, less efficient technology. Color rendition is poor, tending to be bluish-white. Lumen maintenance is also poor. The light levels drop significantly as the lamp ages (25 per cent or more). Some fixtures may have PCB ballasts. On the positive side, lamp life is very long – an average of 24,000 hours.

MV fixtures are typically found in older facilities such as gymnasiums, parking lots, ice arenas and curling rinks, outdoor lighting, and municipal street lighting. As these installations are retrofit, existing MV fixtures are usually replaced with metal halide fixtures.

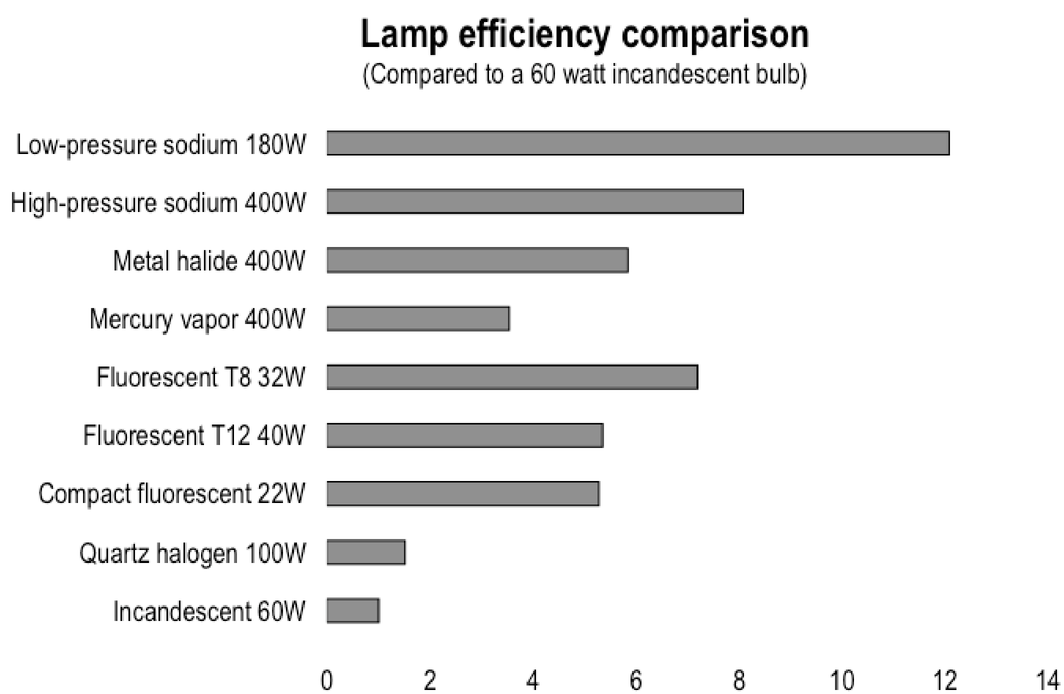


Figure 2

Metal Halide (MH)

Metal halide fixtures have the same application as mercury vapor fixtures. Because they are superior to MV fixtures, MH fixtures have become the standard choice for new or retrofit installations. Efficiency is about 50 per cent higher over MV fixtures (See Figure 2 for efficiency comparisons). The color rendition index ranges from 65 to 75 compared with 15 to 50 for MV.

Lamp lumen depreciation is also high as it is with MV lamps i.e. light levels drop 25 per cent or more over the life of the lamp. Another disadvantage is a relatively short average lamp life of 15,000 hours.

High Pressure Sodium (HPS)

HPS fixtures are about 50 per cent more efficient than metal halide. So why not use HPS instead of metal halide? In appropriate situations, it is used, for example where the golden-white light color is not an issue. Most people tend to dislike the color from HPS lamps when used for indoor installations such as gymnasiums or arenas. The color rendition index (CRI) ranges from 21 to 70. Color improved versions are available but have lower efficiency and lamp life.

HPS lamps are ideal for outdoor lighting such as parking lots, municipal street lamps, building illumination, and security lighting. Average lamp life of 24,000 hours is comparable to mercury vapor (See Figure 3 for a comparison of lamp life and various fixtures). Warm-up time is 5 minutes and restrike time is 1 minute; the shortest of all HID lamps.

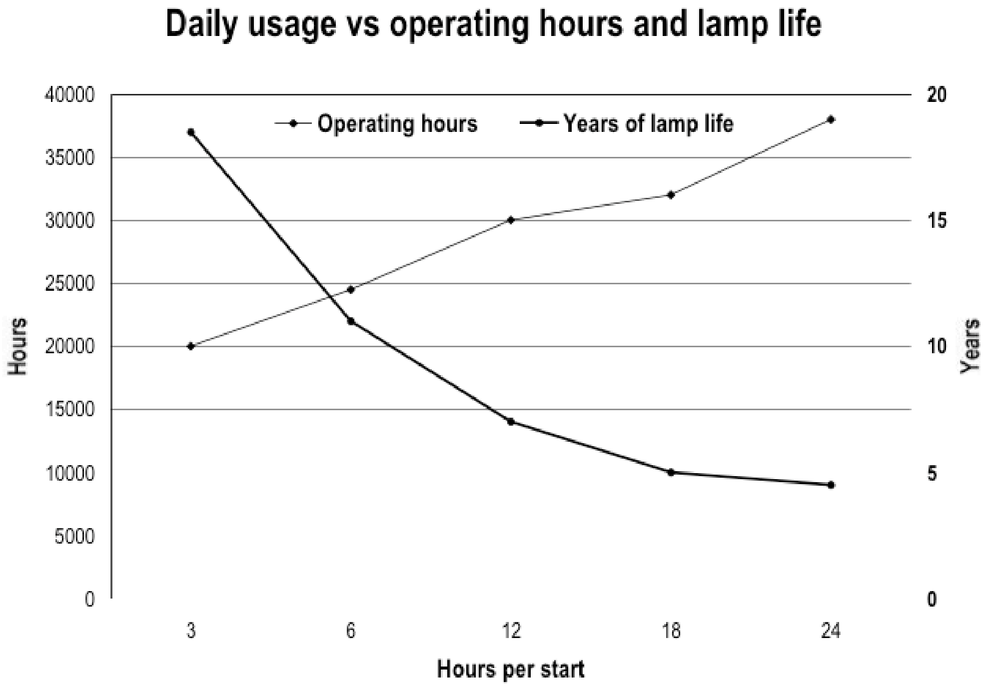


Figure 3

Low Pressure Sodium (LPS)

LPS is the most efficient HID lamp; about 50 per cent more than HPS. Light color is amber-yellowish and monochromatic (emphasis on one color type). Color distortion is very high. Being monochromatic, LPS lamps do not have a color rendition index.

They are specified for use in parking lots, security lighting, outdoor building illumination, and wherever color rendition is not important. A major advantage of LPS light color is that shadows are less noticeable making them very applicable for nighttime illumination. Since the contrast between HPS and LPS is so distinctive, LPS fixtures are sometimes installed at highway intersections to assist emergency vehicles with navigation.

Gymnasiums and HID Fixtures

Gymnasium HID fixtures including mercury vapor, metal halide, and high pressure sodium normally require a 5 to 15 minute warm-up to achieve full intensity. Mercury vapor and metal halide lamps need 10 to 15 minutes of cool-down time prior to restarting; high pressure sodium only requires 1 minute. Some newer types of metal halide lamps with electronic ballasts may be suitable for instant restart. HID lamps are not designed for frequently switching. A general rule is to shut them off if not needed for a half-hour or more. Some gymnasiums with HID lighting also have some fluorescent fixtures, which are intended for short-term use to avoid starting up HID lamps.

LED Exit Signs

LED exit signs utilize electronic light emitting diodes (LEDs) instead of incandescent lamps. Illumination is achieved with 1 to 2 watts of electricity compared with the typical arrangement of 2 °— 20-watt incandescent bulbs. The internal components are very simple, consisting of LED lights, two wires for 120-volt AC electricity and two wires for RESI battery back-up. With no more bulbs to change, little maintenance is required beyond cleaning. An LED exit sign has an estimated 25-year life. Due to high energy savings and reduced maintenance costs, simple payback on investment is usually three years or less.

Controls

Photocells

Photocells are commonly used for outdoor lighting control. Photocells detect outdoor light levels and automatically shut off lights during daylight periods and turn lights on at night. Most photocells have a sensitivity adjustment achieved by moving a metal slider across a round window on the front of the photocell. Photocells normally have a built-in time delay to avoid excessive cycling during cloudy periods or lightning. Check to see if lights are turning on too soon or shutting off too late and adjust accordingly. If lights are on continuously during the day, the photocell may need replacement.

Time Clocks

Time clocks are used to automatically switch both outdoor and indoor lighting. They provide the flexibility to program various on/off cycles at any time of the day.

Where outdoor lights only need to be on for part of the night, time clocks can be used in conjunction with a photocell. An example of this would be a parking lot that is vacated after 10 p.m. The time clock shuts the lights off at 10 p.m.; the photocell turns the lights on at dusk and serves as backup to ensure that the lights are not on during daytime. Where applicable, time clocks do need to be checked and/or reset for changing length of daylight, daylight savings time, operating schedules and occasional electricity outages. The clock itself can also go out-of-time, especially the mechanical type.

Occupancy Sensors

In areas of intermittent, infrequent, or variable usage such as gymnasiums, restrooms and hallways, lights are not required to be on continuously. Because usage varies, however, it is impractical to program light schedules with a time clock. Occupancy sensors are designed to automatically switch lights based on actual room occupancy.

Lighting

Occupancy sensors can detect people by two methods:

- infrared which detects body heat
- ultrasonic which detects motion

Most types of occupancy sensors have an adjustable sensitivity and range of minimum on-time settings. The on-time setting prevents short cycling (going on and off every 10 seconds) leading to premature lamp and ballast failure. For example, once occupancy has been detected, the lights can be set to stay on for a minimum of 30 seconds to 30 minutes, regardless of whether the room is still occupied. The sensitivity adjustment allows fine-tuning how easily the occupancy sensor activates.

The cost effectiveness of occupancy sensors will depend on utility rates, efficiency of manual switching, and the proportion of time the room is vacant. Those buildings with a high demand and low consumption charge will usually have a long payback period. Facilities with higher consumption charges will likely have a reasonable return on investment. Regardless of the benefits of occupancy sensors, the best way to control lighting is to turn lights off manually when the space is unoccupied. No capital investment is needed and the savings are immediate.

Summary on Energy Efficient Lighting

15 Advantages of Energy Efficient Lighting	
1	Typical energy savings of 30 per cent.
2	Improved quality and superior light color (color rendition index) – actual colors of objects are perceived with greater accuracy.
3	There should be fewer complaints about the impact of indoor lighting on health; fewer.
4	Demands for full spectrum lighting.
5	Often, there will be fewer tubes and ballasts to purchase, maintain, and replace.
6	Lamps and ballasts may have a longer life span.
7	No leaking asphalt/silica tar from fluorescent fixtures.
8	Absence of PCBs in ballasts.
9	Increased comfort during the cooling season, especially those buildings without mechanical.
10	Cooling systems; reduced cooling costs in those facilities that do.
11	High quality lighting and comfortable learning environment may help to improve academic performance.
12	Has a positive impact on climate change issues including a reduction of greenhouse gases.
13	Reduction in waste and hazardous materials; no PCBs and less mercury, cadmium and lead.
14	Newer lamps are being manufactured with a reduced amount of heavy metals.
15	Overall reduction in maintenance.

Demand and Consumption

<u>What are a kW and a kWh?</u>

In most buildings, except residential, utilities charge include both electricity demand and electricity consumption. Both demand and consumption are recorded on the electrical meter in a school.

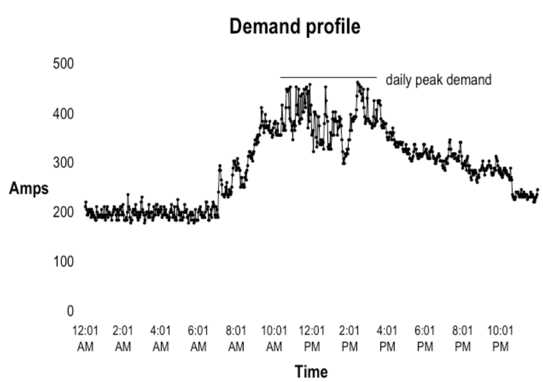
Demand	**Consumption**
The total amount of electricity, measured in kilowatts (kW) or kilovoltamps (kVA), required at a single point in time or the total electricity load. Utilities usually charge for the highest peak demand that occurs in each month. Demand meters are the thermal delay type, which means that a peak load must occur for at least 15 minutes for 90 per cent of demand to be recorded on the meter.	The quantity of electricity used over time, measured in kilowatt-hours (kWh), and calculated by the following: kWh = kW °— hours

Demand in a Building

Figure 4 is an actual demand profile of a school. Note that load peak occurs around noon hour when the cafeteria is operating at maximum. At night, the load is at a minimum — heating pumps, emergency lights, outdoor lights. As the work day starts, the load increases — lights, appliances, and computers being turned on. HVAC equipment is turned on. At the end of the day, the load decreases accordingly.

The area under the curve is kWh. The top of the curve is what registers on the demand meter.

Figure 4



Sample Energy Savings Calculation

Savings by Converting to T8 Lighting

To illustrate the concepts of electricity consumption and demand, a sample energy savings calculation for a retrofit of T12 fixtures to T8 fluorescent fixtures is shown here.

EXISTING ROOM CONDITIONS	RETROFIT
• 10 fluorescent fixtures • 2@F34T12 lamps per fixture • 1 magnetic ballast per fixture • 80 watts electrical load per fixture • 1,000 hours per year usage (25 hours/week @ 40 weeks/year)	• Same quantity of fixtures • 2@F32T8 fluorescent tubes per fixture • 1 electronic ballast/fixture • New electrical load is 60 watts • 1,000 hours per year usage
Calculate annual consumption and demand savings. (See below)	

Existing Facility		
where…		
Number of Fixtures	**A**	**10**
Watts per Fixture	**B**	**80 W**
Hours of use/year	**C**	**1,000**
kW load = (A x B) ÷ 1,000 = (10 fixtures x 80 W/fixture) ÷ 1,000 watts/kW	**D**	**0.80 kW**
kWh consumption/year = C x D = 0.80 kW x 1,000 hours/year	**Y**	**800 kWh/year**

Retrofit		
where…		
Number of Fixtures	**E**	**10**
Watts per Fixture	**F**	**60 W**
Hours of use/year	**G**	**1,000**
kW load = (E x F) ÷ 1,000 = (10 fixtures x 60 W/fixture) ÷ 1,000 watts/kW	**H**	**0.60 kW**
kWh consumption/year = G x H = 0.60 kW x 1,000 hours/year	**Z**	**600 kWh/year**

Retrofit Savings	
kW Demand Savings = D – H = 0.80 kW – 0.60 kW	**0.20 kW**
Annual kWh Consumption Savings = Y – Z = 800 kWh/year – 600 kWh/year	**200 kWh/year**

Misconceptions About Light Switching

- Don't switch lights off because it takes more energy to start them up again.
- Extra switching will cause tubes and lamps to fail prematurely.
- Switching off lights will cost a lot extra.
- When switching on lights, the high start-up current will set a peak demand charge.
- It's too much extra work.

The Facts About Light Switching

Fact One: Start-Up Energy
It is true that instantaneous electrical demand (kW or kVA) does increase about five times more than normal on start-up, but only for less than a second. This is insignificant and has little or no effect on a thermal demand meter. The consumption (kWh) saved from being off for one second will cancel the insignificant amount of extra kWh required for start-up. Figure 5 illustrates an oscilloscope rendering of fluorescent lamp start-up current. The peak start-up current occurs for only 1/120th of a second or half of a cycle!

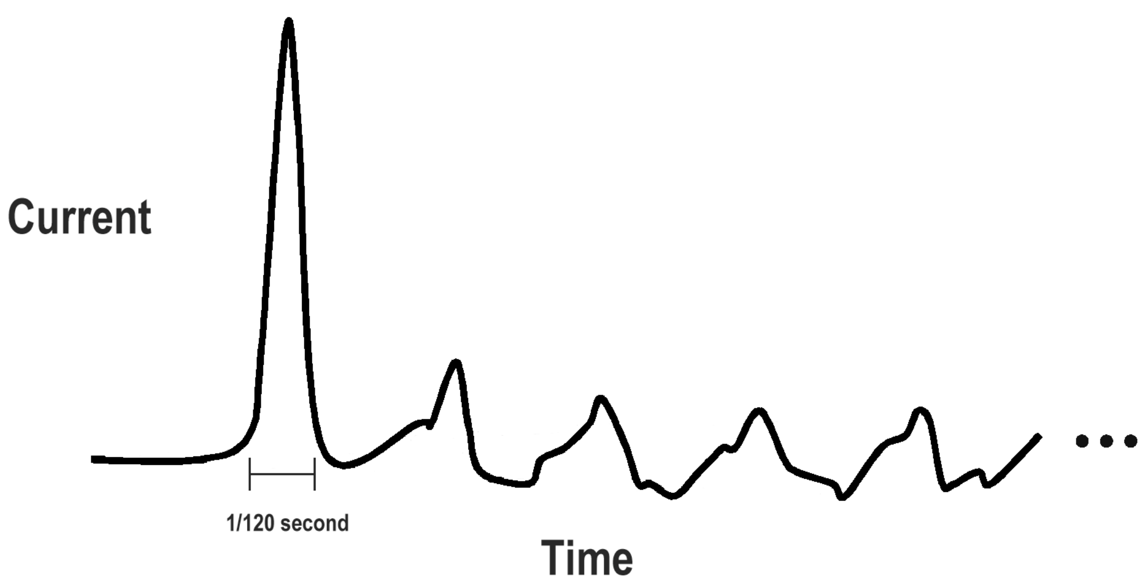


Figure 5

Fact Two: Lamp Life Decrease
Fluorescent lamps are designed to operate economically with a normal amount of switching. It is true that the operating hours do decrease with more switching, but this is offset by 1) longer life in calendar years for the lamps and ballasts and, 2) energy savings.

Figure 6 shows the relationship between operating hours and years of life. A lamp left on only 3 hours per day has a shorter life in hours than one left burning continuously – 20,000 hours versus 38,000 hours for the continuously burning lamp. However, a lamp left on only 3 hours per day has a much longer lifespan in years – 18.5 years versus 4.5 years. Operating hours are reduced by switching, but lamp life is extended in calendar years by operating for fewer hours.

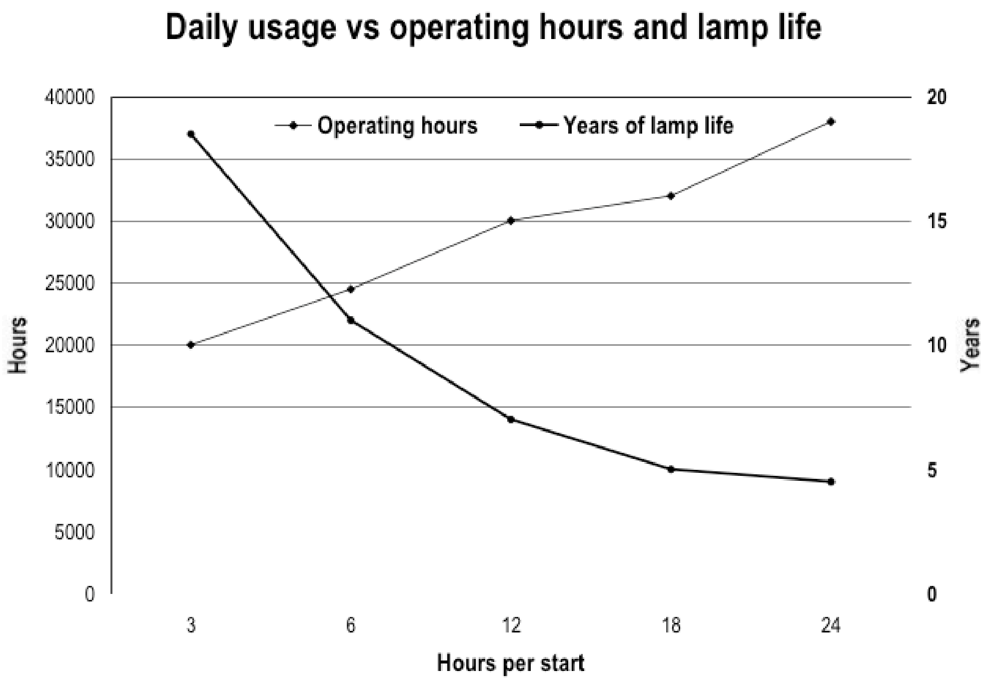


Figure 6

Fact Three: Lighting

Table 1: Energy costs and lamp life (Two T12-34W at 5¢ /kWh)			
Hours per day	24	12	6
Operating hours	38,000	30,000	24,500
Tube life (years)	4.3	6.8	11.2
Energy cost per year	$35.05	$17.52	$8.76

Table 2: Savings through switching (Two T12-34W at 5¢ /kWh for 10 years)			
Hours per day	24	12	6
Tube life (years)	4.3	6.8	11.2
Tube replacements (x2)	3	2	1
Tube replacement cost	$24	$16	$8
Energy cost	$350	$175	$88
Total cost over 10 years	$374	$191	$96

Table 1
Another common objection is the belief that turning lights off increases maintenance costs as lamps or tubes need to be replaced more frequently. Table 2 shows that this is not the case.

The light that is on continuously will burn out after a little more than four years. In a 10-year period the building will have to use 3 sets of tubes for a maintenance cost of $24; the power to run the lights for 24 hours per day for 10 years is $350, for a total cost of $374 after 10 years.

Turning the lights off both increases the overall life of the bulb and reduces the energy cost. Having the light on only 6 hours per day will mean an energy saving of nearly 75 per cent from keeping the light on continuously. (These examples assume lights on 365 days per year).

Table 2
Developing a habit of switching off lights when leaving a room takes very minimal effort and pays large dividends in energy savings. It recommended that fluorescent fixtures should be shut off if not required for 10 minutes or more; incandescents for 1 minute; 2 hours for HID lamps.

Seven More Energy Savings Tips

1. Optimize natural lighting by effective use of blinds. Specify adjustable blinds whenever possible.

2. Shut off breakers or remove bulbs in appropriate areas and during long hours of daylight (e.g. entrance vestibules).

3. Adjust time clocks and photocells for changing hours of daylight, daylight savings time, or incorrect time. Ask the question: when do the lights really need to be on?

4. Only turn on as many lights as are needed for the task.

5. Adjust occupancy sensor for ideal sensitivity and time delay.

6. Consistently shut off lights during recess, noon hour, and any other vacant periods (one person can have a big impact).

7. Try using a smaller wattage bulb or lamp (e.g. storage rooms with screw-in bulb or staff room with pot lights or plug-in lamps).

Maintenance Issues

Tar Leaks from Ballasts
As described earlier, the tar that leaks from electromagnetic ballasts does not contain PCBs. It is actually an asphalt/silica compound used to reduce noise and dissipate heat. Leaks result when the ballast overheats, causing the asphalt/silica to boil out of the ballast. Leaks can be cleaned with solvent.

PCBs
Fluorescent and HID magnetic ballasts manufactured prior to 1980 may have PCBs. Use of PCBs in ballasts was discontinued between 1976 and 1980, depending on the manufacturer. PCBs are heavy oil contained in metal enclosed capacitors inside ballasts. Leakage is unlikely in fluorescent ballasts (under normal conditions). Corrosion on outdoor HID fixtures can sometimes cause PCBs to leak.

Other Hazardous Wastes
Fluorescent and HID lamps contain hazardous wastes including mercury, cadmium and lead.

Cleaning Fluorescent Fixtures
Dust accumulation reduces light output. It is recommended that a damp cloth and mild soap be used to clean the dust from fixture lenses and the inside of the fixture. This should normally be done when the tubes are changed. If the fixture has a specular reflector, use a lint free cloth along with mild soap and water. Also refer to manufacturer's instructions for specific directions on cleaning.

Safety
Only qualified electricians should replace ballasts. Always shut off electricity when changing lamps or cleaning the fixture. Contacting the metal end of the tube or connector could result in electric shock and/or falling off the ladder.

Replacement of Fluorescent Tubes
Replace failed tubes promptly. Ballasts will fail prematurely if left too long trying to start up a failed tube. In addition to risking electric shock, installing a fluorescent tube when there is power to the fixture will reduce the tube life. Most lamp and ballast combinations are designed for rapid start, for example, the ballast warms the cathodes in the fluorescent tube for a few seconds before the arc strikes.

Avoid Mixing T8 and T12 Tubes
T8 and T12 tubes are interchangeable in fixture sockets because the double pin bases are identical. However, T8 tubes matched with T12 ballasts will result in reduced tube life or the tube not starting up at all. A T12 tube with a T8 ballast will burn very dimly or not start at all. The ballast will also be damaged.

Lighting Notes: