ENERGY EFFICIENT LIGHTING UPDATE - 2013

A Public Service of the Churchill Area Environmental Council
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We have been trying to light our way in the dark since the use of fire began. First attempts were simple hearths and torches. **Candles** made of smoky tallow (solid animal fat) and later of cleaner-burning paraffin (from oil, including whale oil) were primary sources of home lighting in the 17th and 18th centuries, and are still used ceremonially or to create special moods. In modern times **lamps** of many types have replaced candles for most lighting needs. Lamps began as small fires in rock hollows using fat-soaked moss. Oil, gas, and kerosene-fueled types illuminated homes and streets through the 19th century. Electricity essentially replaced all earlier energy sources for lighting when Thomas Edison received a patent in 1880 for the first commercially viable **incandescent light bulb**. A new era in lighting was born and innovations followed rapidly. Longer lasting tungsten replaced carbon filaments and became standard. The mercury vapor lamp (a high pressure arc light) patented in 1901 by Peter Hewitt was the forerunner of modern fluorescent lamps. George Claude invented the neon lamp in 1911. giving a big boost to advertising and entertainment. The tungsten halogen lamp was developed in 1960 by Fredrick Moby at G.E.

Energy efficient lighting is evolving with even more urgency today. 50% of the nation's electrical generation is derived from burning coal, although natural gas (particularly from fracking technology) is starting to replace coal in new power plants. Our dependence on fossil fuels has been blamed for significant environmental problems. Extraction processes may result in acid-mine drainage, water pollution, land disturbance, and habitat fragmentation. Emissions from fossil fuel burning can contain dangerous particulates (soot), carbon dioxide (a greenhouse gas connected to climate change), the toxic element mercury, and other components or by-products of the fuel. To reduce these problems by decreasing wasteful energy use, a federal law passed in 2007 requires most electric light bulbs to be 30% more efficient by 2014. Thus, we are taking another leap in lighting technology with an array of new light bulbs, e.g. **quartz halogens**, **CFLs** (compact fluorescent lamps), and **LEDs** (light-emitting diodes).

To understand how these new bulbs are more efficient and how best to use them, here are some key terms:

- **color temperature** - an indicator of the light quality you will see when the bulb is in use in a lamp. Generally, the higher the color temperature the whiter the light will appear. Incandescents produce a yellow-white light at a color temperature of 2,700°K. At 3,000 – 4,100°K bulb light looks bright white, and at 5,000-6,500°K bulbs mimic natural daylight. (°C + 273 = °Kelvin)
- **watt** - a unit of electrical power. It is the rate at which energy is consumed by an electrical device. For example, a 60 watt bulb consumes electrical power at the rate of 60 watts/hour. Your electric bill lists your usage in **kilowatt hours (kwh)**. A kilowatt = 1,000 watts.
- **lumen** - a unit of light intensity derived from the light of a "standard" candle under specific conditions. A 15-watt CFL (compact fluorescent bulb) emits about 1,000 lumens. Look for at least 450 lumens when replacing 40w, 800 lumens for 60w, and 1,600 lumens for 100 watt bulbs.
- **volt** - a unit of electromotive force causing electrons to flow. Power = voltage (driving force) X current (rate of electron flow expressed as amps). It is advantageous for utilities to transmit electrical power at the highest voltage feasible (without arcing or material breakdown) - thus the high voltage lines between power generators and communities. Transformers requiring AC (alternating current) are used to reduce the voltage at house lines to a safe, functional level (typically 110 volts). **DC** (direct current) is always low voltage, suitable for batteries but not for long distance transmission needs.

LIGHT BULB OPTIONS

There are currently four practical light bulb options: **incandescents** (now being phased out), **halogens**, **fluorescents** (including the compact types commonly referred to as **CFLs**), and **light-emitting diodes (LEDs)**. Futuristic choices may include electro-luminescent panels, small versions of which are used in night lights now, but could be scaled to cover whole walls for low level, diffuse, room light with minimal power consumption. As of January 1, 2012 a "Lighting Facts" label on bulb packaging must list brightness, energy use, estimated energy cost, expected life, light color in Kelvin units, and mercury content for CFLs. Read the labels before buying bulbs.

1) Incandescent (or Tungsten) Bulb

While a transition away from familiar household incandescent bulbs has been occurring for some time, they are still available at hardware stores. Incandescent bulbs, sold in wattages from 15 to 100, are inexpensive, but terribly inefficient. Depending on operating conditions, only about 10% of the energy consumed is actually converted to light; nearly 90% is dissipated as heat. An incandescent light bulb has a thin, coiled tungsten filament, heated by an electric current to a color temperature that appears to the eye as a soft, yellow-white light.

Advantages:

Cost - 60-80 cents per 60-watt bulb when purchased in multi-packs
Light Quality - instantaneous warm light commonly expected and preferred; dimmable

Disadvantages:

Gross inefficiency, generates 90% heat and only 10% light
Short operation life span - usually rated at 600-1,000 hours Annual use cost: $4.80

2) Halogen Bulb

Also called "energy saving incandescents," halogens have an internal capsule containing a halogen gas (bromine, iodine) surrounding the filament to increase efficiency and bulb life. These bulbs still produce considerable heat but can be used in place of regular incandescents in ordinary light fixtures. Quartz halogens (which have a quartz envelope) are suitable for hi-intensity desk lamps and flashlights, spotlights, and track lights.

Advantages:

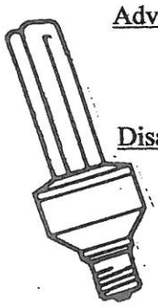
Cost - ≈ $1.50/bulb Light Quality - similar to a regular incandescent
Versatility - dimmable; works well as a spotlight or recessed light; 25% more energy efficient than comparable incandescent bulbs and has 3 times the life span

Disadvantages:

Heat production (can be an advantage for some applications)
Considerably less efficient than CFLs or LEDs Annual use cost: $3.50

3) **Compact Fluorescent Bulb**

Usually called **CFLs**, these bulbs were considered the logical replacement for incandescents and most long fluorescent tubes. That is no longer a certainty as LED technology (see below) continues to advance and improve. However, CFLs have the best cost/efficiency/lifespan ratio of anything currently available for home use and they fit the same sockets as incandescent bulbs. A CFL bulb is a folded or coiled version of the standard, no ballast, long fluorescent tube commonly used in commercial buildings and garages. Its central element is a sealed glass cylinder containing an inert gas (typically argon under low pressure), a small amount of mercury, and a coating of phosphor powder on the inside of the glass. Electrodes at each end are wired to an electrical circuit. When the lamp is turned on, electron drift and heating convert some of the mercury from a liquid to a vapor. High energy light emissions from gaseous mercury atoms excite the chemical phosphors inside the tube. As the excited phosphor atoms fall back to lower energy states, they emit longer (lower energy) wavelengths in the visible part of the spectrum. Phosphor mixes can be tailored for pleasing, softer effects from CFLs in home use.



Advantages:

Cost - ~ $2 - $5/bulb; fits ordinary lamp sockets (unlike long fluorescent tubes)
Efficiency - 75% more efficient than incandescent bulbs
Life Span - 10 times longer than incandescent bulbs - ≈ 6,000 - 10,000 hours

Disadvantages:

Aesthetics - start-up flicker, warm-up time, bulb shape
Light quality - although improving, color, flicker, and flatness are disliked by some users
Versatility - some are not dimmable; do not work well as spotlights
Mercury content - CFL bulbs contain mercury (a toxic pollutant). The amount of mercury per bulb is tiny, but the number of bulbs is potentially huge. Public compliance is difficult to achieve for safe disposal or recycling of used bulbs (see "Other Issues" below). Annual Use Cost: $1.20

4) **Light Emitting Diode**

Often called **LEDs**, the technology behind these diode chips is one of today's most rapidly developing and energy-efficient. The units are relatively expensive, but prices are expected to fall. A diode is a junction of two dissimilar semiconductors (e.g. silicon, lead sulfide, germanium) so that a voltage exists across their junction. For properly chosen and designed materials, when an external voltage is applied (i.e. when you plug in the LED), and current flows, electrons will drop across the junction from higher to lower energy levels, emitting the difference as visible light. The wavelength of that light is dependent on the difference in energy level across the diode junction, so the color of the LED light can be selected by chemical "doping" (impurities) used in the design of the semiconductor. All this works on DC (direct current) only, so a converter (adapter or battery) is needed for household AC (alternating current) outlets, and this is built into the LED fixture.

Advantages:

Efficiency - up to 80% more efficient than incandescent bulbs
Life span - lasts up to 25 times longer than incandescents (some last 10-25 years when used 3 hours/day)
Versatility - works for recessed, spot, and track lights, as well as regular lighting applications
No ultraviolet - Since they emit no UV light, LEDs are perfect for display applications where UV may cause fading or deterioration.

Disadvantages:

Cost - $34-40 for room-size lighting, but prices should come down as research and development continue.
Disposal - LEDs are disposed of as e-waste, like an old computer or TV. Annual Use Cost: $1.00

OTHER ISSUES

More on Mercury - CFLs contain about 5 mg (milligrams) or less of the neurotoxic element mercury (Hg). Hg has the best spectral richness in the visible band and the best efficiency in the conversion of an electric discharge in its vapor to visible light. As lamp engineering progresses, the mercury needed in each CFL bulb is steadily decreasing and has already dropped 60-75% since 2008. All fluorescent lamps, including CFLs, should be recycled at stores like Ikea and Home Depot or at household hazardous waste collections (watch the local news for dates and locations.) As a last resort the tubes and CFLs can be sealed in doubled plastic bags with some sulfur flour (available at home supply stores) and put in the trash. *Consumer Reports* October 2007, has excellent instructions for safe handling of broken CFLs. Mercury comes originally from the ground when coal, with which it is found, is mined. Coal burning, electric generating plants concentrate Hg in the area surrounding the plant (50+ tons annually) creating air pollution. New EPA standards aim to lower mercury emissions by up to 90%, but the industry is fighting implementation. By comparison, the small and ever diminishing amount of mercury in fluorescent lamps is manageable with proper recycling.

Conservation - the best way to save energy, money, and the environment.. It is much cheaper to reduce energy waste than to build generating capacity to cover unnecessary or inefficient energy use. Changing five often-used bulbs to CFLs can save $25/yr. Other money saving and effective conservation moves include insulating the attic, wrapping water heaters and hot water pipes, switching to a programmable thermostat, installing ceiling fans, and mixing non-toxic ceramic powder into house paint to reduce heat loss to the outside through walls.

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