Compact Fluorescent Lamps (CFLs)

What you need to know about low energy lighting

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Introduction

Compact fluorescent lamps (CFLs) are smaller versions of the familiar fluorescent strip-lights found in schools, public buildings and many people's kitchens. Like the strip-lights, they are about five times more efficient than tungsten incandescent lamps at turning electrical power into light. They also last many times longer and the saving in energy over their lifetime more than offsets their extra cost. Governments all over the world are either encouraging or coercing us to replace our tungsten lamps with CFLs to save energy and reduce our carbon footprint.

The principle of operation is the same as a fluorescent strip-light. An electric current is driven through a tube containing argon and a small amount of mercury vapour. This generates invisible ultra-violet light that excites a fluorescent coating (the phosphor) on the inside of the tube, which then emits longer-wavelength visible light.

Environmental impact

Unlike incandescent lamps, CFLs contain toxic chemicals. Each one contains about 4mg of mercury, which is a cumulative poison. However, because coal also contains mercury, which is released into the atmosphere when burned, this too is a source of mercury pollution. If we assume that all our electricity came from coal, then the amount of mercury pollution saved by switching to CFLs is about double that in the lamps themselves (http://www.reuk.co.uk/Toxic-Mercury-in-CFL-Bulbs.htm) so their use could reduce the net mercury burden on the environment.

Nevertheless, there can be problems with local pollution if they are not properly disposed of. In Europe, there are regulations requiring retailers of CFLs to provide free facilities for their recycling but these are poorly implemented in the UK. Most of them still end up in land-fill, where they may be broken and release their mercury and other toxins. This can give high local concentrations, with a risk of contamination to water supplies.

Breakage

We also have to think of what to do if we actually break one indoors. Because mercury vapour is toxic, the best solution is to open the windows and vacate the room for about 15 minutes until the mercury vapour clears. Then wear rubber gloves to clear up the fragments (which also contain toxic phosphors) with a dustpan and brush (not a vacuum cleaner). Any remaining shards of glass should be cleaned up with a moist paper towel and everything double bagged for disposal.

Light output
CFLs are physically larger than the equivalent tungsten lamps and you may have to use a smaller and dimmer one if it is to fit into an existing fitting. They are also not best suited for outdoor use since they perform poorly in the cold. Even indoors, many of them can take several minutes to reach full brightness and are unsuitable for short periods of use such as in a toilet. Not only may they not reach full brightness during you visit, but their life span will probably be reduced to no more than that of an incandescent lamp under these conditions. A further problem with their brightness is that most of them cannot be dimmed with dimmer switches since they tend to be either fully on or fully off.

Colour of the light
The colour of a fluorescent lamp is usually described by its *colour temperature,* which is the temperature to which a metal would have to be heated to give that colour. For example, a warm white lamp has a colour temperature of around 2700 degrees Kelvin (Celsius + 273) whereas natural noon daylight is somewhere between 5000 and 6000 degrees Kelvin. Different colours are obtained by choosing different phosphors. Often, there is a mixture of phosphors to give something that looks like daylight. However, this is an illusion. Real daylight consists of a broad spectrum of all wavelengths, but fluorescent light is a mixture of peaks at different wavelengths with dark areas in between.

Colour-rendering
Even a "daylight" fluorescent lamp doesn't give the equivalent of true daylight because of the gaps in its spectrum. These gaps reduce the "richness" of the colours seen under its light and it make accurate colour matching difficult. It is possible to fill some of the gaps by adding extra phosphors, but these also reduce the efficiency of the lamp so that the number normally added is a compromise. Just how good a particular lamp is for matching colours is measured as its *colour-rendering index.* A continuous spectrum from daylight or a tungsten lamp is taken as 100, whereas a fluorescent lamp may have a *colour rendering index* of between about 50 (very poor) and over 90 (good). *Triphosphor* lamps give good but not perfect, colour rendering with a near daylight colour temperature. However, many people who are used to incandescent lighting find them too "cold" for a living room and prefer the warmer colours such as warm white.

Electronics
Fluorescent lamps will only run on alternating current. They also need a pulse of high voltage and heated filaments at either end to start the electrical discharge that lights them. After that, the current must be limited externally, otherwise too much would flow and they would burn out. In a traditional fluorescent strip light, this is accomplished by the starter switch and the choke (a coil of wire wound around an iron core). Once started, the current flows through the tube as a smooth sine wave at mains frequency, which is 50Hz (cycles per second) in Europe and 60Hz in America. This makes the light flash on and off with each half cycle (i.e. 100 or 120 times a second) and some people, such as epileptics and migraine sufferers find this disturbing.

However, almost all CFLs use electronic control gear. This usually incorporates a *switched-mode power supply* in the base of the lamp itself. It rectifies the AC from the mains to convert it to DC and then chops it electronically into a series of sharp rectangular alternating pulses, which then light the lamp. However, the new frequency, which is usually about 40kHz (40,000 cycles per second) is so high and the gaps between pulses are so short that the relatively slow response of the phosphors can fill them easily. Consequently*, these lamps do not flash.*

Biological effects
Despite the absence of flashing, many people have reported ill effects when using CFLs. Typical symptoms include dizziness, nausea, tinnitus (ringing or buzzing in the ears), headaches and various skin disorders. In particular, many sufferers from migraine and epilepsy have found that they still aggravate their conditions (http://www.dailymail.co.uk/sciencetech/article-505571/Energy-saving-bulbs-cause-migraines-warn-experts.html) (http://www.dailymail.co.uk/sciencetech/article-464080/Low-energy-light-bulbs-trigger-epilepsy.html).

The effects may be due to pulsed electromagnetic radiation.
The symptoms of exposure to CFL radiation are remarkably similar to those reported by electrosensitive individuals when exposed to pulsed electromagnetic fields. Since the lamps do not flash, it seems probable that they are a direct effect of the pulsed radiation on the brain and nervous system. The magnetic component of the radiation is the more dangerous because it can penetrate deep into the human body where it generates electrical voltages proportional to its rate of change. The rapid rise and fall times of these magnetic pulses can therefore give relatively massive and potentially damaging voltage spikes both in living cells and across their membranes.

Contamination of the mains
Poor quality CFLs often allow these pulses to leak back into the mains wiring to contribute to “dirty electricity” and increase the range of their effects to neighbouring rooms or houses. You should be able to detect these by holding a portable radio tuned between stations on an AM band near the wiring. This is because pulses, by their very nature, also contain harmonics (multiples of the original frequency) that can extend well into the radio frequency spectrum. If you hear a buzzing sound from the set, it means that pulses are leaking into the mains and you should replace the offending lamp by another of better quality.

Contamination of the mains to give “dirty electricity” can come from many sources, not just CFLs. Measurements made by David Stetzer in the library of an American school showed it to consist of hundreds of sharp spikes that could be up to hundreds of millivolts high, superimposed on each cycle of the 120 volt mains supply. Although the largest of them was only a tiny fraction of the overall mains voltage, their rapid rise and fall times give them biological activity. The sharp *magnetic* spikes they generate penetrate living tissue easily, where their sudden changes in field-strength induce large voltage spikes.

Several studies by Dr Magda Havas of Trent University in Canada and various co-workers have shown that simply removing these spikes in the mains with "Graham/Stetzer" filters gave improvements in the health, learning ability and behaviour of schoolchildren, reductions in the insulin needed to treat diabetics and an alleviation of the symptoms of electrosensitivity.

Electrosensitivity

People who are affected badly by weak electromagnetic fields in this way are described as being electrosensitive or as suffering from electromagnetic hypersensitivity (EHS). Only about three percent of the population are thought to suffer from EHS at present, although this proportion is expected to rise as more people become sensitised and people who are already sensitive but do not realise it discover that their symptoms are related to electromagnetic exposure.

The symptoms of electrosensitivity are many and varied and not everyone suffers in the same way or to the same degree. Some of the effects are on the brain and nervous system and often become apparent during or shortly after exposure. They include dizziness, tinnitus, pins and needles, sensations of burning, numbness, fatigue and headaches. Longer-term effects include skin disorders, gut problems and an increased tendency to allergies and multiple chemical sensitivities (see http://www.es-uk.info/info/recognising.asp).

Mechanisms of electrosensitivity

Electrosensitive individuals are physiologically different to the rest of the community. Eltiti and her co-workers at Essex University showed this very clearly in a project for the mobile phone industry and the UK Government. They wanted to see if electrosensitive individuals could detect the radiation from mobile phone masts. They excluded epileptics and people wearing pacemakers for cardiac arrhythmia who might be particularly sensitive and most of their results were less conclusive than they should have been. However, they did show very clearly that their group of EHS sufferers had skins with a significantly higher electrical conductance than the non-sensitive controls ($p < 0.001$). This means that their skin cells were more permeable to ions (charged atoms and molecules) that normally carry electricity in living tissues. There is now considerable evidence that most of the symptoms of electrosensitivity result from ions leaking through membranes in response to electromagnetic fields. Consequently, if electrosensitive individuals already have abnormally leaky membranes, they will be more likely to be affected by these fields.

Sensory disturbances

Membrane leakage can account for the neurological symptoms of EHS sufferers. We know that weak electromagnetic radiation can temporarily remove structurally important calcium ions from cell membranes to make them leak (http://www.hese-project.org/hese-uk/en/papers/goldsworthy_bio_weak_em_07.pdf). Unfortunately, all of our senses depend on ions flowing through the membranes of sensory cells at a rate that depends on the strength of the stimulus. This works well for most of us most of the time, but if the sensory cells of electrosensitive individuals are already leaky, any further electromagnetically-induced leakage will be more likely to trigger them to generate nerve impulses and give false sensations.

The effects on the ear are like motion sickness

The main sensory cells of the ear are the *hair cells*. Hairs at the apices of these bend when they sense movement in the surrounding medium. This makes ions leak through their membranes to reduce the voltage across them. They respond by releasing neurotransmitters that stimulate neighbouring nerve cells to send signals to the brain. Those at the ends of the semicircular canals have their hairs embedded in a light jelly, which deforms in response to movements of the fluid within. Because the fluid inside the canals tends to stay stationary when the head twists suddenly, it appears to flow past the jelly so that it measures rapid changes in the orientation of the head. The jelly in other parts of the ear is weighted with mineral granules (otoliths) and deforms in response to gravity and linear acceleration. The hair cells in these regions act like plumb-lines and give us most of our sense of balance.

We are all familiar with what happens if we feed them false information. If we spin our bodies rapidly and suddenly stop, the fluid in the semicircular canals continues to swirl for a while, the signals from the hair cells conflict with what we see around us and we feel dizzy. The stress and nausea of people who get motion sickness is due to a similar conflict between the signals from the ear and those from the other senses such as touch, sight and pressure on specific regions of the skin. It is therefore not surprising that false signals generated by electromagnetically-induced leakage in the hair cells cause dizziness and nausea in some electrosensitive individuals.

It can also cause tinnitus

The hair cells in the cochlea (the hearing part of the inner ear) respond to sound. They are arranged in a graded sequence with different length hairs along the length of the cochlea. Like the strings of a harp, they resonate at different frequencies. When an incoming sound matches their resonant frequencies, the hairs vibrate more strongly. This makes the cells concerned leak more ions, and trigger neighbouring nerve cells to send impulses to the brain. Which cells are stimulated tell it the pitch of the note. The frequency of the impulses tells it the loudness. False stimulation of these cells by electromagnetic radiation can in some people cause tinnitus, which can range from a mild ringing in the ears to buzzing and complex sounds that may be loud enough to drown out normal conversation.

Effects on the other senses

There are countless cells all over our bodies that sense various forms of touch (mechanoreceptors) temperature (thermoreceptors) and pain (nocireceptors). Each group contains many specialised variants but they nearly all function by letting ions flow through their membranes at a rate that depends on the strength of the stimulus. This reduces the voltage across the cell membrane, which triggers the transmission of nerve impulses to the brain, either by the cell itself or by releasing neurotransmitters to stimulate neighbouring nerve cells. Electromagnetically-induced membrane leakage in sensory cells in the skin explains the pins and needles, sensations of burning and pain experienced b EHS sufferers.

The eye is different

The light-sensing rods and cones in the retina of the eye are an exception in that when they respond to light they *increase* rather than decrease the voltage across their membranes. Consequently, any uncontrolled electromagnetically induced leakage here might be expected to reduce their sensitivity. It may be no coincidence that electrosensitive people whose vision is affected usually report a blurring or partial loss of vision rather than seeing things that aren't there.

Effects on the brain

It isn't just the sensory cells that are affected by electromagnetic radiation. False nerve impulses can be generated by electromagnetic fields in the neurons of the brain. These can cause hyperactivity, make it more difficult to sleep, trigger random thoughts, and result in a loss of concentration and confused thinking (http://www.hese-project.org/hese-uk/en/papers/cell_phone_and_cell.pdf). It may therefore not be advisable to use CFLs in a study or any other place where a great deal of concentration is required, especially if you are electrosensitive. This effect is probably the real reason why we are four times more likely to have an accident by using a mobile phone when driving, since using a hands-free type is no better but talking to a passenger has little or no effect.

Non-neurological effects

Spurious action potentials caused by membrane leakage in the heart muscle can give rise to cardiac arrhythmia and an increased risk of heart attacks. Increases in the permeability of skin cells can give rise to dermatological problems as well as a greater tendency to develop allergies and multiple chemical sensitivities. Electromagnetically-induced increases in the permeability of the gut to toxins, carcinogens and its partially digested contents, might be expected to cause a whole array of disorders and have been implicated as a risk factor in the development of autoimmune diseases such as multiple sclerosis and type-1 diabetes (http://www.hese-project.org/hese-uk/en/papers/cell_phone_and_cell.pdf). *All of these illnesses have been linked scientifically to electromagnetic exposure, so people with a tendency to any of them should take the utmost caution in the use of CFLs and avoid using them totally if possible*.

Are there alternatives?

If you are affected by CFLs, an obvious solution is to stock up on incandescent bulbs before they are phased out. If this is not an option, try using high voltage halogen incandescent lamps as a replacement since there are no immediate plans to phase these out. However, do not use the low voltage types, since many of them use switched mode power supplies to reduce the voltage. These could well give the same symptoms as CFLs.

What next?

It is becoming increasingly obvious that CFLs are not the best option for low energy lighting, and special dispensation needs to be made to supply alternatives to people whose health is unduly affected by them. Even so, we should regard CFLs as being just a stopgap until LED (light emitting diode) lighting is perfected. LEDs last indefinitely, they run on DC or rectified AC without generating damaging electromagnetic pulses, and the best of them are already more efficient than CFLs. At the moment, the main problem with them is with their colour; the most efficient “white” ones have a harsh blue tint. Although they are commonly used in flashlights, they have very poor colour rendering abilities and aren’t really suitable for domestic lighting. Their spectrum can be improved by adding phosphors to absorb some of the blue light and re-emit it as other colours, but this causes a dramatic loss of efficiency. An alternative is to use an array of differently coloured LEDs so that between them they give a spectrum that corresponds more closely to true white light. Hopefully, research on these devices will be given a high priority so that cheap high-quality LED lighting for domestic and industrial installations becomes available and CFLs, with all their attendant problems, become things of the past.