

Lighting and Mercury

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In speaking with other attendees at the recent Takoma Park Green Building Conference and other similar events, I heard some confusion about whether using a compact fluorescent lamp (CFL) is really good for the environment, considering that it contains mercury. One person said that a CFL contains only 3 micrograms of mercury. At some booths, I was told that CFL lighting was irrelevant, as light emitting diode (LED) lighting is available, more efficient, and cost-effective. Another person said that efficiency does not matter because solar cells can provide ample power at lower costs. (Contact the author for articles about lighting technology and efficiency versus alternative energy.)

The "back of the envelope" calculations in this article address the question: What are the environmental and cost tradeoffs in using lamps that contain mercury compared with using conventional lamps that are much less efficient? (I call these calculations "back of the envelope" because they are based upon limited data and are approximate.)

Many types of lamps, particularly efficient lamps, contain mercury. This paper will focus on CFL lighting.

To assess the impact, it important to consider the following factors:

1. If any lamp is properly disposed of, the mercury is recovered and not discharged into the air, land, or water.
2. The electric generating stations emit mercury as well as other pollutants in proportion to power demand.
3. Conventional (incandescent) lamps demand more power than CF lamps.

How mercury harms humans

An NIH web site¹ states: "Elemental (metallic) mercury and all of its compounds are toxic, exposure to excessive levels can permanently damage or fatally injure the brain and kidneys." The site describes the life cycle through which mercury emitted by burning coal can accumulate as it travels up the food chain and becomes part of the food we eat.

How much mercury is emitted per unit of electric energy?

Wisconsin, like the Mid-Atlantic region, relies most heavily on coal-fired electricity generation, except during rare summer peaks. A report² for the State of Wisconsin, Table 1-3 shows emissions of about 0.05 pounds of mercury per GWh. (1,000,000 kWh). Using common conversion tables, this is equivalent to 0.023 milligram (mg) per kWh. This electrical generation also produces other pollution such as oxides of sulfur and nitrogen and global-warming gases. A coal-fired generating station emits about two pounds of carbon dioxide (CO₂), the most common global-warming gas, for each kWh of electricity. We can also choose higher-cost electricity produced from alternative energy, such as wind.

How much mercury do CF lamps contain?

"Mercury Use in Lighting"³ paper, Table 2, shows that 66% of CF lamps have 0 to 5 milligram; 30% have between 5 and 10 mg and 4% have between 10 and 50 mg of mercury. Assuming that each lamp in its cluster has the middle level of mercury, the level computes to 5.1 mg mercury. We can now compare CF lamps with conventional lamps. (A milligram (mg) is 1/1000 of a gram. A microgram is 1/1000 of a mg.)

Ten 100 watt conventional lamps with a lifetime equal to one CF lamp

Each conventional incandescent lamp lasts 1000 hours. The ten lamps then consume 1000 kWh (100w x 10,000 hours) over their lifetimes. To supply these lamps, power plants will emit about 23 mg of mercury and 2,000 pounds of CO₂. A consumer will spend \$5 to buy these lamps (50¢ each) and \$100 in energy

¹ NIH Office of Research Facilities, <http://orf.od.nih.gov>, search "mercury hazards"

² Focus on Energy Public Benefits Evaluation Estimating Seasonal and Peak Environmental Emissions Factors—Final Report May 21, 2004 Evaluation Contractor: PA Government Services Inc.

³ "Mercury in Lighting, <http://www.newmoa.org/prevention/mercury/imerc/factsheets/lighting.pdf>, Northeast Waste Manage Officials' Association

costs to power them at 10¢ per kWh for a total of \$105. The light output is 1500 lumens or about 15 lumens per watt. Note: conventional bulbs may contain lead solder; lead is a powerful toxin as well.

One 23 watt CFL with equivalent output as a 100 watt incandescent lamp

The lamp lasts 10,000 hours and consumes 230 kWh over its lifetime. To supply that lamp, power plants will emit about 5.2 mg of mercury and about 460 pounds of CO₂. If the lamp is not disposed of properly - for example if it is consumed in a municipal incinerator, the 5.1 mg in the lamp will enter the environment. In this case the total emissions will be 10.3 mg mercury or about half of the emissions using conventional lamps. However, most jurisdictions provide facilities that allow residents to responsibly dispose of CFL lamps and other hazardous waste. For example, Montgomery County residents can dispose of CFL lamps at its transfer station and at special hazardous waste collection events. Ikea stores have recycling stations that accept light bulbs, batteries, and plastic bags. You can find out more about lamp recycling through the web sites of Earth911.org and LampRecycle.org. One can buy these lamps at Home Depot and other places for \$2.50 each and spend \$23 (again at 10¢ per kWh) to power them at a total cost of just \$25.50 versus \$105 using conventional lamps. The light output is 1500 lumens or 65 lumens/ watt.

LED Lighting

Light Emitting Diode (LED) lighting has a bright future, but may not be ready for prime time for most applications. I found it difficult to obtain comparable data on available LED lamps in lumen output. However, Lighting Science sells a flame tip lamp for \$16.95, which emits a warm-white glow of 25 lumens and uses 1.2 watts or about 20 lumens per watt. We would need 60 lamps to match the lighting output of a single 100-watt incandescent or 23-watt CFL lamp. Reports from Sandia National Laboratories⁴ and the Lighting Research Center⁵ predict significant progress in solid state lighting in light output and lighting efficiency. It is also worth noting that LED lamps last 5 to 10 times longer than CFLs and 50 to 100 times longer than incandescent lamps.

Other Lighting Resources

Lighting vendors are beginning to address the need for sustainable lighting solutions. For example, Philips developed a web page⁶ that can help assess a "Sustainable Lighting Index".

Conclusion

CFL lighting results in less mercury and other pollution than conventional lighting even if these lamps are not disposed of correctly. Of course, it is far better to responsibly dispose of these lamps. Efficient lighting is a very cost-effective way to reduce pollution while saving money. The fact that monetary and environmental costs of electricity far outweigh the costs of the lamps themselves overrules the ethic of not discarding anything that is working; one should replace conventional lamps immediately.

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⁴ <http://lighting.sandia.gov>

⁵ <http://www.lrc.rpi.edu/programs/solidstate/index.asp>

⁶ <http://www.nam.lighting.philips.com/us/sustainability/>