Indicators and Displays: A Judicious Use of Light

Indicators and displays are everywhere, demanding our attention. From simple on/off indicators and network router lights, to smart phones and multicolored graphical displays, modern devices use light to convey information to users. The ubiquity of these devices makes them a significant target for reducing energy consumption. Energy efficiency can be improved by producing light more efficiently and then using more of the light rather than wasting it. In some cases, a low- or zero-energy solution can be achieved by using reflected ambient light to illuminate the indicator or display.

Indicators and Simple Information Displays

Indicators and simple information displays use single or multiple light sources (usually depending on the number of colors to be displayed) and convey simple status information such as power on or off, or more complex information such as time. Consider the number of small lights in your home or office: the simple on/off indicator light on the television, clocks on appliances, network equipment status lights, alarm clocks, doorbell buttons, wall switches that illuminate in the dark, battery charger status lights, and so on. In fact, most electronic devices have some sort of indicator or simple information display that is always on. Individually, these indicators and simple displays use small amounts of energy, but added up together in a household, a country, or across the world, they use significant amounts of energy. In developed countries, residential standby energy consumes about 175 to 500 kWh/yr per household,[1] up to 25% of which may be used to produce light used by indicators and simple displays. We can save energy by using new technologies, such as high efficiency light emitting diode (LED) lamps and reflective liquid crystal display (LCD) indicators, which are discussed below.

Graphical Displays

Graphical displays, such as those on smart phones, tablets, computers, and TVs, convey more information and use more energy than simple displays. In fact, displays dominate the power consumption of devices such as laptops and cellular phones, and lowering this power consumption in such portable devices is important

to increase battery life. Liquid crystal displays (LCDs) are the most common display technology for consumer electronics. LCDs have approximately 15 optical layers that together control how the light emitted from a backlight will be seen by the user. Unfortunately these layers also absorb a portion of the light. This is mitigated by using brighter backlights, which in turn consumes more energy. A household with two LCD TVs, one LCD computer monitor, a laptop, and a few cell phones can use as much electricity on those items as on a standard-sized refrigerator (about 400 kWh). The same new LED and LCD technologies that are making indicators and simple displays more energy efficient are also being used to make new graphical displays more energy efficient.

Making Light More Efficiently with LEDs

Light in indicators and displays may be produced by many different lamp types such as neon, incandescent, fluorescents, and LEDs. LEDs are the most efficient light source, and they can be up to 20 times more efficient than incandescent lights in indicators, and 50% more efficient than cold cathode fluorescent lamps in graphical displays. LED efficacy continues to improve; high-efficacy LED indicators require far less power than older technologies. Thin film LED technology developed over the past decade has led to increased light output for the same amount of power (see the table below), thus increasing overall efficacy. If we were to replace an incandescent indicator with a new, high-efficacy LED indicator, we could save about half a watt of power per indicator, or 4 kWh per year. If every household in Australia replaced five incandescent indicators with efficient LED indicators, the savings would total more than 160 million kWh per year.

[1] Lebot, B., A. Meier, and A. Anglade. 2000. Global Implications of Standby Power Use. Proceedings of ACEEE Summer Study on Energy Efficiency in Buildings. LBNL-46019.

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Improving Led Efficacy With Thin Film Technology

Year	Legacy Red LED (lumens/watt)	Best Available Red LED (lumens/watt)
1980	1	-
1990	20	-
1997	25	20
2000	30	25
2002	-	70
2005	-	105
2008	-	120

Don't Waste It Once You've Made It: Light-Recycling Films

Once a display device produces light, the light is directed through an LCD panel to create a picture on the display screen. Much of this light is wasted because it is absorbed as heat by the LCD panel or other parts of the device. Manufacturers use light-recycling films to reflect and redirect light, increasing the amount of light that reaches the user's eyes with no additional power consumption. By combining efficient LED light production with advanced light-recycling films, energy consumption can be halved compared to a typical LCD display. For example, the difference in energy use between a high-efficiency and a middle-of-the-market 58 cm LCD monitor is about 30 kWh per year.[2] At an electricity price of AU $0.20 per kWh,[3] this equates to a utility bill savings of $6 per year.

Harvest Ambient Light: A Low-Energy Solution

High performance buildings commonly use daylight harvesting to offset the use of electrical lighting systems. Similarly, advanced light harvesting films allow LCDs to operate harvest ambient light (both natural and artificial), saving the energy that would normally be used for backlights. A reflecting film is placed behind the LCD panel and reflects light passing through the LCD panel. If the film is able to reflect as well as transmit light (a so-called transflective film) then a backlight can be used, but only when needed.

[2] http://www.toptenusa.org/Top-Ten-Monitors/Top-Ten-Large-Monitors
[3] http://www.originenergy.com.au/2087/Electricity-tariffs-QLD

These displays are typically used in devices that are exposed to sunlight, such as cell phones and handheld GPS products, but transflective displays are also being used in laptop and tablet computers. Since a display backlight consumes about 70 to 90% of the total energy used by a display device, we can expect that a transflective display saves about 75% of the energy used by a conventional LCD display device. Transflective displays might be used in computer displays to harvest light in office settings and reduce the power consumption of laptops and monitors.

More Efficiency on the Horizon

Perhaps the best way to save energy is to turn off indicators and displays when nobody is looking at them. Presence sensors that draw negligible power can help achieve this and are already being used on smart phones to turn off the display when the phone is next to the user's ear. A few TVs on the market detect whether or not a person is watching TV. If not, the TV backlight turns off but the sound remains on. One can imagine many other applications in which a presence sensor would draw less power than an indicator or display and yield energy savings, from turning off the hundreds of indicators in a server room when nobody is present, to turning off home network indicator lights or smart appliance displays unless someone is looking at them. For more information, see our 'Other Promising Technologies' report.

For graphic displays, emerging organic light-emitting diode (OLED) technology offers additional electricity savings. It does not require a backlight and can be lighter and thinner than an LCD, increasing portability while decreasing energy use. OLED displays are currently expensive and rare, but market intelligence suggests that these will make a large-scale market entrance in 2012/13.

Next Steps

LED efficacy is expected to continue to improve by 10 to 20% per year for several years, meaning that if trends continue, LEDs will again halve their power consumption in the next three to four years. Future research may focus on the appropriate brightness of indicators and simple displays and identify opportunities for dimming appropriate indicators to save energy.

There continues to be room for innovation and improvement of graphic displays. New brightness enhancing and light spreading films will allow manufacturers to use fewer LEDs in backlight units, decreasing cost and energy use.

Further research and in situ studies of transflective displays should assess display performance and energy savings. If color transflective displays can be improved so that they can operate indoors as well as in bright outdoor lighting conditions, large energy savings may be realized, but this remains an uncertainty.

Although it may be difficult to formulate universal standards for efficient displays, the technologies here may justify tighter efficiency standards for products with active displays (televisions, laptops, desktop monitors) and lower standby targets for products with a significant number of indicators (routers, modems, TV and computer peripherals, and battery chargers).