

# The Switch Is On

By Mark Fischetti

**I**ncandescent lightbulbs may be history. As of 2007, compact fluorescent lightbulbs (CFLs), which are more energy-efficient, had made only modest inroads because they were more expensive. But in December the U.S. Congress passed a major energy bill that included a new lighting standard. By 2012 manufacturers selling any 100-watt (W) bulb must make it 30 percent more efficient than today's 100-W incandescent bulb. Similar requirements will phase in for 75-W bulbs in 2013 and 60-W and 40-W in 2014. Europe has passed its own rules, too. CFLs already meet the specs, and although makers will try to improve the old hardware, the new bulbs clearly have the edge and continue to improve.

The technology inside a lightbulb is quite advanced [see illustrations]. The tungsten filament in an incandescent glows at more than 2,200 degrees Celsius and must be made perfectly uniform because any tiny imperfection will cause it to rapidly burn out. Yet only about 10 percent of the electricity entering the bulb is emitted as visible light; 90 percent or so is radiated as heat. A CFL is about four times as efficient as an incandescent bulb. A 26-W CFL can therefore shine as brightly as a 100-W incandescent, requiring only one quarter of the energy. The tubular fluorescent bulbs common in overhead lighting are slightly more

efficient still but do not fit standard light sockets, as CFLs do. CFLs still present some problems, which manufacturers are solving. For example, some consumers find the light too harsh. "The human eye wants to see all color wavelengths," says James Dakin, senior consulting engineer at GE Lighting in Cleveland, but the phosphor coating inside the bulbs fails to emit certain wavelengths. Phosphor improvements are filling in those holes, Dakin explains.

Early bulbs took several minutes to reach full output and may have hummed or flickered, but the electronic ballasts that have replaced the original magnetic ballasts have ended those shortcomings and also allowed smaller tubular shapes. "We have a huge effort under way to create CFLs that are suitable for more applications," says James Meyer, general manager of GE Lighting. Lowering cost further, he says, is now mostly a matter of even greater mass production.

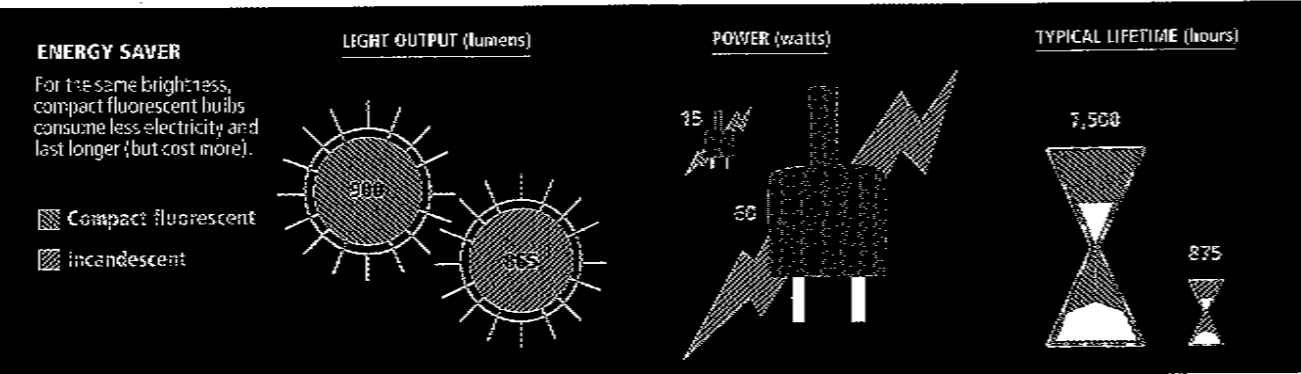
Light-emitting diodes (LEDs) could also pose competition in years to come; the solid-state lights are about as efficient and last three times longer than CFLs. But the screw-in versions struggle to outshine even a 25-W incandescent and cost far more. For now, CFLs have the brightest future.

### DID YOU KNOW ...

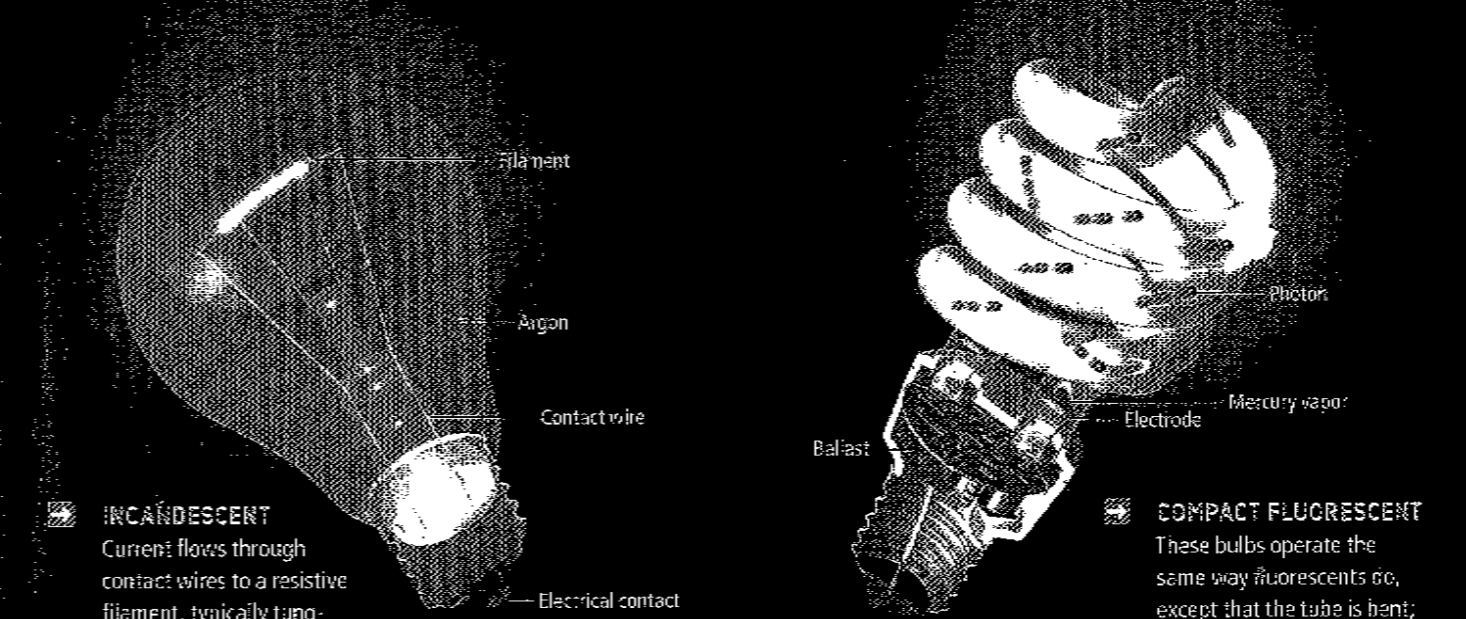
**NO 100-WATT BULB** actually emits less than the common incandescent bulb rated for a maximum operating current of 100 watts. The actual power used in a different current socket—like a dimmer or a low-voltage transformer—can be as low as 25 watts. CFLs were developed as a high-efficiency alternative to incandescent bulbs that required less wattage to replace the low-temperature filament. CFLs have a higher power factor, meaning they use less energy to produce the same amount of light.

**DEAD BULBS** contain small amounts of mercury. Dead bulbs must be properly disposed, not thrown away. Manufacturers are trying to lessen the mercury needed. They also consider CFLs as a more environmentally friendly alternative to incandescent bulbs that have a shorter life span. The same applies to LEDs, if the power is produced by burning coal.

**THINNING FILAMENTS** that gradually evaporate form a filament that collects in one area on a glass bulb, creating a bright spot. In the bulb's base, sealed or vented with tungsten, mercury vapor can form a thin film of yellow or blackening deposits.

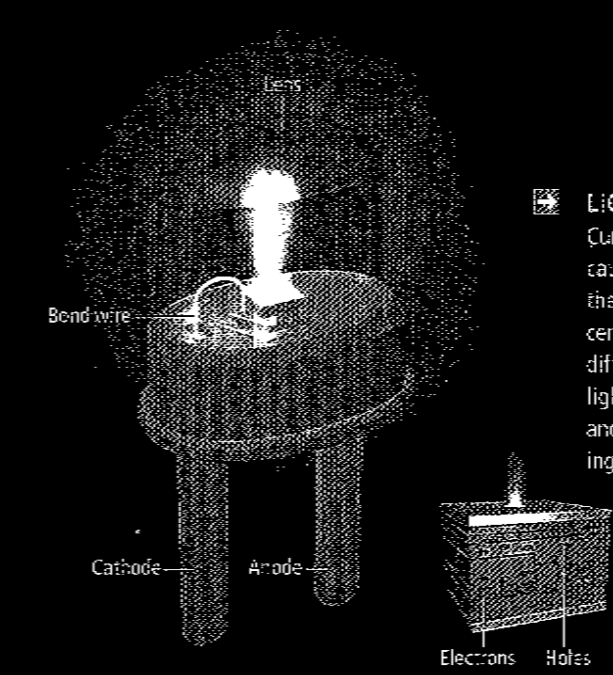


**FLUORESCENT**  
A ballast (far right) provides a high voltage that creates an electric arc across tungsten electrodes. The arc excites mercury vapor atoms, which discharge ultraviolet photons. The photons strike phosphor coatings on the glass, causing them to emit visible light (fluoresce). The ballast then regulates voltage and power at a lower level to sustain the arc. Argon (not shown) in the tube quickens start-up and enhances brightness.



**INCANDESCENT**  
Current flows through contact wires to a resistive filament, typically tungsten, causing it to heat so much it glows (incandescens). Over time tungsten atoms evaporate inside the evacuated chamber, thinning the filament until a threadbare spot breaks. In bulbs higher than 25 watts, manufacturers fill the chamber with an inert gas such as argon or xenon to slow evaporation.

**COMPACT FLUORESCENT**  
These bulbs operate the same way fluorescents do, except that the tube is bent; both ends terminate in one base that can fit a conventional incandescent socket.



**LIGHT-EMITTING DIODE**  
Current flows through a semiconductor diode, causing electrons and holes to move; when these entities meet, they emit a photon of a certain color. Different semiconductors emit different colors. The appearance of white light can be created by combining red, blue and green diodes within one bulb or by coating a blue diode with a yellowish phosphor.

**DIODE** emits light when electrons and holes collide.

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