The LED Advantage

When Congress passed the Energy Independence and Security Act of 2007 (EISA), the incandescent bulb's days officially became numbered. The law mandated strict new energy standards for lighting designed to kick-start a new era of greener, longer-lasting, more cost-efficient light bulbs -- and this meant kicking outdated, inefficient bulbs to the curb. The rising standards have already rendered 100- and 75-watt incandescents obsolete, and on January 1, 2014, their 60- and 40-watt cousins will met the same fate.

LEDs now come in more-attractive designs that mimic standard lightbulbs.
Like all lightbulbs, light-emitting diodes (LEDs) produce illumination by turning a given amount of electric current into light. LEDs perform this conversion more efficiently than standard incandescent bulbs: According to the U.S. Department of Energy, a typical Energy Star-rated LED uses 20 to 25 percent of the energy that an incandescent bulb uses; the LED lasts up to 25 times longer, too. The amount of light a bulb generates can be measured in a unit called lumens. Electrical power is measured in a unit called watts. Due to their methodology of converting electricity into light, LED bulbs feature a higher ratio of lumens to watts than incandescent bulbs.

Lumens

A lumen is a measurement of light directly relevant to human beings. Instead of trying to measure the number of photons or raw radiated energy, the lumen scale describes the amount of light, or brightness, that the human eye perceives. All modern lightbulb packaging shows the number of lumens the bulb produces. An average 100-watt incandescent bulb, for example, produces about 1,600 lumens.

- 40 watt incandescent = 380 – 460 Lumens
- 60 watt incandescent = 750 – 850 lumens
- 75 watt incandescent = 1100 – 1300 lumens
- 100 watt incandescent = 1700 – 1800 lumens
- Direct sunlight = 100,000 lumens.

One reason LEDs are so attractive is that with a fraction of the power use (watts) you can get the same amount of light (lumens) as an incandescent.

- 5W LED Candelabras = 400 lumens
- 7W LEDs A19s = 600 lumens
- 12W LED PAR30 = 850 lumens

You can get as many as 110 lumens per watt with an LED bulb. Compare that to an incandescent, which only produces 12-17 lumens per watt.

Watts

A watt is a measurement of electrical power, formally equal to the amount of energy in 1 ampere of current flowing at 1 volt. A lightbulb that is rated at, say, 200 watts uses more electricity to produce light than a bulb rated for 100 watts. The benefit, however, is that the 200-watt bulb produces significantly more light than the lower-rated bulb. The relative efficiency of different lightbulbs can be gauged by comparing how many lumens they produce for every watt of electrical power.

Watts and Lumens in LEDs

LEDs that are bright enough to replace incandescents for household use---that is, producing the same number of lumens as standard 40- or 60-watt bulbs---typically only use 9 to 12 watts. The U.S. Department of Energy advises that consumers who want to replace a 60-watt bulb should look for an LED that produces close to 800 lumens; for a 40-watt bulb, look for 450 lumens. As of March 2011, manufacturers were just starting to produce high-powered LEDs for the home. LED Genius developed a 60-watt replacement that only uses 12 watts of power, and a 40-watt replacement that uses only 10 watts of power.

Light Quality

Lumens don't describe the quality of the generated light---its color, tone or other variables. Some people find they don't like the light that certain LED bulbs produce, describing it as "cold," "pale" or "dim." The biggest challenge for LED manufacturers is creating bulbs that mimic conventional ones in shape and light quality. **Light color** is measured on a temperature scale referred to as Kelvin (**K**). Lower Kelvin numbers mean the **light** appears more yellow; higher Kelvin numbers mean the **light** is whiter or bluer. Most ENERGY STAR qualified bulbs are made to match the **color** of incandescent bulbs at 2700-3000K.

Operating Temperature

Operating temperature refers to the temperature of the surrounding / ambient air during LED operation. The temperature range of -40 degrees Celsius to 100 degrees Celsius is the general acceptable operating temperature of LED. Unlike fluorescent sources, cold temperatures do not impact the performance of LEDs.

How LEDs Work

When electrical current runs through an LED, the electrons in the current flow into a semiconductor material containing electron "holes"---spaces waiting to be filled with electrons.

When the electrons fill those holes, energy is released as photons, or light that is emitted outward, turning the LED into a lightbulb. In contrast, incandescent bulbs generate light from the electrical resistance of a metal filament. The resistance method requires more electrical energy to heat up the filament to a point that it glows and emits light.

LEDs

Average cost: $10 - $25
Average wattage: 4 - 22 watts
Average life expectancy: 20,000 hours

A typical LED uses a fraction of the wattage required to power a bright incandescent bulb, and this makes LEDs dramatically more cost-effective over the long run. A 12-watt LED that puts out 800 lumens of light (lumens are units of brightness for a light source, more on that in just a bit) will add about *$1.50* per year to your power bill if you're using it for 3 hours a day at an energy rate of 11 cents per kilowatt hour (kWh). Under those same parameters, a 60-watt incandescent bulb that puts out 880 lumens will cost about *$7.50* per year.

LEDs are also rated to last for tens of thousands of hours, which can translate to decades of use. Compare that with the year or so you typically get out of an incandescent, and you can begin to see why so many people find these bulbs appealing. At a price of about $15, that 12-watt LED would pay for itself in 2.5 years, then keep on saving you money for years to come.

Decades? Really?

Yes, really -- at least, according to Energy Star and the Illuminating Engineering Society (IES), the independent organization that created the testing procedures manufacturers use to rate LED lights. Most LED bulbs have only been commercially available for a few years now, not nearly long enough to see direct proof of their longevity claims. Fortunately, there's enough transparency with LED testing that we're able to dig a little deeper into what these claims are actually saying.

First, it's important to understand that LED lights don't "burn out," the way that incandescents do. Instead, they undergo "lumen depreciation," gradually growing dimmer and dimmer over

time. The test that the IES uses to determine a bulb's longevity is known as the LM80, and it calculates how long it will take for an LED to fade noticeably. Engineers run the bulb for nine months in order to get an accurate read of the light's rate of decay, and using those figures, they can calculate the point at which the light will have faded to 70 percent of its original brightness. This point, known as "L70," is the current standard in LED longevity. If an LED says it'll last 25,000 hours, it's really saying that it will take the bulb 25,000 hours to fade down to 70 percent brightness.

This isn't to say that LEDs don't fail. They definitely do. As with any device relying on tiny, delicate electrical components, things can always go wrong. Fortunately, more and more LED bulbs come with multiyear warranties for cases of mechanical failure.

CFLs

Average cost: $5 - $20
Average wattage: 9 - 52 watts
Average life expectancy: 10,000 hours

Before LEDs exploded into the lighting scene, compact fluorescent lights (CFLs to you and me) were seen by many as the heir apparent to incandescent lighting. Despite the fact that CFLs use between one-fifth and one-third the energy of incandescents, and typically save one to five times their purchase price over the course of their lifetime, many people weren't thrilled at the idea of switching over. Some find the whitish light output of CFL bulbs less aesthetically pleasing than the warm, yellow tone of most incandescents. Others are quick to point out that CFL bulbs that regularly get powered on and off for short periods of time tend to see a significant decrease in life expectancy. There's also the common complaint that most CFLs aren't dimmable, and that they often take a second or two after being switched on in order to fully light up.

Additionally, most CFLs aren't intended for outdoor use, and some will fail to turn on in colder temperatures -- although you can find cold-cathode CFL bulbs rated for temperatures as low as -10 degrees Fahrenheit.

Aren't CFL bulbs dangerous?

Like all fluorescents, CFLs contain trace amounts of mercury -- typically 3 to 5 milligrams (mg), although some contain less. This creates the potential for pollution when CFL bulbs are improperly disposed of, something that led to a unique environmental argument *against* the phasing out of incandescents (although, to be fair, this was before LEDs were seen as such a viable option).

Incandescents

Average cost: $2 - $10
Average wattage: 40 - 150 watts
Average life expectancy: 1,000 hours

When I tell you to picture a light bulb, chances are good that you're envisioning an incandescent. This is the classic bulb of Thomas Edison: a tungsten filament trapped within a glass enclosure. Electricity heats the filament to a point where it glows, and voila, you have light.

Aren't incandescents banned?

As a matter of fact, they aren't. EISA doesn't actually ban anything, at least not directly. What EISA *does* do is raise efficiency standards -- specifically, the minimum acceptable ratio of lumens (light) per watt (electricity). Incandescents aren't banned; they simply have to become more efficient. Also, keep in mind that appliance lights and other specialty classes of incandescents are for now exempt from the new standards. It's true that traditional incandescents unable to keep up with the times will be phased out.