Compact Fluorescent Lights (CFLs) Primer *Enlightening Facts*

MYTH VS. REALITY

Fluorescent light bulbs get a bad, and badly outdated, rap. Technological advances in the last twenty years have introduced the compact fluorescent light bulb (CFL) with electronic ballast and, in the process, have eliminated three of the four most common objections to fluorescent lights.

Myth 1: Fluorescent lights flicker.
Yep, they used to. Modern CFLs, with their electronic ballasts, do not flicker.

Myth 2: Fluorescent lights are slow to start.
While CFLs don't start at full intensity like incandescent bulbs, nearly all CFLs turn on (without flicker) instantly and reach full illumination very quickly. Of the nearly thirty different types we've tested, all come on instantly at close to full illumination. Only the flood light styles start at noticeably less than full illumination, but within 20 to 30 seconds they are at over 80% illumination. Interestingly, we've come to prefer softer initial illumination. When we enter a room the slightly softer initial illumination is more welcoming, and the CFL is easily at full illumination by the time we begin any light-dependent tasks.

Myth 3: Fluorescent lights are always cold-feeling and remind us of office lighting.
Older, standard, long fluorescent tubes do emit a cool (bluish) light (4,500+ Kelvin, see Kelvin definition below), but today there are CFLs in a complete range of hues, and many CFLs are available that produce exactly the same warm white light (2,700 to 3,000 Kelvin) as traditional incandescent bulbs.

Myth 4: Fluorescent lights won't fit in my fixtures, candelabra, or recessed lights.
We agree that this can still be a problem in certain situations. A CFL is often not an exact size substitute for an existing incandescent bulb, but a far greater range of sizes is available than is generally realized. We've already successfully substituted standard, globe, flood, candelabra, three-way and dimmable bulbs. To get the widest range of shapes, it is often necessary to shop online or at a lighting store.

The EPA's Energy Star rating, when applied to CFLs, insures the buyer of a CFL that it comes on instantly, comes quickly to full illumination, is a warm/soft white hue (unless marked otherwise on the package) and renders colors with excellent accuracy. Are CFLs the same as the traditional incandescent bulbs with which we are familiar? No. But as discussed below, they are significantly cheaper to operate in the long run, are much better for the environment, and enjoy a number of other advantages.

> ***Did you know**...that a new Energy Star-rated CFL bulb should last between five and ten years?*

In recent years, as the quality of CFLs has risen, their price has dropped. Today, high quality 60-watt equivalent CFLs can be purchased for under $2 in many stores or online. High quality recessed flood lamp style CFLs run between $5 and $10. Even though the cost of a CFL is 1.5 to 4 times more than a standard incandescent bulb, CFLs are a substantially cheaper source of light. A typical CFL uses less than a quarter the electricity of an incandescent bulb with similar brightness, and it lasts 6 to 12 times longer, meaning less time and effort is spent buying and replacing light bulbs. There are many online calculators attainable to estimate the savings available with CFLs.

The reason that standard incandescent (and halogen) lights are so energy inefficient is that they produce their light as an incidental result of generating heat. In fact, 90% of the electricity consumed by an incandescent bulb is used to generate heat, while only 10% is used to generate light. (Don't get excited—incandescent bulbs are NOT an efficient way to heat an area; conventional heating is much more energy efficient.) Therefore, in warmer seasons or locations, incandescent lights make a space warmer than necessary and may drive us to turn on the air conditioning, thus leading to even more energy consumption. By contrast, CFLs (and all fluorescents) generate their light more directly. 70% of the electricity a CFL consumes is used to generate light and only 30% goes to generate heat.

Below, we attempt to present a realistic picture of what a household can save in energy costs and labor. The following table gives the details of the bulbs that were compared. We compared two bulb styles: a standard light bulb (called an A-19 by the lighting industry) and a reflective recessed flood light (the R30, a mid-sized flood light). Each of these is compared to a commonly available GE™ light bulb. In this comparison we assumed that flood lights are in hard-to-reach locations and incandescent buyers would prefer the long-life version of the GE™ flood light.

Comparison of CFL and Incandescent Bulbs

		CFL				Incandescent			
Bulb Type	Wattage	Bulb	Sold By	Bulb Life	Cost	Bulb	Sold By	Bulb Life	Cost
Standard (A-19)	14 watt CFL/60 watt incandescent	Commercial Electric Ultra-mini / Soft White™	Home Depot,™ Park City, UT	10,000 hrs	$1.67	GE Soft White™	Amazon.com	750 hrs	$1.09
Recessed Flood Light (R30)	20 watt CFL/90 watt incandescent	Value Brand™	1000bulbs.com	8,000 hrs	$7.07	GE Soft White/Long Life™	Amazon.com	2000 hrs	$6.99

To simulate a realistic household situation, we varied three cost assumptions in the data and included a labor savings calculation:

- First, we considered two types of bulbs, a standard A-19 and a recessed flood light, and assumed a 70%/30% mix, respectively, of the two types.
- Second, we used two electricity cost rates, the national average cost ($0.11 per kilowatt hour) and a high cost rate ($0.18 per kilowatt hour).
- Third, we considered two residence sizes, an apartment or very small house (20 bulbs) and a medium sized home (50 bulbs).
- Fourth, we assumed that changing a light bulb and remembering to buy replacement bulbs takes, on average, 3 minutes
  per bulb.

The results are truly compelling and are shown on the bottom line of the following table. The cost savings in the table include the savings in electricity used and the bulb replacement savings, i.e. since CFLs have such longer lives than incandescents, their replacement costs (over the life of the CFL) are usually cheaper. For an apartment resident living in an average cost electric market, converting just 20 bulbs could save, over the life of the CFLs, $1,400 and 10.5 hours in bulb maintenance and shopping. For an owner of a medium sized home in an expensive electric market (NY, CT, MA, HI, AL and parts of CA and NJ), converting 50 bulbs could save nearly $5,200 and 26.3 hours of bulb maintenance. We estimated the labor savings from using CFLs because we wanted to show that the initial time required to convert a house to CFLs is easily offset by the labor savings from not repeatedly changing the incandescent bulbs.

CFL Cost and Labor Savings

			Cost Savings @ $0.11/kWh			Cost Savings @ $0.18/kWh			Labor Savings over CFL life		
Bulb Type	Wattage	Bulb Mix	Per Bulb	Per 20 bulbs	Per 50 bulbs	Per Bulb	Per 20 bulbs	Per 50 bulbs	Per Bulb	Per 20 bulbs	Per 50 bulbs
Standard (A-19)	14 watts CFL/60 watts incandescent	100%	$63	$1,269	$3,172	$96	$1,913	$4,782	40 mins	13.3 hrs	33.3 hrs
Recessed Flood (R30)	20 watts CFL/90 watts incandescent	100%	$82	$1,650	$4,125	$122	$2,434	$6,085	12 mins	4.0 hrs	10.0 hrs
Standard (A-19)		70%		$1,383	$3,458		$2,069	$5,173		10.5 hrs	26.3 hrs
Recessed Flood (R30)		30%									

CFLs last between 5 and 10 years depending on average daily usage. Over the coming 5 to 10 years, electricity rates will

surely rise on average. As electricity costs rise above the static rates used here, the savings will grow accordingly.

For those who want more information:

- This site gives a range of technical and detailed usage information: **http://www.gelighting.com/na/business_lighting/faqs/cfl.htm**
- Canadians typically pay more attention to energy efficiency than Americans do. The Canadian OEE (Office of Energy Efficiency) has a very useful FAQ for consumers: **http://oee.nrcan.gc.ca/energystar/english/consumers/questions-answers.cfm?attr=4**

> ***Did you know**...that if every US household makes its next lightbulb an ENERGY STAR-rated CFL, we will save more than $800 million on our national energy bill and 8.4 billion kWh of energy? That's enough to power over 808,000 homes for one year - about the number of homes in Boston, Denver, and San Francisco combined.*

ENVIRONMENTAL BENEFITS

The above analysis shows the savings that can come from converting to CFLs. Using CFLs can also lower pollution generally and greenhouse gases specifically. The beauty and curse of electricity is that its costs are usually invisible to us. It arrives effortlessly in our homes, and we seldom directly experience the pollution that results from the burning of fossil fuels (mostly coal) to generate it. Coal is used to generate 51% of the electricity used in the US. Most generation from coal produces enormous amounts of carbon dioxide and significant amounts of other pernicious pollutants.

The table below shows the reduction in atmospheric pollutants and carbon dioxide that results from converting to CFLs. Again we show the results for an apartment (20 bulbs) and a medium-sized home (50 bulbs).

Carbon Dioxide and Other Pollutant Reduction by CFLs

23W CFL v. 100W Incandescent

(over 7.3 year life of CFL)

Pollutant	Impact	Per Bulb	Per 20 bulbs	Per 50 bulbs	Derived From:
Sulphur Dioxide	Main cause of acid rain	3.42 lbs	68.5 lbs	171.2 lbs	http://science.howstuffworks.com/question481.htm
Nitrogen Oxides	Cause smog and acid rain	3.5 lbs	69.9 lbs	174.7 lbs	http://science.howstuffworks.com/question481.htm
Carbon Dioxide	Green house causes global warming	.6 tons	12.7 tons	31.7 tons	http://science.howstuffworks.com/question481.htm
Mercury	Causes brain damage	11.1 mg	221 mg	555 mg	http://www.energystar.gov/cflsandmercury

Converting to CFLs can help to decrease the amount of released atmospheric carbon dioxide, the most prevalent human-made greenhouse gas. Converting just 20 incandescent bulbs to CFLs can help eliminate 12.7 tons of carbon dioxide and converting 50 bulbs can help eliminate the production of nearly 32 tons of carbon dioxide over an assumed 7.3 year life of the CFL.

Sulphur dioxide and the various nitrogen oxides contribute to acid rain and visible smog. Converting 20 bulbs to CFLs can help reduce around 70 lbs. of each of these types of pollutants, and converting 50 bulbs can help reduce over 170 lbs. of each, over the 7.3 year life of the CFL.

Mercury, another dreadful pollutant, is a necessary, but minute, component of each fluorescent light. The amount of

mercury in a typical CFL bulb is about the size of the tip of a ballpoint pen or 5 mg. This is one-fifth the amount found in a watch battery and one-one hundredth the amount in found in dental amalgams or older household thermostats. But mercury is also released when coal and other fossil fuels are burned to generate electricity.

To protect the environment, we want to produce the least amount of atmospheric and landfill waste mercury. While incandescent bulbs contain no mercury, their excessive consumption of electricity, compared to CFLs, results in greater mercury waste. Even if burned-out CFL bulbs are just tossed in the trash and their mercury is released, the result is less environmental mercury than using incandescent bulbs for 3 or more years, due to the mercury released in burning the additional fossil fuel needed to power the less efficient incandescent bulb. Therefore, since CFLs typically last six or more years, using CFLs generates less than half as much mercury as using incandescent light bulbs - even without recycling.

Currently, federal law for hazardous materials does permit including CFLs in household trash. However, as with all hazardous waste, we encourage appropriate recycling. This can be done by contacting your local recycling center or, in some instances, returning the used CFLs to the store where they were purchased.

Additional sources:
http://www.nema.org/lamprecycle/epafactsheet-cfl.pdf
http://www.lamprecycle.org/

> ***Did you know**...that if every household in the United States made the next lightbulb they purchase an ENERGY STAR, it would be like removing the pollution of 1.2 million cars for one year?*

PRACTICAL CONSIDERATIONS

Color. Light color has been the biggest impediment to our own conversion to CFLs. (Size and fit were the other major ones.) We understood little when we started, and so had to learn a lot by experimenting with different products. However, in the past year, CFL labeling has improved, which helps new users with their initial purchases. There are two general metrics used in rating the color of the light emitted by bulbs: color correlative temperature (CCT) (stated in Kelvin) and the color-rendering index (CRI). The CCT or Kelvin number (ranging from 2,700 to 6,500) is a simplified measurement that indicates the general color emitted by a bulb, whereas the CRI (ranging from 0 to 100) indicates how accurately the emitted light renders the color of illuminated objects.

Kelvin numbers derive from the temperature (in Kelvin) of a theoretical black body (made of carbon) as it emits different colors of light when heated to different temperatures. For our purposes, the following table gives the three main Kelvin ranges, with their characteristics and general uses.

Color Temperature/Kelvin Table:

Kelvin	Color	Impact	Usage	Compares to
2700 to 3000	Warm	adds yellow to whites and green, which dulls blues and enhances reds	homes, restaurants, lobbies	standard incandescents
3500 to 3900	Neutral	does emphasize yellow or blue	retail: supermarkets and showrooms	
4100 +	Cool	adds blue to whites and green, which dulls reds and enhances blues	offices and hospitals	average daylight (4100K)

For home use, most individuals prefer soft- or warm-white (~2,700 Kelvin) in the living areas and bedrooms and cool white (3,500 to 4,000, Kelvin) in the kitchen and in work and reading areas. The CCT of an Energy Star rated bulb will be between 2,700 and 3,000 Kelvin unless otherwise marked on the package.

The CRI is not directly related to the CCT. In fact, two bulbs can have the same Kelvin number and different CRI

numbers. The CRI rating indicates how accurately the emitted light renders the color of an object. In light that has a CRI less than 60, the finer features of an object will appear somewhat washed out when compared to light with a CRI rating over 80. While the CRI uses a 100-point scale, it is important to note that any number over 80 is considered excellent. The follow table summarizes the general range of CRIs:

Color Rendering Table

CRI Range	Rating	Typical Applications
80+	Excellent	Homes, retail, restaurants, lobbies
60-80	Good	Offices, classrooms, supermarkets
Less than 60	Poor	Street lighting, warehouses

Source (both tables):
goodmart.com/facts/light_bulbs/application_guide.aspx

The CRI of any Energy Star-rated CFL must be 80 or above. Should you want a more technical/in-depth background on either color temperature or color rendering, visit:
http://www.lrc.rpi.edu/programs/lightingTransformation/colorRoundTable/pdf/MarketAcceptanceOfCFLsFinal.pdf

Requirements for CFL Energy Star Ratings
Less than 1 second to start-up, less than 30 seconds to run-up to at least 80% maximum lumen output. Greater than 6,000 hours average life (5 1/2 years at 3 hours). CCT must be 2,700 to 3,000 K (warm/soft white) unless marked on package. CRI must be 80% or greater.

http://www.energystar.gov/ia/partners/product_specs/program_reqs/cfls_prog_req.pdf

Sizes and Shapes. While there are many color options for each prospective bulb replacement, the size and shape of the current fixtures or locations may limit the available replacements. A key to avoiding frustration is to know the style and dimensions of each bulb you wish to replace. Most stores carry the most common sizes and shapes of bulbs. If you need to replace a wide range of sizes and shapes, you should consult various online lighting websites since they frequently show images of the styles of bulbs and list the color and wattage options within each category. A brief background on sizes and shapes can help orient the consumer.

The archetypal light bulb shape is what the industry calls a standard A-19 bulb. It usually comes with the common screw base called a medium Edison base.

Standard Bulbs. Within limits, different wattages can be placed in the standard A-19 shape. What makes a CFL compact is that a tiny fluorescent tube has been wound into a spiral to be able to fit in the shape and space of a traditional incandescent light bulb. Not surprisingly, therefore, CFLs are sometimes called spirals, mini-spirals, or spring bulbs. The coiled tube can take the place of the standard bulb glass, or it can be placed inside a glass shell of a standard looking bulb to make it appear more conventional, in which case there is a modest loss of luminance. In most cases, the coiled tube of a CFL takes up more space than the bulb of a conventional bulb. So knowing the available space where the bulb is to be used is important. However, the mini-spiral 14-watt CFL, the replacement CFL for the common 60-watt conventional bulb, takes up less space than the conventional bulb.

Globe Bulbs. Most conventional globe bulbs are standard bulbs with an enlarged, globe-shaped glass. Since the glass is already enlarged in these conventional globe bulbs, the replacement CFL globe is usually exactly the same size. In fact, most globe bulbs (incandescent and CFLs) are sold by the diameter of the glass globe.

Floodlight or Spotlight Bulbs. Many homes today have recessed or built-in lighting that use a range of reflector bulbs. Reflector bulbs come in three primary sizes, R20, R30, and R40, small, medium and large, respectively. Within each size

it is possible to get a range of different wattages. When other letters are prefixed to a reflector bulb's designation, they refer to special aspects of the glass face or reflector shape. Common prefixes include BR (bulbous reflector) and PAR (parabolic aluminized reflector). The PAR bulb represents the high end of reflector lights and is designed both to provide a focused light (with little light spread) and to be used in damp locations (like showers or outdoors).

Candelabra and Tulip Bulbs. Candelabras, sconces and smaller lamps often require a flame- or tulip-shaped bulb. Conventional versions of these bulbs come with either frosted or clear glass bulbs, with the latter meant to suggest a more flame-like appearance. Also, these bulbs come with both the small candelabra screw base and the medium Edison screw base. Presently, it is difficult for comparable wattage CFLs to match the small size of these bulbs.

Three-way Bulbs. Standard CFLs do not work properly when used in a three-way socket. A special, enhanced electronic ballast is built in to three-way CFL bulbs to make them work properly in three-way sockets. CFLs are now available in a full range of three-way wattages and colors. These are most frequently available as spiral or spring bulbs. They work precisely like conventional three-ways, but are somewhat larger. Higher wattage three-way CFLs are usually sold with extension clamps to raise the lamp shade slightly in order to make more room for the larger CFL bulb.

Dimmable Bulbs. Many wattages and styles of dimmable CFLs are now available. Even though dimmable CFLs generally work well, most dimmable CFLs will not dim to as low an illumination as a conventional incandescent bulb.

If you'd like a comprehensive review of many types of CFLs available through a wide range of suppliers, visit this web site: **http://www.execulink.com/~impact/fluorescent_lights.htm**.

Other limitations and benefits. One limitation, which was not mentioned above, relates to the use of CFLs with timing devices. CFLs usually work best with mechanical timers. Often, though not always, electronic timers lower the voltage supplied to a CFL.

In addition to cost savings, labor savings and environmental savings, we find three other benefits to CFLs. First, thanks to their lower heat production, CFLs are far gentler to shades and fixtures than the persistently hot incandescent bulbs. This helps to protect fabric shades from showing burn spots or becoming fragile over time. Similarly, CFLs are much less likely to cause browning or flaking on the decorative frosting or coating of glass shades.

Second, unlike incandescent lights, at the end of their useful life, CFLs don't fail suddenly when the light switch is turned on. Rather, they may take longer to reach full illumination, the level of full illumination may become inconsistent or the ballast may start to buzz. This is an advantage because CFL bulbs give us some warning instead of suddenly leaving us in the dark.

Third, the slight delay-to-full illumination of CFLs is also a benefit. While this did take some getting used to, we now appreciate not being blasted with full illumination upon entering a room. The initial, near-full illumination, is easily sufficient to move about in a room. By the time we have set to any light-dependent task, the room is fully lit.

PERSONAL EXPERIENCE

In the first week of 2007, we attempted to convert all the incandescent bulbs in Hal's Deer Valley, Utah, home to CFLs. The house was completed about four years ago, two years prior to Hal's conversion to "green," and included recessed lighting in nearly every room. When we began we had no idea of the number or types of bulbs used in the house.

To start our conversion, we bought a sampling of lights from a nearby Home Depot and from Wal-Mart as well as from a couple of large online lighting stores. With these samples in hand we experimented with the color of the light, bulb fit and start-up times. Based on this pilot run, we made three determinations:

- We preferred the 2,700 to 2,850K (warm white) light in all locations except over the main kitchen island where we used
  a 3,500K (cool white) light.
- We could live with—and actually preferred—the modestly delayed start-up time of most CFLs.
- We could and would replace all incandescent bulbs that had size suitable replacements. This meant that only the three

interior chandeliers, several lamps and the (occasionally used) halogen art lights would not be replaced.

Next, we inventoried all the lights to tally those targeted for replacement. To our utter shock, we had 220 incandescent (non-art) lights. Of these 220 bulbs we targeted 193 (88%) for conversion. Only the small chandelier and tulip bulbs were not convertible, as the fabric shades would not accommodate the larger CFLs.

In our experimental run, we compared a number of bulbs from different providers with similar specifications. This allowed us to observe and then fuss over the mix of relatively small differences in bulb size, color, and start-up times with equivalent incandescent wattage (i.e. light out in lumens). From the preferred bulb options, to keep things simple, we reduced our providers to two: the local Home Depot and the online lighting store 1000bulbs.com. Home Depot is, of course, a well-known retailer. Of all the online lighting stores we inspected, 1000bulbs.com had the most user-friendly website, as well as competent sales staff and a low-price guarantee.

The result of our research resulted in the following selections, shown with their targeted replacements. Due to the broad selection range of 1000bulbs.com, the majority of our bulbs were bought online. However, Home Depot had several very pleasing high-quality CFL bulbs, which as replacements represented an immediate upgrade in lighting quality over the older incandescent bulbs. These were the 60-watt equivalent soft white mini-spiral and the 40-watt soft white fan bulb (used for make-up mirror lighting), both carrying the Commercial Electric™ label.

Selected CFLs

	Floods				Spiral	Globe	Chandelier
Summary	**warm/65/R30**	**warm/85/R30**	**warm 85+/R40**	**cool/85+/PAR38**	**warm/60**	**warm/40**	**candelbra-small and medium bases**
Pirmary Use	**recessed ceiling light (medium ceiling height)**	**recessed ceiling light (high ceiling heights)**	**recessed ceiling light (high ceiling heights)**	**kitchen ceilings over main cooking island**	**standard 60-100 watt light locations.**	**bathroom make-up lighting**	**indoor or outdoor candeliers which don't have shades that attach to each light.**
Store	http://www.1000bulbs.com	http://www.1000bulbs.com	http://www.1000bulbs.com	Home Depot	**Home Depot**	**Home Depot**	http://www.1000bulbs.com
Bulb	NeptunR30/33016	Value Brand R30	ComEl:warmwhite/85	n-vision cool flat PAR 38/ bright white	ComEl:ultra-mini spiral/softwhite/60	n:vision soft white/fan40/ES	Dimmable Flame Tip
Wattage	16	20	19	23	14	9	5
Incandescent Eq.	65	90	75	90	60	40	40
% Wattage	25%	22%	25%	26%	25%	23%	13%
Lumens	750	1100	950	1000	900	450	n/a
Kelvin	2850	2700	2850	3100	n/a	2700	2850
Average Life (hrs)	10,000	8,000	10,000	8,000	10,000	8,000	25,000
Price	$5.93	$7.07	$7.50	$10.97	$1.67	$4.97	$8.50

Several points of learning are worth sharing. First, during the pilot test, several bulbs buzzed audibly when installed. When this happened we tested the same bulb in a different location and a different CFL in the same location to determine whether it was the bulb or socket. In one instance, we determined it was the socket. In another instance we determined that the bulb was the problem and eliminated that bulb from our list of candidates.

Second, several rooms had very high recessed lights that we misjudged to be R40 when they in fact were the smaller sized R30s. Given the height above the floor of these recessed lights, we preferred higher wattage R30 CFLs, i.e. 85-90 watt equivalent, in those lights. Since higher wattage R30 bulbs (CFL or incandescent) are uncommon, this left us with only one option, which we got through 1000bulbs.com.

Third, a CFL's speed to reach full illumination is temperature dependent. In mountain climes (where the Deer Valley house is), it is not unusual for top-floor ceilings to be cold, and therefore CFLs in such locations reach full brightness more slowly than in other rooms. So, if you need near full illumination quickly and your room ceiling is under a cold or snow-covered roof, you should consider standard straight tube fluorescent or keep your existing incandescent bulbs.

We admit the experimentation and investigation phases required organization and discipline to complete. However, when the time came to install the CFL bulbs, the process was easy and left us with great satisfaction. Overall, we are pleased with the financial and environmental benefits of using CFLs, and the family seems quite happy with the lighting results.

We now look forward to years of beautiful light with minimal maintenance.

- *Hal Hinkle, Kasia Duda*