Doing Well While Doing Good

Conservation of Energy as a Rational Financial Investment

Andy Kerr

Warm, inviting, and energy efficient—a bright compact fluorescent (left) and not so bright LED (right) light the porch.

Many years ago, I installed compact fluorescent lightbulbs (CFs) because of "personal virtue." They weren't very good, and they were darn expensive. Now their economics put the recent booming stock market to shame. Measured by either simple payback in years or return on investment, investing in CF lightbulbs is an extremely rational investment for the consumer.

I became interested in financial rates of return, not so much because of the money, but because people often use "payback" as an excuse for not switching to solar energy. While there are compelling environmental arguments to convert to solar energy, environmentalists and solar energy advocates must address the economic issues as well.

Many people I've talked to don't consider the financial costs of operating an electrical device, whether they are buying a lightbulb, a refrigerator, or a furnace. They tend to go for the lowest initial price. Such behavior is not just environmentally insensitive, but also economically irrational.

This malady is not just limited to uninformed consumers, but often to business types, who spend each working minute trying to make money. Energy philosopher Amory Lovins has noted the disconnect in many businesses between capital costs and operating expenses. When a new plant is designed, most often the lowest-cost motors are bought to keep construction costs down. But purchasing more efficient motors, albeit twice as expensive, may have a payback in one or two quarterly reporting periods.

Most people who do consider operating costs will only purchase the more expensive, albeit more efficient, device if it has a payback of no more than three years. They want the additional capital cost to be recouped in energy savings (both measured in dollars, of course) within three years. In other words, roughly a 33 percent return on investment. It doesn't seem to matter that the

device may well last several times the payback requirement.

Do these same people insist that their saving accounts, certificates of deposit, bonds, stocks, and mutual funds have a similar return on investment? Of course not. Even the tremendous run-up of the stock market these last few years was between 20 and 30 percent, and that was an anomaly.

It turns out that the compact fluorescent (CF) bulb, depending on how it is used, can have a rate of return that is still illegal for most financial institutions to charge. Any energy consuming device should be considered, not only for environmental impact, but also in terms of pure, simple, capitalistic economic efficiency. If they were, both consumers and the environment would generally be better served.

Simple Payback & Return on Investment

Many consumers can grasp the concept of simple payback. Say you buy something that costs X instead of Y and the Y device saves you Z amount each year. How many years must pass to recover the increased capital cost (Y - X) resulting from saved annual operating costs (Z)? While this approach is not financially elegant, since it doesn't factor in the time value of money (interest), it's close enough for consumer work.

Since capitalists and governments all live and die using return on investment (ROI), shouldn't you at least factor it into your purchasing decisions? You probably already do in your own personal financial planning. Why not also in your consumption planning?

In calculating ROI, the variables are:

- Capital cost (of a lightbulb, for example), and
- Operating cost (in dollars used per year).

For electricity operating costs, two additional variables are:

- Cost of electricity (per kilowatt-hour), and
- Amount of time operated.

In the context of energy consuming devices, ROI is calculated by using four simple steps:

1. Determine the price difference between the lower cost item and the higher cost item.
2. Estimate the annual operating savings of the higher cost versus lower cost item.
3. Divide the annual operating savings by the difference in capital cost.
4. Multiply by 100 to get a percentage return on investment.

Classic styling and conservation can mix.

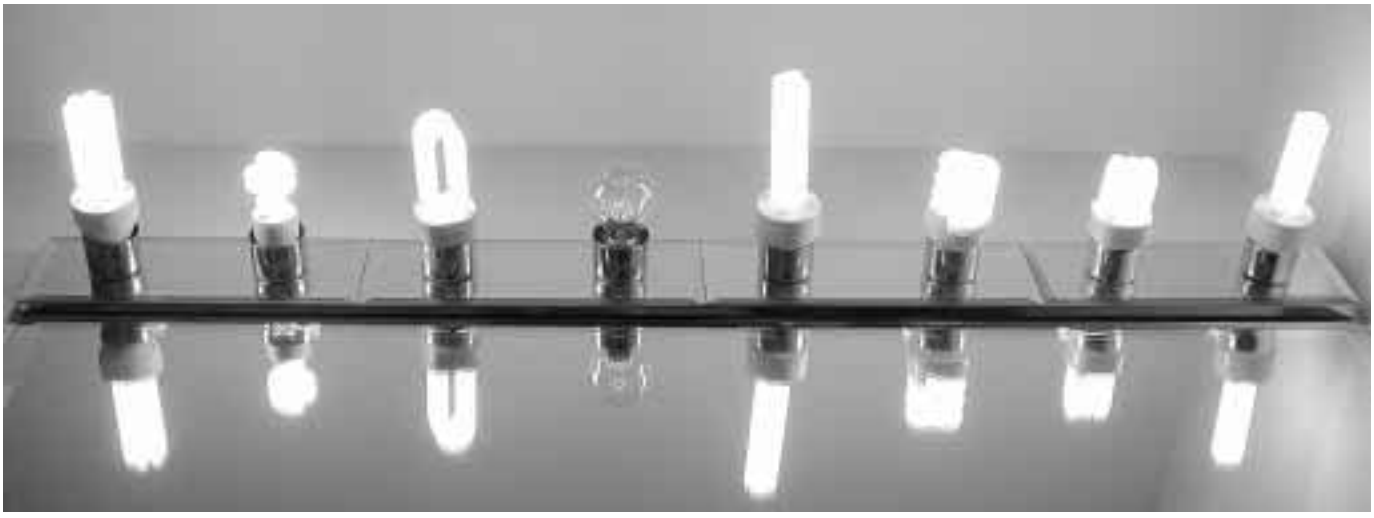
This article evaluates the ROI for five examples: compact fluorescent lightbulbs, solar water heating, the Toyota Prius, home solar-electric energy generation, and LED lightbulbs. I have invested in all of these items in the past year, so the examples are based on my own experiences.

Compact Fluorescent Lightbulbs

Every woman I've ever lived with wanted to leave the porch light on at night. It didn't make sense to me, since I am asleep then. I finally learned that it makes sense to her, because she is asleep then. So I bought my first CF, although they didn't work well in very cold weather back then. Until recently, on my porch, two 15 watt CFs ran an average of eleven hours a night, 365 days a year.

A CF bulb that produces the same amount of light as an incandescent lightbulb uses a quarter of the energy. Light intensity, by the way, is measured not in watts, but in lumens; watts are a measurement of power drawn. Lumens good; watts bad.

Assuming eleven hours of on-time per night, my US$8.99 CF saves me US$10.84 (181 KWH at US$0.06 per KWH) of electricity annually, compared to a typical US$0.40 incandescent bulb. I live in a region of "cheap" electricity, based on hydropower (which is only



Compact fluorescent lightbulbs (left to right): General Electric (25 watt), FEIT Electric (13 W), Phillips (23 W), LEDtronics (0.7 W, the narrow focus of the LED beam makes it difficult to see in this photograph), Osram (20 W), Lights of America (15W), Phillips (15 W), Osram (15W).

cheap if you are not a salmon). That works out to an annual return on investment of 121 percent over a one year period. Do you have any (legal) investments that pay over 100 percent annually?

The table below shows various returns on investments for investing in a US$8.99 compact fluorescent lightbulb versus buying a US$0.40 incandescent lightbulb. It all depends on how much the light is used and how much you pay for electricity. According to the U.S. Department of Energy, Idaho has the lowest electricity rates in the nation, with a statewide average of US$0.04 per KWH. Hawaii has the highest average rates, at US$0.12 per KWH. And rates have been increasing rapidly in many parts of the country.

The table covers costs for grid-produced electricity and off-grid electricity, which may cost more. A perversion in return on investment analysis is that the more you use the bulb, the greater the ROI and the shorter the payback period. Imagine leaving it on 24 hours (like all those exit lights). You'd have a fantastic rate of return, but you would be wasting money (not to mention wasting energy and harming the environment).

Long-lasting compact fluorescent bulbs save money. It takes time (aka money) to change lightbulbs, especially if the bulb is in a hard place to reach. CFs are normally rated at 10,000 hours of average use; incandescent bulbs at 1,000 hours. CFs are also a hedge against higher electricity costs.

Annual Percent Return on Investment
$8.99 Compact Fluorescent Bulb Over 40¢ Incandescent Bulb

Rate ¢/KWH	*0.5 Hrs./Day*	*1 Hrs./Day*	*2 Hrs./Day*	*4 Hrs./Day*	*6 Hrs./Day*	*8 Hrs./Day*	*10 Hrs./Day*	*12 Hrs./Day*	*24 Hrs./Day*
4¢	4%	7%	14%	29%	44%	58%	73%	88%	175%
6¢	5%	11%	22%	44%	66%	88%	110%	132%	263%
8¢	7%	15%	29%	58%	88%	117%	146%	175%	351%
10¢	9%	18%	37%	73%	110%	146%	183%	219%	438%
12¢	11%	22%	44%	88%	132%	175%	219%	263%	526%
14¢	13%	26%	51%	102%	153%	205%	256%	307%	613%
16¢	15%	29%	58%	117%	175%	234%	292%	351%	702%
18¢	16%	33%	66%	132%	197%	263%	329%	395%	789%
20¢	18%	37%	73%	146%	219%	292%	365%	438%	877%
22¢	20%	40%	80%	161%	241%	322%	402%	482%	965%
24¢	22%	44%	88%	175%	263%	351%	438%	526%	1,052%

Compact Fluorescent Return On Investment Spreadsheet

ENTER THESE VARIABLES	UNITS	ENTER HERE	EXPLANATION
Bulb use	Hours/day	***10***	Enter your estimate of how many average hours the bulb is on each day.
CF bulb size	Watts	***13***	Enter wattage size of CF bulb (not what the packaging says in the incandescent equivalent).
Brightness	Lumens	***805***	Enter lumens rating from packaging. Brightness is measured in lumens, not watts.
Rated CF bulb life	Hours	***8000***	Enter rating from packaging.
Cost of electricity	$/KWH	***0.060***	Enter your cost per kilowatt-hour for electricity.
Wattage of incandescent bulb replaced	Watts	***60***	Enter wattage of incandescent bulb replaced.
Lumens of incandescent bulb replaced	Lumens	***865***	Enter lumens rating from packaging.
Rated incandescent bulb life		***1000***	Enter rating from packaging.
Cost of incandescent replaced	$	***$0.40***	Enter the price of incandescent bulb being replaced.
Cost of CF bulb (before any rebates)	$	***$6.47***	Enter cost of CF bulb. First, subtract any rebates from utilities or government.
Rebates	$	***$0.00***	Enter amount of any rebates or kickbacks for buying the bulb.
Combined federal and state tax rate	%	***35***	Enter your combined federal and state tax rate as a percent.
Cost of CF bulb (after any rebates)	$	***$6.47***	
Marginal increase in cost for CF bulb	$	***$6.07***	The cost of your "investment instrument."
Power used	KWH/year	47.45	This is the amount of electricity the bulb uses in a year.
Money spent on electricity consumed	$/year	$2.85	This is how much money you will spend annually with a CF bulb.
Money saved on electricity not consumed	$/year	$8.54	Three times what is spent. A comparable CF bulb uses 1/4 the energy of an incandescent.
Brightness efficiency of CF bulb	Lumens/watt	61.92	The amount of brightness per unit of energy consumed. Lumens good; watts bad.
Brightness inefficiency of incandescent bulb	Lumens/watt	14.42	Brightness is measured in lumens, not watts.
Number of incandescent bulbs you don't change	Pains in ass	7.00	
Simple payback on intial investment	Years	0.76	This is simple payback in years.
Return on investment (tax-free)	%/year	140.71	This is a tax-free figure as a percent of the cost of the CF bulb.
Return on investment (taxable)	%/year	216.47	This is the equivalent rate of return of a taxable investment. Money saved need not be earned.

Working spreadsheet available in the Downloads section of www.homepower.com

The returns on investment depicted in the table for investing in a CF lightbulb are far in excess of what you can get in a money market checking account, passbook savings account, certificate of deposit, mutual fund, or stock market index fund. Investing in compact fluorescent lightbulbs is safer than a federally insured account as well. Even if you have the cheapest grid power and use a bulb just over an hour per day, it's a better return than a historic stock market yield. The stock market has averaged about 8 percent return on investment over the very long term.

The New Champion

Compact fluorescent bulbs have steadily improved. They are now brighter, smaller, less expensive, and have great light quality. However, until recently, no one produced a CF bulb with comparable brightness that was not larger than a standard incandescent bulb. In light fixtures with tight tolerances, anything larger than a bad old regular lightbulb won't fit.

A new entrant in the market is FEIT Electric's ECOBulb. It's no larger than a standard incandescent, and emits 825 lumens, just 5 percent less than a standard 60 watt incandescent at 865 lumens. A comparable Lights of America 15 watt bulb puts out 860 lumens, but is somewhat bigger than the standard bulb. FEIT's bulb draws 13 watts, but only has an average life of 8,000 hours, rather than the more typical 10,000 hours. Even with the shorter lifespan, it pencils out economically to be the best replacement CF for the 60 watt standard incandescent bulb.

You can download an Excel spreadsheet to easily determine your own capital and operating costs for lightbulbs. You enter the variables (bulb cost, energy cost, lumens, etc.) and the spreadsheet determines the rest. It's available in the downloads section of *Home Power's* Web site—www.homepower.com

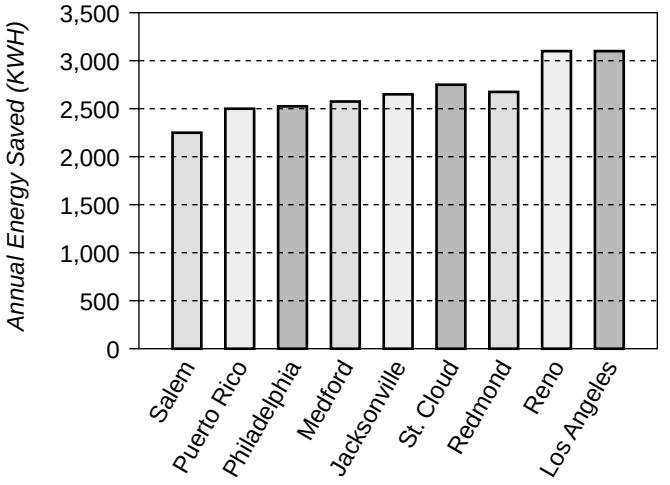
Solar Water Heating

Only after my third solar water heater in three different houses did I get around to doing a return on investment analysis. The table on page 100 depicts the costs of my new system. It is sized for a family of four. It was obviously very nice to have the government pay for about half of the cost of the system. But what about payback or return on investment? Running the numbers tells the story.

According to the Oregon Energy Office, a typical solar domestic water heater provides between 50 and 60 percent of a home's water heating needs. The graph on page 100 depicts annual energy saved in kilowatt-hours for various locations in the nation, with a bias toward Oregon. Though where I live in Ashland is sunnier than Medford, let's use the 2,600 KWH of annual energy saved noted in the graph.

Hot water panels on the front porch roof and the 30 watt PV panel that runs the circulation pump.

Solar Water Heater Performance



But what about maintenance costs, and how long will the system last? It should last decades with little maintenance. Ashland's water is pure, so scale buildup isn't an issue. In about five years, the antifreeze may discolor (indicating breakdown due to excessive heating), and need to be replaced, at an estimated cost of US$100. You can also install a drainback solar thermal system, but it uses more electricity to circulate the fluid.

If you have more maintenance, the ROI will go down a bit, and simple payback will go up some. If electricity rates increase, the opposite will occur. Even without the government assistance, the ROI is 4.7 percent, or still a respectable, long-term, tax-free investment. (To learn more about my system, see www.andykerr.net/energy/hotwater.)

Iowa Street Solar Water Heating

System Cost

Item	*US$*
Cost of system (parts and labor)	$3,650
City of Ashland Electric Department rebate, paid to installer	-500
Initial capital cost to homeowner	$3,150
State of Oregon Energy Income Tax Credit	-1,500
Actual capital cost to homeowner, after next tax filing	$1,650

ROI & Simple Payback of Supplemental Solar Over 100% Electric

Item	*Amount*
Annual cost savings (2,600 KWH x $0.06 KW)	$156
Payback time	10.6 years
Return on investment (tax-free)	9.4%
Green bragging rights	Priceless

Toyota Prius

If you are in the market for a new four-door sedan (not everyone is buying SUVs), what's the return on investment of buying one of those new Toyota hybrids? (See my article in *HP85.*)

If gas prices continue to rise, you may be able to economically rationalize additional cost through anticipated fuel cost savings. It depends on how much you are spending on fuel annually. Compare a new state-of-the-art Prius and a conventional Toyota Echo, which has the same body (sans rear spoiler) as the Prius.

The difference in the manufacturer's suggested retail price between the Prius and the Echo is US$9,455 (before any government rebates). Assuming you are "average" as defined by the EPA and drive 15,000 miles (24,000 km; 45 percent highway, 55 percent city) per year, the average annual fuel cost (US$1.70 per gallon for regular gas) is US$531 and US$729 respectively. Dividing this US$198 marginal savings by the marginal cost difference yields a return on investment of 2.09 percent (tax-free). If you drive more, you save more money, and the ROI is greater.

At least two states (Oregon and Maryland) offer US$1,500 tax credits for purchasing a Prius. (Go ahead, figure the ROI with such a credit.) With special plates in Virginia, you can drive solo in the high-occupancy

Andy and the Prius make 2.09%.

vehicle lane (a priceless intangible). And one of the bright spots in President Bush's tax plan is a proposed federal tax credit for hybrid vehicles.

Solar-Electric Production

I recently installed a 3 KW solar-electric system at my home. A full report is being prepared for *Home Power,* after working out the system kinks and getting good data on production and costs. The report will include return on investment and simple payback numbers.

I can only report now that from a purely financial standpoint, my solar-electric system appears to be a very marginal economic investment. Although I qualified it for as much government assistance as possible, certain site-specific costs conspired to drive up the price of the system.

I also bought the Lexus version of a PV system rather than the Neon version. It provides other hard-to-quantify variables such as being able to offer my neighbors a cold beer or cup of hot tea as may be required during a blackout. Of course, now that I've invested a boatload of money in fixed costs for my electricity, I'm hoping that electric rates go through the roof. It would help my ROI...

3.2 KW of photovoltaics power the Kerr household.

LED Lightbulbs

OK, I confess: I paid US$123 for a lightbulb. Obviously, this was not just any lightbulb, or even a gold-plated compact fluorescent bulb. It is a light emitting diode (LED) bulb. These are quite possibly (but certainly not quite yet) the next generation of lighting, though most of this generation hasn't yet graduated to CF bulbs. I must have personal virtue coming out the wazoo.

Many years ago, I swallowed hard when I bought my first CF for US$30. CFs are much less expensive today and are much better in quality. Like most new products, quality improves over time. Organic foods, recycled paper, store-bought bread, microbrewed beer, computers, automobiles, and washing machines come immediately to mind. CFs today are the same quality (and just about the same size) as incandescent bulbs.

The AC LED—Very efficient, but not quite bright enough for the front porch, and still expensive.

Marketers describe me as an early adopter. I'm rarely among the very first to buy something new, but I usually am first among my friends and colleagues. I just had to try one of those new, 120 volt AC, light emitting diode lightbulbs.

An LED is a semiconductor device that works by electroluminescence, and very efficiently converts electrical energy to light. Very little heat is produced. In contrast, an incandescent bulb is 90 percent heat and 10 percent light.

Some new LED lightbulbs on the market look just like "normal" incandescent lightbulbs. They screw into a

standard Edison socket. Unfortunately, though the bulbs are unbreakable and will last 100,000 hours, the light quality is comparable to the early compact fluorescents—lousy.

For my porch light application (11 hours per day), at my price of electricity (US$0.06 per KWH), my return on investment for the LED lightbulb is 12 percent, compared to an incandescent bulb. Fifty percent better than the historical stock market, but very different from the 121 percent ROI for a compact fluorescent lightbulb.

Unfortunately, the LED lightbulb failed a more important test—usability. My wife couldn't work the combination lock on her bicycle at night with the puny output from the LED. Money isn't everything.

Home Power publisher Richard Perez notes that producing an 850 lumen LED bulb is more of a financial hurdle than a technical one. One company has the patent on white LEDs and it doesn't yet see the benefits of high-volume, low-royalty per unit sales. In time, price will decrease and quality will increase, along with sales.

Richard does note that "seven to eleven of these white LEDs make a great flashlight. These flashlights are showing up everywhere now, and are bound to replace the incandescent models on battery life alone." Not to mention bulb life.

Financial Rationality

Here are my take-home messages:

- Immediately change out every incandescent lightbulb you have, except for those in appliances like refrigerators, stoves, washers, and others that get very little use.
- If you have the right site, install solar water heating now.
- If you're in the market for a new four-door sedan, the Prius can make financial sense, especially if gas prices rise.
- Solar-electric production can be a cost-effective financial investment if site conditions are right, government subsidies are generous, and electricity prices are high enough. You have to figure it out for your own situation.
- It helps to have a business where you can write off intellectual larks like US$123 lightbulbs.

Tax Consequences

The financial savings of investing in energy conservation and renewable energy is in money saved by not having to buy energy. The savings are tax-free—money you don't have to spend is money you don't have to earn.

If you want to compare and contrast your tax-free investments in energy savings with your other taxable investments, use the following formula:

r = f ÷ (1 - t)

Where:

r = return on taxable investment

f = return on tax-free investment

t = taxpayer's combined federal and state tax rate as a decimal

For lightbulbs, this calculation is done for you in the downloadable spreadsheet mentioned previously.

Insufficient Capital?

Some of us think we can't afford the up-front capital cost of investing in energy efficiency. This may be really true for things like cars and water heaters (even though grants, rebates, and low-interest loans are often available for both).

But lightbulbs are a different matter. The capital cost is relatively low and the return is quite high. On top of that, many utilities are now bribing the economically clueless with rebates to make the consumer reach for that initially more expensive lightbulb.

Money Is Not the Measure of All Things

Having said all this, I still believe that money is not the measure of all things. I do not fixate on return on investment. The things that we value most—self, family, community, and environment—are irrational economic investments within a capitalist system, since they have too low a return on investment. Humans may well fail to save the Earth, and ourselves, because economists say it is inefficient and accountants say it is a poor return on capital.

Consider global warming. What's it worth to not have the last of the old-growth redwood forests die out? To not have to worry about getting malaria in Missoula? To not have sea levels rise and flood out much of the developed world? If these things are important to you, it is worth considering other factors in addition to financial return on investment.

It boils down to this question: What's your internal rate of return? Many of our goods and services are provided to us at very low prices. These prices are so low that slavery (clothes), substandard wages (food), pollution (paper), and natural resource exhaustion (wood products) are necessary to do it.

For most goods and services, the moral thing to do is pay more for environmentally friendly products made by socially just companies. But in the case of compact fluorescent lightbulbs and solar hot water, anyone ought

to be able to see the economic rationality of energy efficiency.

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For every $1 spent on energy efficiency, $3 to $5 are *saved* on PVs and system components