Eco-fficiency: Green this and Green that*

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"We will make electric light so cheap that only the rich will be able to burn candles."
- Thomas A. Edison, announcing his electric light bulb in 1879.

Efficiency

In this eco-friendly era, renewable energy sources like wind and solar are getting a lot of attention as a way to reduce the impact of energy use on the environment. This nonetheless, even enthusiastic supporters of alternative energy agree that energy efficiency is the "low-hanging fruit" in reducing greenhouse gas (GHG) emissions and avoiding looming energy shortages. Even proponents of renewable energy technologies acknowledge that conservation is the most immediate and often the most cost-effective way to reduce oil dependency. Although opportunities for saving money while conserving energy abound, the extra effort and upfront costs of obtaining energy-saving devices have deterred many U.S. industries and consumers from investing in them.[1]

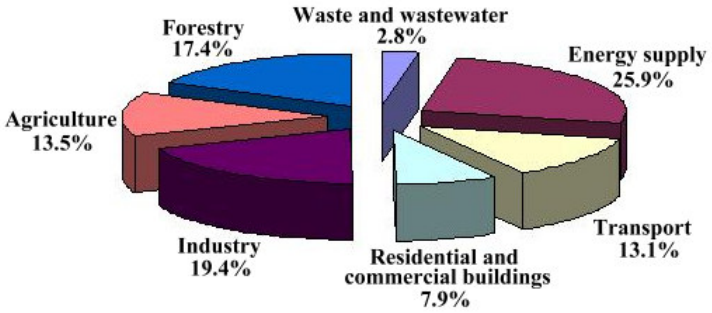

Figure 1. Total greenhouse gas emissions from different sectors. The percentages for residential and commercial buildings (7.9%), and industry (19.4%) do not include energy supply. (Source: IPCC).

Globally, buildings are responsible for greenhouse emissions of about nine billion tons of CO_2eq per year, which is about 18% of the total. Most of this comes from energy (ab)use. Although

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insulation had improved and appliances have become more efficient over the past few decades, the way we use energy in our buildings is still incredibly wasteful, a combination of pouring GHGs into the atmosphere and money down the drain.[2]

The good news is that technologies already exist to put this right. Though some of this would cost money to implement, much would come absolutely free, or even save money, thanks to the savings in energy costs. For example, simply using the most efficient new forms of lighting could reduce the energy used to light a typical American home by up to 75%.

Even in the short term, over the next fifteen years we could cut at least 30% from the projected rise in emissions from buildings without paying a penny. That is not counting changing our behavior in buildings, which would enable us to cut even more. Changing behavior is one of the many areas where individuals can make a dramatic difference.

It makes climate sense to ensure that our homes are as well protected from the elements as possible. Any heat that escapes in the winter (or cool air in summer) means that we will have to waste more emission. Heating and cooling take up to more than half of the energy use in a typical U.S. home, and most of our homes are overheated in the winter and overcooled in summer.

In warmer regions, many of us have learned to rely on energy-hungry air-conditioning to keep the interiors of our buildings cool. However, another approach is simply to let the building itself act as a filter, selectively letting in daylight, warmth, and cool air, depending on the needs of the moment. This practice is not something new. Early architects were doing this before anyone had even heard of oil and electricity. This is probably how the Chinese feng shui started —to make life comfortable in a hormonious environment. The designer of Moorish palaces in Andalucia (14th century), for example, knew all about how to set the slope of a roof so that it blocked the searing overhead summer sun, but let in the gentler, more sloping sunbeam of winter.

Modern buildings can also be designed to do this expertly, but in the meantime any of us can work with what we already have. When the sun is shining directly on the windows, close the shutters or draw the blinds.

Negawatt 1.0

Nega what? Yes, negawatt, that movement that came to the fore at the end of the dismal 1970s, the convulsive decade of energy crisis in the U.S, a consequence of the Arab oil embargo. Advocates peddled “negawatts”—new efficiency as the alternative to new power.

A negawatt is a unit in watts of energy saved; it is basically the opposite of a watt. Amory Lovins, who saw a typo—“negawatt” instead of “megawatt”—in a Colorado Public Commission report, adopted the term to describe electricity that was not created due to energy efficiency.[3]

Lovins has advocated the “negawatt revolution” by arguing that utility customers do not want kilowatt-hours of electricity; they want energy services such as cold beer, clean clothes, good mileage…, which can come more cheaply if electricity is used more efficiently. Thus, the efficiency debate spans not only bulbs, but also refrigerators, washing machines and car engines.[4]

Compact Fluorescent Lamps—Then and Now

We can learn much about the dynamics of efficiency by focusing on lighting.

The European electronics firm Philips introduced the compact fluorescent lamp (CFL) in the U.S. with much fanfare in 1979 just as the nation’s second energy crisis of the decade was getting under

way. This long-lasting, swirl-shaped light bulbs have clear advantages over the widely used incandescent light—it uses 75% less electricity, lasts 10 times longer, produces 450 pounds fewer greenhouse gases (GHGs) from power plants and saves consumers $30 over the life of each bulb. (See Table 1).

Table 1. Stores in the U.S. are promoting the use of compact fluorescent light bulbs over incandescent ones. (Sources: EPA, Environmental Defense).

	Incandescent	Fluorescent
Energy used	60 watts	13 watts
Light output	850 lumens	800 lumens
Average cost	$0.25–$0.60	$2–$4
Annual savings	$0	$8
Annual carbon savings	0	100 pounds
Life	1,000 hours	5,000–10,000 hours
Mercury in the bulb	None	4 mg
Mercury emissions	10 mg	2.4 mg
Number sold annually	1.5–2 billion	130 –150 million

But it is eight times as expensive as a traditional bulb, gives off a harsher light and has a peculiar appearance. Lighted by sparking an efficient chemical reaction rather than heating a metal filament, it was ungainly, took several seconds to light up and often did not fit into traditional light fixtures. As a result the bulbs have never captured the public imagination and have languished on store shelves for a quarter century.

Slowly, the negawatt crowd converted utility regulators and federal energy officials to their cause. Utilities were required to subsidize with coupons and cash rebates to residential consumers for the purchase of fluorescent bulbs. The federal government directed all its building managers to buy nothing else, and kicked in federal dollars to help subsidize household purchase as well.

Forcing a utility to pay for the super-efficient bulbs deployed by its customer would be cheaper, cleaner, and more efficient than building a new power plant. Instead of investing in concrete and coal, the utility would invest in better ballasts and such, which consumers would effectively rent from the utility, through their monthly electric bills, whether or not they actually bought the now highly subsidized bulbs.

But the power stakes were high. Some 10 to 15% of a typical household's electricity is used for lighting. This could be cut to well under 5%, and the challenge was simply to get the right (yes *right* light bulbs) bulbs into the sockets because they can be purchased for a low subsidized price.

Refinements have made CFLs far more convenient to use, reducing their size and price as well. Yet Wal-Mart, the giant discount retailer, sold only 40 million in 2005, compared with about 350 million incandescent bulbs, according to people briefed on the figures.

"Just by doing what [it] does best—saving customers money and cutting costs," said Glenn Prickett of Conservation International, "Wal-Mart can have a revolutionary impact on the market for

green technologies. If every one of Wal-Mart's 100 million customers in the U.S. bought just one energy-saving compact fluorescent lamp, instead of a traditional incandescent bulb, they could cut carbon dioxide emissions by 45 billion pounds and save more than $3 billion."[5]

That, 100 million bulbs, would send "shockwaves"—some intended, others not—across the lighting industry. Because compact fluorescent bulbs last up to eight years, giant manufacturers, like General Electric and Osram Sylvania, would sell far fewer lights. Because the bulbs are made in Asia, some American manufacturing jobs could be lost. And because the bulbs contain mercury, there is a risk of pollution when millions of consumers throw them away.

In August 2006, Wal-Mart sold 3.94 million, nearly twice the 1.65 million it sold in August 2005. But to reach 100 million, Wal-Mart has to do much more. In the fall of 2006, the company began reaching out to competing retailers, Internet companies and even Hollywood. The goal was to turn its sales campaign into a broader cultural movement—sort of a Negawatt 2.0.

One proposal headed by Lawrence Bender is to create a Web site that would track sales of compact fluorescent bulbs at major retailers. The result would be a real-time map, with data collected by a third party, showing how much Americans have saved by using the energy-efficient bulbs. Hopefully such a map would help consumers see this as something bigger than buying a bulb. Bender is famous for producing former U.S. vice president Al Gore's 2006 documentary, "An Inconvenient Truth."

At the same time, Google and Yahoo! are in to use their search engines to promote the bulbs. But Home Depot and Lowe's balked at the idea of cooperating with their larger rival. Then there is the mercury inside the bulbs, a problem Wal-Mart is working with the federal government and environmental groups to resolve, possibly by collecting the bulbs at its stores or off-site locations for recycling.

In the end, though, the biggest obstacle to overcome is America's love affair with cheap, familiar-looking incandescent bulbs—a habit 130 years in the making.[6]

Lights Out, Please

The incandescent light bulb, one of the most venerable inventions of its era but deemed too inefficient in this eco-friendly era, will be phased off the U.S. market beginning in 2012 under a new energy law.

Moving to more efficient lighting is one of the lowest-cost ways for the nation to reduce electricity use and GHGs. In fact, it actually will save households money because of lower utility bills. Ninety percent of the energy that an incandescent light bulb burns is wasted as heat. And yet, sales of the most common high-efficiency bulb available—the compact fluorescent lamp (CFL)—amount to only 6% of the light bulb market.

In 2007, Australia became the first country to announce an outright ban by 2010 on incandescent bulbs. The changeover in the U.S. will be more gradual, not mandated to begin until 2012 and phased out through 2014. However, some manufacturers may phase out earlier.

Each cone-shaped spiral CFL costs about $3, compared with 50 cents for a standard bulb. But a CFL uses about 75% less energy and lasts five years instead of a few months. A household that invested $90 in changing 30 fixtures to CFLs would save $440 to $1,500 over the five-year life of the bulbs, depending, of course, on the cost of electricity.

Turning a CFL on and off frequently shortens its life, which is why the U.S. government's Energy Star program suggests to leave them on for at least 15 minutes at a time. Also, if a home has

dimmable light fixtures, it should buy CFLs labeled "dimmable." All CFLs that carry the government's Energy Star label are required to carry a two-year limited warranty.

When they first hit the market, CFLs had a limited range of tones. Now, manufacturers offer a wider variety, but there is not an agreed-upon labeling standard. The U.S. Energy Star program is working to change that. But for now, lower "Kelvin temperatures" like 2,700 to 3,000 give off "redder" light, closer to old-fashioned incandescent bulbs, while bulbs with Kelvin temperatures of 5,000 and 6,500 provide more "blue" and intense light.

Consumers are rightly concerned about the toxic substance mercury that helps CFLs produce light. Even though the amount sealed in each bulb is small—an old-fashioned thermometer had about 100 times as much mercury—it should be properly disposed of. Environmentalists agree that more work must be done on bulb recycling programs.

By 2012, the chances are good that consumers will have many more options to replace incandescent bulbs. Manufacturers already are deploying advanced incandescent bulbs that are efficient enough to stay on the market after 2012, although they are not yet as efficient as CFLs. Even more exciting are the developments with light-emitting diodes (LEDs), which are jazzing up holiday lighting. Philips in 2007 acquired several pioneering small technology companies and plans a big push to make LEDs practical for ordinary lighting purposes. LEDs last even longer than CFLs and will make bulb buying more like an appliance purchase than a disposable item.

The incandescent bulb has had a good run, with the technology little changed since 1879, when Edison produced light with a carbonized thread from his wife's sewing box. The breakthrough that ushered civilization out of the candle era was so revolutionary that the light bulb itself became the culture's iconic image to illustrate any thought, brainstorm, or idea. The incandescent bulb is (soon to be was) a good idea; but energy-efficient CFLs and LEDs are better ideas.[7]

Home Thrift Home

If our homes are just an empty shell of walls and lightings, a good design (or excellent feng shui) and installing energy-efficient light bulbs will be all that it takes to be eco-fficient. But we demand convenience and comfort out of our dwellings, and luxuries out of modern mores and wants. Thus there are still many things we can do to be more eco-fficient within the house.

Indeed, a McKinsey Global Institute research group's study found that energy saving opportunities in American homes are immense with current technology, but new product standard mandates will be needed. The study concludes that projected electricity consumption in residential buildings in the U.S. in 2020 could be reduced by more than a third if CFL bulbs and an array of other high-efficiency options including water heaters, kitchen appliances, room-insulation materials and standby power were adopted across the nation. (See Figure 2).

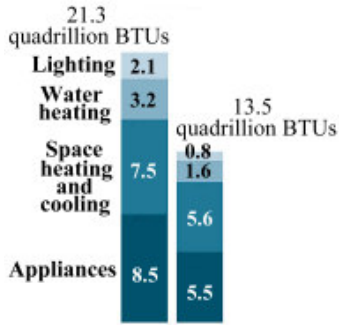

Figure 2. Residential energy use could be reduced by wider use of existing technologies, encouraged by the adoption of some mandatory efficiency standards. Total U.S. residential home energy consumption in 2020: (Left) Based on current pattern of use; (Right) With adoption of current technologies and some regulations. (Source: McKinsey Global Institute).

Yet market forces alone, even considerably higher energy prices, will not be enough to cause wholesale adoption of the most energy-efficient technology. The study makes a strong case for what economists tend to shy away from—market intervention—but this would be an intervention to correct market distortions that exist. Such distortions result from individuals' lacking adequate information to make the best decisions or the market's failure to encourage individuals to make energy-efficient investments.[8]

For example, a person renting an apartment may be using appliances that consume a lot of electric power. The landlord has little incentive to buy new, more efficient appliances because the tenant pays the electricity bills; the tenant, who may intend to stay for a year or two, has scant incentive to buy energy-efficient appliances. Consequently, a lot of electrical power is wasted.

A way to correct for this is more stringent product standards so that all new appliances are energy-efficient models. The McKinsey policy prescriptions are not something new; they resemble those of the California model. Starting in the 1970s, the state began imposing requirements for appliances and building materials, among other energy-saving measures.[9]

Robert N. Stavins, an environmental economist at Harvard University, was skeptical about the size of the efficiency gains the McKinsey study projected. He countered that the notion "massive free lunches in energy efficiency" will result from tweaking the market with new regulations and standards is misguided, as the following example exemplifies.

With appliances, the household with the greatest incentive to buy a more expensive energy-efficient washing machine is the one that does many loads of laundry each week, while a person who does a load or two has less incentive. Energy-efficiency requirements raise the prices of products and can impose "significant costs on the less affluent."

So some economists, including Stavins, say that putting a price on carbon—through a tax on carbon emissions or a pollution-trading system—is the preferred method to promote efficiency and curb global warming. For example, a $100-a-ton tax on CO_2 would increase the cost of coal-fired electricity by 400% and natural-gas-generated power by 100% while hydropower costs would not increase at all.[10,11]

Energy Hog Within

Amazing though it sounds, those little lights on TVs and videos and all the other accoutrements of appliance standby modes really do make a big contribution to greenhouse emissions. The

International Energy Agency (IEA) estimates that standby mode could be causing a full 1% of the world's greenhouse emissions, which is nearly as much as the aviation industry.

The instant-on circuit in a television draws about 8 watts—a pretty big piece of the 35 watts round-the-clock average for the entire device. Altogether, home appliances consume about 50 watts in standby power. The circuits do not draw all that much power, but they draw it around the clock, and that is the killer.[12]

A PC, even when not in "real use," continuously draws about 134 watts all night.

Now throw in other devices in a typical modern American home: a TiVo digital video recorder (DVR) is consuming about 30 watts when it is not playing or recording a show; a Comcast digital cable set-top box made by Motorola is drawing about 40 watts; a DVD player is drawing 26 watts while idle, and an audio system—which is rarely turned off—is using 47 watts. In addition, power adapters and chargers, each drawing 1 or 2 watts, not to mention several other devices sipping energy to keep clocks running or to be ready to turn on at the push of a button.

All of this wasted power can cost money and pump unnecessary CO_2 into the atmosphere. The PC alone is contributing 2,000 pounds of CO_2 annually; the DVR is adding 543 pounds. Indeed, the Department of Energy (DoE) estimates that in the average home, 40% of all electricity used to power home electronics is consumed while the products are turned off. Add that all up, and it equals the annual output of 17 power plants.

Products that idle in what the industry calls low-power mode, or lopomo, consumed about 10% of total electricity in California homes, according to a 2002 study prepared for the California Energy Commission by the Lawrence Berkeley National Laboratory. A few of those devices, even those with Energy Star ratings that signal that they are less wasteful, still use a lot of power. Some of the larger big-screen TVs consume as much energy each year as a new refrigerator.

To be eco-fficient, you do not have to use a smart energy meter, which identifies electric use in more detail, to reduce consumption. If you do not turn off your PC when it is not in use, make sure it goes into a low-power sleep, suspend or hibernate mode. That does not always happen automatically.[13]

The Case of Green Big Apple

Residents of the Big Apple (moniker for New York City) have often been told that they use less energy than most Americans, partly because they live in the most densely populated city in the country. To some extent, that is true.

New Yorkers have the benefit of an extensive mass-transit system, which means lower auto emissions, but the city's residential buildings are not necessarily more energy-efficient than those in many other places in the country, particularly in eco-friendly states like California.

The main reason that New Yorkers use much less electricity is that their apartments are so much smaller than homes in other cities. In fact, most Big Apple buildings, both commercial and residential, are wasting thousands of dollars a year on energy. Energy use by buildings accounts for almost 80% of the city's greenhouse gas (GHG) emissions, and residential buildings for about a third of that. These gases are released in creating the energy used to heat, cool and light the buildings, as well as to run myriad household appliances and gadgets.

Mayor Michael R. Bloomberg has created a blueprint, called PlaNYC, to control future development in the city, with a goal of reducing total GHG emissions in 2030 by 30%, compared with 2005 levels. If building the whole city from ground up were an option, some reductions could be

accomplished by toughening the requirements for new construction. Since this option is economically impossible, and about 85% of the buildings that will exist in the city in 2030 are already standing, those buildings would need to go on an energy diet.[14]

There are a number of relatively inexpensive things that residential buildings could do that would immediately lower their energy costs and "carbon footprints." The easiest, and cheapest, is to install energy-efficient light bulbs, discussed earlier, in all common areas. More expensive plans—the costs of which can often be offset by loans and grants from New York State—include replacing old inefficient boilers with more efficient modern ones and installing solar panels on the roof.

Many buildings start with the least expensive measures with the biggest immediate payoff—buying fluorescent bulbs for about $4 each, for example, or thermostatic radiator valves for about $90 each. But that is where a lot of building eco-fficiency improvements stop. These efforts should reach a bit further, to measures whose costs could be recouped in two to five years. The next step, for example, might be installing motion sensors that would dim the lights by 50% when the hallways and stairwells were not in use.

Take as an example a 60,000-square-foot building with 40 apartments. Hiring an electrician to install motion sensors might cost $11,000. The building could save that much in lower electricity bills over two years, assuming that it was already using fluorescent bulbs, and the sensors alone would reduce its CO_2 emissions by about 40 metric tons per year. That would be the equivalent of driving a car that gets 25 miles per gallon for 110,250 miles. And since the average American sedan car lasts for 120,000 miles, that is the same as saying driving till the car drop dead!

As expected, it would take longer to recoup the costs of more expensive measures. For example, that it would cost about $20,000 to weatherize that 60,000-square-foot apartment building, which could be paid for by five years of lower heating bills. Weatherizing would include sealing gaps around windows, exterior doors, and interior pipes and wiring.

Some residential buildings might also consider installing solar panels on the roof, to tap the sun to provide a nonpolluting source of electricity to light the hallways and run the elevators. Experts recommend doing this only after more glaring energy inefficiencies have been addressed, because in a large apartment house, solar panels are not going to produce enough energy until other energy hogs have been dealt with.

For now, solar requires patience. It could take up to 15 years to break even on $19,000 spent on solar panels, and that is after subsidies and tax breaks offered by the state and federal governments. (See Table 2).

In many ways, environmentalists often sell themselves short by focusing too much on payback periods. Who ever asks what the payback period is for a marble lobby? But if a lot of large commercial and residential buildings installed solar panels, that could go a long way toward reducing the city's overall impact on global warming. And through economy of scale, the price of solar panels will drop drastically.[15]

We have taken the Big Apple as an example, but the discussion applies to other cities, even those in other parts of the world with different climates. Differences being instead of heating, we may have cooling, and et cetera, and cost of labor and parts.

Table 2. Existing buildings in cities such as New York may be upgraded to improve efficiency. As a working example, based on a 60,000 square-foot building with 40 apartments, the cost of improvements, savings and payback time are as follows: (Source: Optimal Energy Inc.).

Building Part	Work	Cost/Cost	Annual	Payback

		Difference	Savings	
Roof	Install solar panels with state incentives and federal tax credit.	$19,000	$1,250	15 years
Halls and	Switch to fluorescent bulbs.	$1,120	$24,233	3 weeks
Stairs	Install motion sensors.	$11,000	$5,500	2 years
Apartments	Install thermostatic radiator valves.	$3,000	$1,000	3 years
Exterior	Buy new triple-glazed windows instead of new double-glazed windows.	$40,000	$3,700	11 years
	Seal windows, exterior doors and cracks.	$20,000	$4,200	5 years
Basement	Replace an old boiler with the most efficient gas unit rather than the cheapest oil unit.	$50,000	$6,500	8 years
	Upgrade existing boiler system and install computerize controls.	$15,000	$6,000	2.5 years

~~White~~ Green House

The best option yet is to start a broader cultural movement when building new buildings. To this end, human inertia is a factor that has to be contended with. For now, this movement has to start some place, with showcasing concept buildings and educating the public. By inviting them into one of these new show houses, the message will move virally. They will build these houses. Their friends will come and be in these houses, and they'll want a little.

As a matter of fact, green show houses—sponsored by magazines, nonprofit groups and developers—are appearing across the U.S., spreading a message about environmentally conscious building to designers, builders and home buyers, and helping to sell building products.

Environmentalism may turn out to be the biggest thing to hit the construction industry since aluminum siding, which also happens to be recyclable. By 2012, green building could be a $20 billion business, blossoming from a roughly $2 billion, according to a National Association of Home Builders'/McGraw Hill market forecast. But some builders are unfamiliar with the new materials and how to use them. And buyers may not know enough about them to request them.[16]

Creators of the new show houses hope that their projects will showcase practices that support the basic tenets of green building: clean indoor air, energy and water efficiency, and recycled or locally produced materials. Suppliers of building materials and designers are eager for exposure, especially on high-profile projects. In exchange for their association, owners receive free products from companies (for example, a dual-flush toilet, with different water flow rates for solid and liquid waste).

Some developers are also focusing their attention on design students. For example, interior design students are given tours of town houses being built with a hybrid solar-thermal/gas-fired climate control system, cork and stone flooring, recycled glass countertops and sorghum stalk kitchen cabinets.

These students are likely to be the ones making the decisions in a decade or two. In using the town houses as an educational tool, companies hope to drive potential buyers and tomorrow's designers to their stores—sort of like McDonald's have playgrounds for children to cultivate a future generation

of customers. Green vendors believe they have to educate consumers to want what they are starting to market and sell.

Homes of Tomorrow 2.0

As with any new concept, until there is an economy of scale, concept houses do not come cheap.

Green houses in the U.S. are coming on the market at around $2.4 million (in Brooklyn) a piece, a price that seems totally doable, since buyers will definitely pay a premium for ground up new development, and the development will be billed as green. Some green building advocates hope that their practices will catch on at the lower end of the market (~$200,000) as well. Omaha's Concept House is called the "Toyota of green building" by its builder. The house is designed according to the three pillars of creating affordable green housing: flexibility—embodied, for example, by modular carpets and wireless light switches, which make remodeling and redecorating easier; construction efficiency—pre-built window trim that takes minutes to install; and sustainability—long-lasting materials like stain- and scratch-resistant countertops or the standing seam metal roof that can survive for decades.

The Eco-Home, a solar-powered, doubly insulated cottage is estimated to be three times more energy efficient than an average home of comparable size. Before putting the house on the market, Eco-Home was open as a classroom for a year. Every aspect of the house was broken down into dollars and cents: how much doing a double-studded wall with nine-inch insulation will cost; the cost of adding a solar-electric array; the cost of fiberglass triple-pane windows. An estimate is the house costs $20 more per square foot to build than a comparable non-green one.

In many ways, today's green show houses hark back to the Homes of Tomorrow, which were introduced at the 1933 World's Fair and became a popular way of showcasing new technologies. Some of the early ones—dishwashers and central air conditioning—caught on; others, like baked enamel siding and personal airplane hangars, did not.

Similar to a green house, a green office building may be outfitted with sensors that adjust lighting according to the amount of daylight. It may harvest rainwater from the roof and has formaldehyde-free furniture and low vapor paints and sealants. Consequently, it will never suffer from what is called a "new building" headache—the kind that arises from off-gassing finishes and furnishings like vinyl floors or standard paints.[17]

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His career started with short stints at the Strong Memorial Hospital, New York, then at the Laboratory for Laser Energetics (LLE) at the University of Rochester, and later computational work using computers at the John von Newmann Center at Princeton University. In 1995, he advanced his career to California after having been at Florida State University for eight years. In May 1996, he was on the BioMass Panel organized by the American Association for the Advancement of Science (AAAS) at Stanford University.

Hal currently resides in Santa Clara, "The Heart of Silicon Valley"[SM], California, USA. To get his feet wet in the eco-business, he worked with a quartz/solid surface company (Lexmar), and spent a year and a half to complete a certification in interior design (IDI) as a side interest.