CHAPTER 10

Energy Efficiency Is Profitable

Nothing is so difficult as not deceiving oneself.

Ludwig Wittgenstein

My neighbor Ming recently described her participation in an energy-saving contest of her local electric utility. It started when two college students on a summer work placement convinced her to enlist in the company's promotion.

According to the eager students on her doorstep, reducing her electricity demand would save money and help the environment. As a bonus, if she cut her average electricity use by 15% in six months, relative to the previous year, she would win $100. What sold Ming were the brochure testimonials in which parents described the contest's family-bonding benefits. With parents feeling guilty about their kids' devotion to texting, internet browsing, TV watching, and gaming, the prospect of a successful family project was appealing. Ming's kids, Tania and Sam, were 13 and 15 at the time.

From the utility's pamphlets, Ming and her husband Dave learned that efforts to cut energy use entail either 'efficiency' or 'conservation.' Efficiency involves replacing your appliances, lights, and other devices with higher efficiency models. These tend to have a higher purchase price than less efficient devices, but they should save money over time through lower electricity consumption. Conservation involves changing behavior or lowering one's expectations for energy services. Examples include switching off unused lights and computers, taking shorter showers, washing clothes with cold water and drying them on the line, and accepting a slightly lower indoor temperature in winter and a slightly higher temperature during air-conditioning season.

The brochures advised Ming and Dave to start with easy measures that didn't require a focused behavioral change: washing laundry with cold water, lowering the temperature setting for the hot water tank, and reprogramming the thermostat down to 11 degrees Celsius (52˚F) from 11 pm to 6 am, and to a maximum of 20 degrees Celsius (68˚F) during winter days. Although the last action saved natural gas rather than electricity, their electric utility's strategy was to promote a non-discriminating 'culture of energy saving.'

So far so good. These conservation efforts might be thought of as lifestyle changes, but they didn't require a conscious effort to act differently on a daily basis, nor any cooperation from their kids. That challenge came next.

Turning off lights in unused rooms is a no-brainer when it comes to reducing energy use, but it does require a conscious effort. Ming and Dave discussed this with Tania and Sam, and they resolved to try. Ming even detected a note of enthusiasm, which made her appreciative of the family-bonding angle in the promotional brochures.

Hanging clothes on the line instead of using the dryer sounded doable, but involved tricky planning for her and Dave. Since both had full-time jobs, she wondered how to match laundry chores to sunny weekend days.

Dave purchased power bars for all electrical devices. By remembering to switch off the power bars, the family could eliminate vampire load from idle TVs, DVD players, audio systems, microwave ovens, wireless transmitters, coffee machines, cell phone rechargers, computers, and so on. Everyone promised to click the power bars after finishing with a device.

Six months later, I asked Ming how it was going.

"Well, at first everyone was enthusiastic, but in the end it kind of unraveled."

"How so?"

"It was harder than expected to change our habits. We made some progress at first, including hanging clothes outside."

"Yes, I noticed – or, at least, for a while."

"Exactly! Drying clothes outside is *complicated*. You have to have a sunny day; you have to do the laundry in the morning; you have to stay home to put it out after washing; and you have to be ready to pull it in if the weather changes, even if still wet. That means lugging wet laundry back downstairs to rehang in the basement or toss in the dryer, which we increasingly did.

"Couldn't you delegate the hanging and removal of clothes to the kids?"

"We tried. But they were unreliable unless we nagged them. And that's just the half of it. Pretty soon they were forgetting to turn off lights in unused rooms and switch off the power bars. What started out as a fun family challenge broke down into increased bickering between the kids about who was to blame for failures."

"And the results?"

"Not great. There are just too many other things to think about. It's like regularly flossing your teeth. Over time, good intentions dissipate."

"Weren't you also going to switch to more efficient appliances? That's supposed to be the easier way to save energy since it only depends on a one-time decision rather than constant behavioral monitoring."

"But how many of these decisions do you make in six months, let alone six years? All our major appliances are less than five years old."

"There was nothing you could replace?"

"Actually, we did make one new acquisition. Dave and the kids were at the mall when they stumbled on an "unbelievable" sale of wide-screen plasma TVs. After they brought it home, we realized it uses eight times the power of our previous TV!"

"Ouch."

"It gets worse. For our anniversary, my mother bought us a new device for the kitchen counter. It's a digital picture frame which continuously scrolls through illuminated photos of my parents, us, and the kids. Since my mother drops by unexpectedly, I can't risk unplugging it during the day, although I try to remember at bedtime."

"What about lighting? Conventional light bulbs don't last more than a year or two. And because they're cheap you can replace even the ones that are still functioning."

"We did switch several. But even that wasn't as easy as the college kids said it would be. In some light fixtures, the new lights looked ugly, although it took us some time to admit this. That meant an extra trip to the store to return them. And some of the new lights don't give the warm glow we're used to, so we brought them back too. Some bulbs, which one store refused to take back, now sit in a drawer. I guess our efficient lights save electricity, but what value do you put on all the time we killed learning what worked for us?"

* * *

I didn't tell Ming that her stories rekindled memories of my pioneering experiences 30 years earlier as one of the first adopter of efficient lights. A new professor and homeowner, obsessed with energy efficiency since my teens, I dazzled my grad students and wife with calculations of the monetary and environmental benefits of energy efficiency, with lighting as the example.

Back then, the efficient bulbs were compact fluorescents. At $20 to $30 each, they presented a serious financial commitment. But I had done my homework. While my wife's interest in my calculations quickly faded, tuning out was not an option for my captive grad students. My numbers showed that though an efficient light bulb would cost 10 to 20 times more than an inefficient incandescent bulb, this extra investment would eventually be compensated by the annual savings from buying less electricity. But how much less electricity depended on how long the lights were illuminated. They needed to be lit an average of three hours a day over the year to earn sufficient bill savings to compensate for the higher cost. Only a few lights in high use areas of the house reached the profitability threshold of averaging three hours a day. My wife cheekily offered to leave lights on in empty rooms to improve my benefit-cost calculation.

I remember the day in 1988 when I brought home my first efficient lights. I and my students had calculated that my $160 investment in eight of these for the highest use fixtures would achieve payback in the ninth year from electricity bill savings, just in time, since their rated life expectancy was 10 years. But on arriving home, I opened the end of one package before realizing that earlier in the store, to view my treasure, I had opened the other end.

After sweeping up $20-worth of broken glass, I dutifully re-calculated my payback, this time incorporating the bulb's untimely demise. As feared, to recover the initial investment, all remaining light bulbs now needed to survive twelve years. Chastened, but undeterred, I installed the surviving bulbs, neglecting to mention the mishap to my devoted students, or my wife.

Eventually I realized that what had first seemed like a hiccup on the path to profitable energy efficiency was symptomatic. My initial calculations failed to include the standard risk of which any sound investor, indeed any prudent householder, is all too aware: the greater likelihood of premature failure with new technologies, and the greater financial risks of higher-cost technologies.

Research shows that new technologies typically experience a higher failure rate than tried-and-true technologies, and this was no different with efficient light bulbs. Within a year, two new lights inexplicably stopped working, one turning an ominous dark shade in its final days. And my calculations didn't include the probability of accidental breakage, in spite of my traumatic first day. This error became obvious when, near the end of the second year, my rambunctious kids and our dog toppled two lamps in a birthday bash. Breaking two $20 bulbs is different than breaking two $1 bulbs, which explains why people instinctively gravitate to devices with lower up-front costs, even if these have higher operating costs.

It was during this period that another problem emerged. I returned from an energy efficiency conference to find that two of my cherished lights had disappeared. My wife sheepishly confessed to removing them during my absences. She needed respite, however briefly, from the "night-of-the-living-dead ambiance they gave to the living room." On this occasion, she had forgotten to re-install them before my return.

Finally, the light switched on – the one inside my academic head – and my students and I began to probe the literature. As it turns out, there is an extensive technical literature assessing the failure rates of new equipment and devices. New technologies have a higher failure rate, making them riskier. There is also a business literature assessing how consumers and corporations value new products and equipment that may differ in the quality of service they provide (like lights with a different hue). New technologies are rarely perfect substitutes for conventional ones.

Some researchers combine these factors to estimate the full financial and intangible costs of new energy-efficient technologies. Since these technologies are rarely perfect substitutes, and since their newness and high cost make them riskier, my initial calculation failed to tell the full story about the likely profitability of energy efficiency investments. Many consumers and firms instinctively suspect this problem, hence their wariness of claims by energy efficiency advocates.

The compact fluorescent lights are today much cheaper and more dependable than 25 years ago when I was an early adopter. That's because they're no longer new. After almost three decades of trial-and-error by manufacturers and consumers, it's easier to convince people to buy them, especially since their price has fallen 80% and their reliability and hue are much improved. Today, though, compact fluorescents are being overshadowed by highly efficient LED lights. Now it's this technology that faces concerns about long-term performance, attractiveness, and the economic value of its higher up-front cost, especially if installed in low-use fixtures or where there is risk of accidental breakage. Healthy consumer skepticism remains a challenge for new energy-efficient technologies.

In a cruel irony, some students visiting my house castigated me for still having some compact fluorescent lights instead of LEDs, the latter being more efficient and higher quality. They were a bit more understanding when I pointed out that I was still trying to recoup some of the losses from my initial foray into home energy efficiency.

As for Ming, her family reduced their electricity use 5%, far short of the 15% needed to win the $100 incentive. She has not checked if their consumption increased afterwards. Like most ratepayers, she only looks at the dollar amounts of her monthly bills, if at all. But the experience cured her of the notion that energy efficiency is easy and profitable.

* * *

Governments and utilities have promoted energy savings for more than three decades. They've done it with advertising, labeling, contests, promotions, and subsidies. A dominant narrative is that saving energy is the first step in deep decarbonization because we reduce emissions *and* make money. It's the "low-hanging fruit."

In 2011, then US Secretary of Energy, Stephen Chu, said, "For the next few decades, energy efficiency is one of the lowest cost options for reducing US carbon emissions."[1] In 2012, Exxon Mobil's website stated, "Energy efficiency is one of the largest and lowest cost ways to extend our world's energy supplies and reduce greenhouse gas emissions."[2]

Statements such as these were reinforced by widely circulated studies of the McKinsey management-consulting firm.[3] These estimated the potential for profitable energy savings and reduced carbon pollution throughout the US, using the same simplistic method with which I had calculated my expected profits from switching to efficient lights. In other words, their studies ignored the hidden risks and costs of untried technologies that require long payback periods and consumer acceptance. McKinsey concluded that the US could reduce energy use 45%, which would also reduce GHG emissions 30%, and all of this at a profit.

With reports like these, it's no wonder that politicians and opinion leaders claim that reducing carbon pollution is easy and profitable because saving energy is easy and profitable. But what happens when we enrich the analysis of McKinsey with real-world evidence about the hidden costs and risks that Ming and I discovered? In Chapter 5, I described how the Energy Modeling Forum at Stanford University conducts collaborative studies in which multiple teams of researchers address the same set of energy-related questions. In its EMF 25 study, completed in 2011, all research teams estimated the US energy efficiency potential based on technology and cost.

In our contribution to EMF 25, my grad student at the time, Rose Murphy, used our US model to produce two scenarios.[4] One scenario reproduced the McKinsey results by assuming that newer, higher-cost efficient technologies were perfect substitutes with no additional risks. The other scenario accounted for the hidden costs and risks estimated in the research literature and incorporated them in the parameters of our US model. Like all the other EMF 25 modelers, our results indicated a dramatically smaller potential for profitable energy efficiency.

This is where things stand today. On one side, energy efficiency advocates, sometimes supported by high-profile consultants, argue that saving energy is cheap and easy. On the other, most independent researchers, like those assembled by the Energy Modeling Forum, find evidence contradicting the claims of a large potential for profitable energy saving. But politicians and other opinion leaders are more attracted to the former than the latter, for obvious reasons. It is easier to argue that saving energy offers a win-win path to reducing carbon pollution.

This inaccurate view of energy efficiency's profitability might seem harmless. But it isn't if it could inadvertently delay the carbon pricing and regulations that should have been implemented decades ago. Its advocates need to vigorously champion these compulsory policies if they are to avoid inadvertently assisting the opponents of deep decarbonization. A brief history of energy efficiency explains this point.

The two decades prior to 1970 were heady times for energy companies, as energy demand and economies grew in lock-step. Energy supplies were plentiful, corporate profits strong, and no one worried about wasting energy. But the oil price spikes in 1973 and 1979 alerted people to the possibility of a different future, one in which sudden and perhaps sustained energy price increases could become the norm. Wasting energy might no longer be okay. That's when a physicist named Amory Lovins published the book, *Soft Energy Paths*, in which he popularized the method of calculating energy efficiency benefits that I later used for my light bulbs and McKinsey for its studies.[5] With this method, he estimated that the US could profitably reduce its electricity use by a whopping 75%. (He coined the term 'negawatts' to describe the reductions in demand due to energy efficiency.) This means that investments in more efficient energy-using devices in industry, buildings, and transportation would make profits and obviate the need for three quarters of the stock of US electricity plants, oil refineries, and so on.

His case for the benefits of energy efficiency gained prominence thanks to a string of exceptional events around 1980. When President Ronald Reagan chose to fight inflation with tight monetary policy, interest rates rose to unprecedented levels, deepening what was already an economic recession. This happened just as many US utilities had built up massive debt to fund new nuclear plants. With electricity demand suddenly stagnant, the new plants would not have enough sales and therefore revenue to cover debt payments. Regulators allowed utilities to raise tariffs to make these payments, but the rate increases caused the electricity demand to fall even further, erasing the need for many of the plants. Pundits labeled this cycle of rising tariffs and falling demand a "utility death spiral." The resulting fleet of idle and unfinished nuclear plants, plus widespread utility bond defaults, taught investors that the electricity market can be risky.

With demand no longer predictable, electric utilities warmed to the idea of managing electricity demand to reduce financial risk. This new focus transformed Lovins from an anti-growth pariah to an industry savior. At conferences and in corporate boardrooms he explained how utilities could stabilize their balance sheets and reduce risk with energy efficiency programs. Thus, through the 1980s and 90s, US electric utilities pursued energy-saving programs like the one offered to Ming, a combination of enticing information and monetary inducements.

I played a small role in this process, serving from 1992 to 1997 as Chair of the British Columbia Utilities Commission. Working in parallel with states like New York and California, we ordered our electric and gas utilities to prioritize energy efficiency, mandating millions of dollars in information programs and subsidies to consumers and businesses to acquire high-efficiency equipment. Eventually the evidence, which I described in Chapter 9, convinced me that these subsidies had little effect on energy demand. And the experience of leading a quasi-judicial institution, involving evidence, testimony, and cross-examination, opened my eyes to how people fixate on the evidence that supports their interests and desires, and ignore the counter-evidence.

The slower growth of North American electricity demand seemed to vindicate the energy-saving programs. But economists noted that electricity prices also rose during this time, and higher prices motivate savings. Skeptics also noted that the structure of the US economy changed, with more energy-intensive industries moving offshore, reducing electricity demand. Demand also fell because of more stringent efficiency regulations. Consumers and industry had to buy more efficient models, regardless of whether that increased efficiency was profitable.

Interest in energy efficiency faded in the late 1990s and early 2000s, as energy prices moderated and utilities focused on deregulation of electricity markets. But rising oil prices after 2000, in conjunction with concerns about global warming, rekindled interest in saving energy. And because efficiency advocates again promise profits while reducing carbon emissions, energy efficiency is often portrayed as the first step in climate-energy success.

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Even if much evidence contradicts the belief in energy efficiency's profitability, presumably the evidence at least confirms that energy efficiency reduces energy demand. Not so fast. Humans use energy to get things they value, starting with the increased security and comfort our cave-dwelling ancestors enjoyed thanks to their mastery of fire. Today, that use of energy can be direct, when we burn wood in caves or gasoline in cars, and indirect, when firms use energy to provide non-energy goods and services, like a chair or insurance.

Direct and indirect energy use usually rise with income. The richer we are, the more we use energy in airplanes, hot tubs, vacation homes, and so on. The richer we are, the more goods and services we consume, leading to more energy consumption by manufacturers, retailers, internet servers, restaurants, truckers, and so on. With few exceptions, poorer people use less energy because they are constrained by their limited incomes. This relationship is found between richer and poorer citizens within one country, and between richer and poorer countries.

Of course, per capita energy can differ between individuals with the same income, and between countries of similar incomes. One country may use more energy because of low prices thanks to low-cost hydropower or fossil fuels, or because of cold winters that increase space heating needs, or because of a disproportionate share of energy-intensive industries like steel and cement.

Lower energy prices encourage greater energy use. But even with stable energy prices, the acquisition of a more efficient device will decrease operating cost. A more efficient car decreases the fuel costs for driving a given distance, which may increase the willingness to commute further or take a long-distance trip with the family.

In other words, the reduction in energy costs resulting from an efficiency improvement may induce increased demand for a given energy service, such as the number of miles driven each year, even *without* a decrease in the price of energy. Energy analysts call this feedback the 'rebound effect.' Thus, while a more efficient car should have reduced annual gasoline consumption by say 400 liters (100 gallons), because of the rebound effect the net reduction might be only 300 liters.

Analysts on all sides of the issue generally agree that the rebound effect for most direct energy uses is modest. Even a significantly more efficient car is unlikely to dramatically change someone's driving patterns. Certainly, for energy services like cooking, home heating, hot water, and lighting, the lower operating costs due to efficiency are unlikely to cause major increases in demand. Acquiring a more energy-efficient stove won't motivate me to cook more at home.

However, at an aggregate level, the energy rebound effect is likely significant.[6] Economists have long noted that as the cost of an input to the economy falls, humans innovate new ways to use more of it. The input could be energy, skilled and unskilled workers, or material resources like wood, minerals, and water. If the cost of the input falls relative to the value it can produce, then the economy in aggregate uses more. This is sometimes called the 'productivity rebound.'

William Stanley Jevons first explained this concept in his 1865 book, *The Coal Question*. He claimed that England should not bank on efficiency improvements in coal boilers and steam engines to spare it from depleting its domestic coal supplies.

> It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth . . . Every improvement of the engine, when effected, does but accelerate anew the consumption of coal.[7]

Our historical demand for lighting provides an example of what is today referred to as 'Jevons' paradox.' In a 2006 paper, Roger Fouquet and Peter Pearson tracked the evolution of lighting in the United Kingdom from 1800 to 2000, a period during which the population grew five-fold and GDP fifteen-fold.[8] While this growth in people and economic output would certainly increase the use of lighting, it alone can hardly explain the astounding 6,500 times increase. The more obvious explanation is that over the same period the cost of lighting plummeted to 1/3,000th its earlier level, as measured in \$ per lumen. (Lumen is the lighting measure displayed on today's light packages; an older term is candlepower.) While some of this cost decrease resulted from lower energy prices, it was driven by dramatic improvements in the efficiency of lighting, as technologies evolved from the almost complete reliance on candles to oil lamps in the early 1800s, to gas lamps in the late 1800s, and to electric lights in the 1900s. As Jevons would have predicted, tremendous improvements in the productivity of lighting greatly contributed to a decrease in cost of use, and an explosion in demand.

If we compare the uses of artificial lighting today to those of 1800, we begin to understand the scope of the productivity rebound. Two hundred years ago, artificial lighting was expensive and so there was little of it. All but the very richest households had to carefully husband their candles, mostly relying on light from the fire as they gathered near the hearth. As the cost of lighting services fell, people increased their use of lighting for traditional purposes, mainly interior illumination in the evening, while also developing a multiplicity of new lighting services: security, decoration, safety, entertainment, and information among others. The aggregate effect was a huge increase in energy used for lighting in spite of, or more likely because of, an equally huge increase in energy productivity. At the end of the day, these gains in lighting efficiency did not lead to reduced energy use for lighting. As Thomas Edison said about his cost-reducing innovations, "We will make electric lighting so cheap that only the rich will burn candles."[9]

Refrigeration has seen a similar productivity rebound. Half a century ago, domestic fridges were small, extremely inefficient devices by today's standards. Again, rising incomes and falling energy costs were key in the widespread adoption of this appliance by all households in wealthier countries. At the same time, cooling devices became significantly more efficient, with a dramatic reduction in operating costs. The result? An explosion of demand for all manner of cooling services and devices. A suburban house in North America today could well have air conditioning, a large fridge, a freezer, a water-cooler, a wine and beer cooler, and a desk-top fridge. The family might also have a portable electric cooler for travel.

And this is just at the level of direct energy use. Refrigeration now provides an abundance of once-unimaginable goods and services. Food stores have extensive frozen and cooled food and drinks, often stored in coolers without doors to seal them from the heated interior of the store. Frozen and fresh food is transported long distances in refrigerated trains, trucks, boats, and planes, a non-existent service 50 years ago. Moreover, the amount of refrigerated food that we eventually waste has grown significantly – by some accounts we now discard 40% of the food that at some point was frozen or maintained at a cool temperature. Hotels and motels have small fridges in each room, often running with nothing in them, or cooling beverages that no one uses.

In addition to food, refrigeration devices now provide other services, as Ming pointed out at a neighborhood barbecue.

"I sometimes wish I had never entered that energy contest."

"How's that?"

"I didn't save much energy, but I sure notice things now."

"Like what?"

"Take my local gym. In the past, my work-out was thirty minutes on the treadmill, listening to my iPod. I decompress as my thoughts drift with the music. Lately, instead of relaxing, I notice all the crazy ways the gym uses energy, especially all the new devices. They've got water coolers everywhere, which is pretty bizarre since our tap water is cold. Also, they keep getting more treadmills, exercise bikes and ellipticals. People used to jog or lift weights for a workout. Now, these plugged-in machines are running exercise programs, heart monitors, timers, music, TV. They could be self-powering if they tapped into the energy of the exerciser – like those old mini-generators on bikes that used the spinning wheel to power the light."

"Now you're talking."

"Last year they installed a small TV monitor on every jogging and cycling machine. These are on all the time, although no one seems to be watching. Like me, everyone just listens to their iPod. And now they have a fan in front of every machine. Everyone turns these on, but no one turns them off. Some days I've seen all twenty fans whirring away, with only me

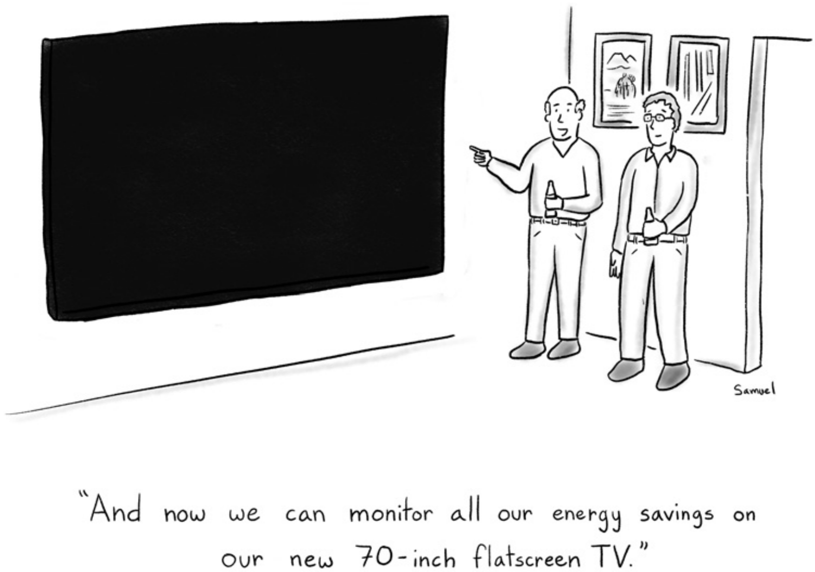

Figure 10.1 Cartoon by Jacob Fox

on a machine. You should see the looks I get as I turn them all off. I'm starting to feel obsessed about this energy waste."

"Careful. Soon they'll be coming for you."

"There's more. They just installed six mini-fridges in the work-out room. Three of these are for drinks, so the fridge door is constantly being opened and closed. And three are for – wait for it – cooling your towel while you exercise. I'm not making this up."

"Did you speak to the manager?"

"I did! He gave me a speech about how they compete with other gyms, and these things are worth the cost. When I asked for proof, he gave me a weird look and made some excuse to get away. I wish I'd never entered that damn energy contest!"

Fearing I might fan the flames, I didn't dare tell Ming Ed Begley Jr.'s story about a typical member of his local gym. "There's this guy who drives his BMW 10 or 15 miles to the gymnasium. He walks inside, and what does he do? He gets on a bicycle and pedals, going *nowhere.* And what do we do with that energy? *Nothing.*"[10]

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Former US Environmental Protection Agency Administrator Lisa Jackson reflected a common view when she said, "We're showing people across the country how energy efficiency can be part of what they do every day … confronting climate change, saving money on our utility bills, and reducing our use of heavily-polluting energy can be as easy as making a few small changes."[11] Yet the evidence of the last two decades has shown that energy efficiency is rarely cheap, involves much more than a few small changes, and can actually increase overall energy use. Why, then, do so many opinion leaders still argue that energy saving is key to our climate challenge? Why do politicians, environmentalists, and corporate heads say it? And why are physicists and engineers such ardent efficiency promoters?

As it turns out, each of these groups has its own motives for claiming that conservation and energy efficiency are critical. By their training, physicists and engineers are sensitized to the fact that humans could use much less energy to attain a given amount of goods and services. Physicists know how little energy is required to heat a room or transport someone from point A to point B. Engineers know about technologies that are far more efficient than the equipment people typically acquire.

But neither of these professions have expertise in human behavior, and therefore on the hidden costs and risks that economists find in any prospective investment, or on the feedback effects that drive increased use as energy costs decline. Time and again, narrowly focused studies of energy-saving potential are produced by physicists and engineers, always concluding that energy savings are profitable, always ignoring evidence from economists, behavioral psychologists, and market experts about the hidden costs, risks, and rebounds.

But what about other key players? Why do environmentalists embrace the idea that saving energy is cheap and easy?

A key factor is the wishful thinking bias that I described in earlier chapters. Those concerned about environmental threats are especially conscious of the wastefulness of human economies that I described in Chapter 7. They see that energy efficiency and conservation will reduce wastes and help transition to a less harmful economy. Unfortunately, when we hope for such changes we are susceptible to the seductive argument that reducing waste is win-win because of its profitability. If correct, this might increase our chance of motivating fellow citizens to act. Telling someone they can make money while saving the world is a lot easier than telling them they must spend money to save the world.

What about industrial leaders? Why do they parrot the call for energy efficiency as the leading climate strategy? Perhaps you can guess. The clamor of physicists, engineers, and environmentalists for a greater effort on energy efficiency lets polluting corporations off the hook. It delays the day when governments finally acknowledge that we must apply regulations or carbon pricing to quickly phase out the burning of fossil fuels. When governments finally do this, life gets trickier for corporations. They must navigate an uncertain period of accelerated technological change in which some firms will thrive while others fail. Will most vehicles be electric, biofuel, or hydrogen? How will homes be heated and cooled? What energy will industrial plants use? Corporations struggle already with uncertainties, and many are nervous that climate-energy policies will amplify these.

What about politicians? While some are sincere about climate change, they also need to get re-elected. They instinctively gravitate to beliefs that are politically saleable, like the serendipitous story that saving energy is profitable. If true, there is little need for compulsory policies. Non-compulsory policies, like information programs and a few subsidies, sound awfully attractive when your goal is re-election in four years.

While we might feel cynical about the energy efficiency jingoism of some political and corporate leaders, especially if these same people are not aggressively pushing for pricing or regulation of GHG emissions, we must recognize that most advocates of energy efficiency also want effective climate-energy policies. And although the evidence may not support their belief in the widescale profitability of energy efficiency, it does support their view that reducing our energy consumption will reduce not just GHG emissions, but also other negative impacts from the production and use of energy. By reducing the size of the energy system, energy efficiency provides multiple benefits.

The global demand for energy grew 12-fold in the last century. With over a billion people still having restricted or no access to electricity and modern fuels, and the global population slated to reach 9 or 10 billion by mid-century, the global demand for energy will grow. Even if people in wealthier countries dramatically cut their energy use, the global use of energy will grow significantly to better the lives of people in the developing world. If much of that energy is provided by the burning of fossil fuels, without carbon capture, GHG emissions will grow.

The only viable strategy is to push hard for a rapid transition to zero-emission energy. But the best chance for this transition is if energy efficiency is rapidly improving at the same time. If accelerated gains in energy efficiency can reduce by 10% or even 20% the size of the global energy system from what it otherwise would be, this improves our chances with the decarbonization task. But this efficiency improvement, to be sustained and substantial, needs rising energy prices. Compulsory decarbonization policies, even if flex-regs rather than carbon taxes, will increase the cost of energy, which improves the prospects for energy efficiency. But to push for energy efficiency first is to put the cart before the horse.

As summarized in the text box, claims for the profitability and ease of energy efficiency can inadvertently help those who oppose effective action on climate by giving climate-insincere politicians an argument for weak or no decarbonization policies. If energy efficiency advocates instead integrate their pursuit of efficiency with the campaign for stringent regulation or pricing of GHG emissions, they improve the prospects for both energy efficiency and success with the climate-energy challenge.

Deep decarbonization requires policies that price carbon or regulate technologies.

These compulsory policies will cause fuel switching to low-emission energy and dramatic improvements in energy efficiency.

The wishful thinking claim that energy efficiency is profitable undermines the argument for compulsory decarbonization policies, because insincere or reluctant politicians can argue energy efficiency will happen from market forces without needing climate policy.

Energy efficiency advocates help the planet and their cause by focusing their policy campaigns on compulsory decarbonization policies.