Chapter 5

Cheaper than Free?

Climate protection would actually reduce costs, not raise them … because saving fossil fuel is a lot cheaper than buying it.

—Amory Lovins, Scientific American, 2005

IF PEAK-OIL PROPONENTS are the pessimists of the energy world, physicists are the optimists. Peak-oil buffs believe that having less oil will "end civilization as we know it," while energy guru Amory Lovins tells us that "oil problems will fade away" and that "displacing most, probably all, of our oil … makes money." Lovins thinks oil production will peak because we'll realize it's a waste of money and largely stop using it.

In the early days of the first OPEC crisis, a number of physicists vigorously advocated conservation as the primary defense against OPEC. They claimed it was cheaper than increasing the supply of oil and sometimes cheaper than free. For example, insulation might save more in fuel costs than it cost to insulate. A couple of years into the crisis, in 1976, Lovins published, in *Foreign Affairs* magazine, a manifesto for the conservation movement. In "The Road Not Taken," he advocated a "soft energy path" to reverse the growth in U.S. energy use by conservation measures that would be cheaper than free. In spite of lacking a degree in physics, this made him perhaps the best-known member of what I will call the physics camp.

While many policy analysts and politicians, including Presidents Gerald Ford and Jimmy Carter, believed in stimulating conservation by raising energy prices, few believed this could be the primary solution to our energy problems. But as it turned out, it was mainly what put an end to OPEC's reign in 1986.

Without question, the physicists were right about conservation's importance. And they were right that, as Lovins puts it, conservation does not have to mean "discomfort or privation (doing less, worse or without)." Most of the physics camp, and many economists, agree that some conservation measures are cheaper than free. But Lovins goes further and claims that everything we need in the way of energy policy is cheaper than free. Is he right about this?

How Cheap is Electricity Conservation?

As with peak oil, we can look to history to evaluate claims that conservation will be cheaper than free. Lovins's 1990 paper "Four Revolutions in Electric Efficiency" provides a historical test of this idea. It concludes that four electricity revolutions were in full swing with no roadblocks in sight (see "Electric Revolutions"). In short, he predicted that by now we could be using almost no electricity—only about 3 percent of what we used in 1990—and that this conservation effort could save us, counting all costs, over two hundred billion dollars a year. To be fair, he did not think we would take full advantage of these opportunities.

Electric Revolutions

In a 1990 article, Amory Lovins predicted that four "revolutions" in electric efficiency would greatly accelerate the conservation of electricity. The revolutions were:

1. Technical Progress. For example, better light bulbs.
2. Markets for "negawatts." Negawatts are watts of electricity not used.
3. Cultural change inside utilities. For example, learning that conservation is profitable.
4. Reforms in regulatory philosophy and practice. In particularly, "decoupling" profits from increased sales.

Lovins's starting point is that already in 1990, "the best technologies now on the market could save about 92 percent of U.S. lighting energy." However for all electrical uses combined he claimed that only three quarters of the electricity used was unnecessary. Moreover, Lovins's tells us that conserving that much would have cost eleven times less than using the saved electricity.

Next he claims that the cheaper-than-free opportunities had doubled in the previous five years, and would do so again in the next five and that he saw "no signs of this slowing down." Better yet, the cost of conserving, would be decreased by three times every five years. (See “Predicting Conservation” for his calculations.)

As it turned out, between 1990 and 2005, electricity use went up 34 percent, not down 97 percent. It’s hard to say exactly what went wrong, because Lovins doesn’t leave behind documentation that others can check. But the point to remember is that counting on energy savings to happen on its own, even when the potential seems gargantuan and monetary savings enormous, is risky business.

Predicting Conservation:
By 2005 we could use only 3 percent as much electricity.

Lovins is famous for his command of facts and numbers, which seem to prove that amazingly cheap conservation is possible. But, a close look at his numbers in “Four Revolutions” reveals that the individual claims not only sound amazing, but are in fact completely unbelievable, as confirmed by history. (Warning, math ahead.)

First claim: The levelized cost of that quadrupled end-use efficiency averages about 0.6 cents/kWh.

“That quadrupled end-use efficiency” refers to the entire electricity sector, which Lovins says could have used four times less electricity in 1990. In 1990, the cost of electricity was 6.6 cents/kWh, so saving electricity for only 0.6 cents/kWh, is eleven times cheaper than buying it.

Second claim: We now can save approximately twice as much electricity as we could five years ago, but at only a third of the real cost. That is about a six-fold gain in cost-effective potential in five years, and nearly a 30-fold gain during the past 10 years. I see no signs of this slowing down.

Here Lovins tells us how fast things are getting better. Every five years we can save “twice as much” electricity as before, and he sees “no signs of this slowing.” So his original “quadrupled” efficiency, a 4-fold gain in 1990, doubles to become an 8-fold gain in 1995, then doubles to a 16-fold gain in 2000, and finally becomes a 32-fold efficiency gain in 2005.

This would mean using 32 time less electricity—only 3 percent as much as in 1990. Meanwhile, with the cost of efficiency starting so low and dropping so quickly, the efficiency measures would cost almost nothing. Instead of conserving, fools that we are, we are using 34 percent more electricity, and spending $290 billion dollars per year on it.

Hypercars and Formula One Race Cars

After predicting revolutions in electricity conservation, Lovins refocused on "Hypercars," vehicles designed to get such good mileage that they will, according to Lovins, "ultimately save as much oil as OPEC now sells." They were in the news on and off for ten years, so you may have heard of them, but do you know what ever happened to them? They sounded great. Were they too expensive? Were they underpowered? Let's follow their development to find out.

The story begins in 1981 with the McLaren MP4/1 Formula One race car—the first built on a carbon-fiber chassis. Carbon fiber is almost pure carbon. It is stronger than steel but much lighter. It is also much more expensive. In Formula One racing, where money is no object, carbon-fiber frames immediately rocketed in popularity. Ferrari has also used carbon fiber in a $500,000 supercar, as has Tesla Motors in its electric sports car, which has a base price of only $98,000.

In December 1990, while Lovins was writing about top-of-the-line cars that would get 60 miles per gallon, General Motors was planning its Ultralite, a four-passenger, carbon-fiber car that could go 135 miles an hour. In April 1991, the company began chassis fabrication. By then, Lovins was reviewing state-of-the-art industry car designs. In July, when Lovins presented his ideas on fuel efficiency to a committee of the National Academy of Sciences, which was working on a report on fuel efficiency. Someone from General Motors heard the talk and invited Lovins to a sneak preview of the Ultralite. By December 1991, the company was showing the car to the press. Although General Motors claimed the car got 100 miles per gallon at 50 miles per hour, the Environmental Protection Agency tested it at only 88 miles per gallon.

By March 1994, Lovins was speeding toward the Hypercar:

> "We are currently working with approximately 20 capable entities eager to bring Supercars [the original name for Hypercars] to market, and there are more entities joining the list almost weekly. Several are automakers. … There's been an astonishing flurry of licensing and other partnering arrangements just in the last few months with many of the key enabling technologies."

Lovins was guessing that he would see "significant production volumes starting around 1998 or 1999." He expected that by 2000 the end of steel cars would be in sight, and that by 2005 "most, if not all, of the cars in the showroom will be electrically propelled."

Later that year, specifics of the car emerged. “Analysts at Rocky Mountain Institute have simulated 300–400-mpg four-seaters with widely available technology.” To Lovins, this was not such a stretch, considering that he thought cars could get “more than 600 mpg with the best ideas now in the lab.” Lovins’s new concept that supposedly made all this possible was the idea of combining a car body like that of the Ultralite carbon fiber body with an electric hybrid motor. Neither idea was new, but after combining them, Lovins believed he had found a “powerful synergy between ultralight construction and hybrid-electric drive; the 1-plus-2-equals-10 equation.” All this sounds impressive, but the theory may be better than the reality (see “The Hypercar Fallacy”).

“By spring 1996,” Lovins says, “commitments to ultralight-hybrid development totaled ~$1 billion, recently doubling in less than a year.” In early 1998, Lovins urged the plastics industry to build one Hypercar for demonstration purposes, estimating it “could cost on the order of $10–100 million.”

Hydrogen Hypercars

By early 1999, With the rising interest in hydrogen, Lovins saw another opportunity for increased efficiency and cost savings. He would replace the Hypercar’s hybrid motor with a hydrogen-fuel-cell motor. But this created a new hurdle—how to develop a hydrogen economy to support hydrogen-fuel-cell Hypercars. Lovins recognized that two problems, each insurmountable on its own, could be combined, using the logic of the one-plus-two-equals-ten equation. The combination would yield an efficient and even profitable solution.

In April 1999, he published “A Strategy for the Hydrogen Transition.” It explained how, when Hypercars were parked at work, their hydrogen fuel cells could generate electricity and pure water for the buildings they were near. This would soon make hydrogen Hypercars the dominant paradigm of the emerging hydrogen industry.”

“As should become clear in the marketplace in the next year or two, this alternative strategy is already starting to be accepted by some large energy and car firms. We expect its logic will gradually make it the dominant paradigm of the emerging hydrogen industry.”

Even earlier, in 1995, Lovins had realized that Hypercars would kill the oil industry:

The Hypercar Fallacy: "1 plus 2 equals 10"

Lovins believed that combining two efficiency ideas would get us more than the sum of their savings, and called this his "1 plus 2 equals 10 equation." Let's check the math.

First efficiency idea: using carbon fiber: GM's carbon-fiber Ultralite got 88 miles per gallon. That's about four times better than normal cars were getting. For round numbers, say the "carbon" idea takes a normal car from 20 to 80 miles per gallon.

Second efficiency idea: hybrid motor: This is the idea Lovins combined with carbon to come up with the Hypercar. Using both ideas, he claimed that a "300-400-mpg four seater with widely available technology was possible." For round numbers, say the hybrid idea takes a carbon car from 80 to 320 miles per gallon. That's four times better than a carbon car, and 16 times better than a normal car.

So a four-times-better idea (carbon) combined with another four-times-better idea (hybrid) is 16 times better. So in this example, "4 + 4 = 16." That's what Lovins meant by "1 plus 2 equals 10." The miles-per-gallon more than add up.

But the idea is to save gasoline, so we had better check gas savings.

Suppose the normal 20 mpg car used 800 gallons in a year. Then the carbon car would use only a quarter of this, or 200 gallons, and it would save 600 gallons a year.

Similarly, adding a hybrid motor to a normal car would quadruple the miles per gallon and save 600 gallons a year.

But if a hybrid motor is added to a carbon fiber car what happens?

Intuition: Since a carbon car only uses 200 gallons, there is no way adding a hybrid motor can save 600 gallons.

Math: Adding a hybrid motor to a carbon car cuts gas usage four times, from 200 to 50 gallons, for an additional savings of 150 gallons, and a total savings of 600 + 150, or 750 gallons saved.

So a 600-gallon idea (carbon) combined with another 600-gallon idea (hybrid) makes a 750-gallons-saved idea. In this example, "600 + 600 = 750."

The truth is that the hybrid-motor idea saves much less, not much more, when applied to a super-good car like GM's Ultralite instead of to an ordinary car. This is well known, and it's why GM never "thought of" adding a hybrid motor to a carbon fiber car.

> "The Middle East would therefore become irrelevant and the price would crash. With so little demand, most of the oil in the ground would be no longer worth extracting."

And by mid-1998, as Lovins contemplated the switch to hydrogen-fuel-cell technology, he realized it could completely displace the coal and nuclear industries as well, as he wrote in a letter to Science magazine:

"Ultralight hybrid-electric cars have multi-billion-dollar private commitments, are coming quickly to market, and will ultimately save as much oil as the Organization of Petroleum Exporting Countries now sells. The most efficient will use H2 fuel cells whose immediate commercialization, now feasible, can displace most if not all oil, coal, and nuclear power at a profit."

By June 2001, Lovins had expanded his list of industries that the Hypercar would impact. It would also bring about the "end as we know them" of the automobile, oil, steel, aluminum, coal, nuclear, and electricity industries as we know them.

And it would not take long to bring these industries to their knees because, as Lovins put it, "Hypercars will be widely available in about five years [2006], dominant in about ten years [2011], and the old car industry will be toast in twenty years." At first I was puzzled by the disappearance of the electricity industry, but of course, Hypercars were to replace most of the large power stations by generating electricity from hydrogen when parked at work and at home.

In November 2000, as Lovins explained, Hypercar Inc., had "developed for a few million dollars in 8 months, on time and on budget," the first show-car version of the Hypercar, which they dubbed the Revolution.

The Last of the Hypercars

While realistic in appearance, the Revolution show car lacked a carbon-fiber body and any motor at all. The car was not full sized—it was just for show. Amory Lovins never did get to drive a Hypercar.. In 2004, Hypercar Inc. changed its name to Fiberforge and stopped trying to convert the world to Hypercars. Current hydrogen-fuel-cell cars would cost about $500,000 each if companies mass-produced them, according to the October 2007 Consumer Reports. And they would still lack a carbon-fiber body.

What's Wrong with a Little Optimism?

Optimism can inspire action, but it should not cloud our vision. Believing that Hypercars will end oil addiction and ward off climate change can make policy-based approaches seem unnecessary. As Lovins says,

> "Growing evidence suggests that besides fuel taxes and efficiency regulations, there's an even better way: light vehicles can become very efficient through breakthrough engineering."

In other words, Lovins is saying his "better way" makes energy efficiency policies unnecessary. But Lovins proved, by rigorous experiment, that this "even better way" is next to impossible. He had a better chance than anyone of finding it, and he did his best for nearly fifteen years. In the end he could not get a single prototype Hypercar produced.

It may have been what Lovins calls "cultural barriers"—in other words, a lack of faith by others in his concept—but if so, Lovins saw this from the start and did his best to breach those barriers. On the other hand, it may have been that the Hypercar was just too expensive, as industry leaders apparently decided. If so, Lovins has demonstrated that betting on breakthrough technologies is far too risky, even when the world's leading energy guru places the bet.

Perhaps Lovins claimed that government policies were unnecessary only as a way of promoting the virtues of his Hypercar. Perhaps he didn't mean it. But Lovins's paper "Four Revolutions in Electric Efficiency" seems to confirm his dismissal of efficiency regulations. It's like the Sherlock Holmes mystery about the dog that didn't bark when a crime was committed. In twenty pages, his paper contains no hint of appliance standards, even though that's the first thing one would have expected.

In 1978, California passed the first refrigerator-efficiency standards. The federal government followed in 1987, scheduling eight appliance standards, including refrigerator standards, to take effect on January 1, 1990. This was the most publicized, and most high-impact electric efficiency event ever, and it was in progress while Lovins wrote his article on electric efficiency. Why would Lovins fail to mention it?

In effect, his article argues that we do not need standards because the four revolutions he sees happening on their own will be vastly more effective. The nicest think I can find Lovins saying about building codes and appliance standards is that they are "better than nothing."

The trouble with Lovins's optimism is that it is not just a little optimism. It overwhelms all other approaches. It says we don't need efficiency standards and really any government policies. All we need to do is wait to buy a Hypercar and keep an eye out for new efficient technologies that will save us money. New technology will crush OPEC, the coal industry and nuclear industry. Global warming will fade away.

Lovins is right to favor conservation, and right to favor the use of markets. Some of his ideas are practical. But three centuries of technical progress have brought unimaginable efficiency gains—and vastly increased use of fossil fuel—without solving our energy problems. Something more is needed than Lovins's promise of "breakthrough engineering" and faith that corporations will break down their "cultural barriers." Lovins objectives are well intentioned, but his hyper-optimism is a barrier to almost every effective energy policy.