MORE PROFIT WITH LESS CARBON

BY AMORY B. LOVINS

Focusing on energy efficiency will do more than protect Earth's climate—it will make businesses and consumers richer

A basic misunderstanding skews the entire climate debate. Experts on both sides claim that protecting Earth's climate will force a trade-off between the environment and the economy. According to these experts, burning less fossil fuel to slow or prevent global warming will increase the cost of meeting society's needs for energy services, which include everything from speedy transportation to hot showers. Environmentalists say the cost would be modestly higher but worth it; skeptics, including top U.S. government officials, warn that the extra expense would be prohibitive. Yet both sides are wrong. If properly done, climate protection would actually *reduce* costs, not raise them. Using energy more efficiently offers an economic bonanza—not because of the benefits of stopping global warming but because saving fossil fuel is a lot cheaper than buying it.

The world abounds with proven ways to use energy more productively, and smart businesses are leaping to exploit them. Over the past decade, chemical manufacturer DuPont has boosted production nearly 30 percent but cut energy use 7 percent and greenhouse gas emissions 72 percent (measured in terms of their carbon dioxide equivalent), saving more than $2 billion so far. Five other major firms—IBM, British Telecom, Alcan, NorskeCanada and Bayer—have collectively saved at least another $2 billion since the early 1990s by reducing their carbon emissions more than 60 percent. In 2001 oil giant BP met its 2010 goal of reducing carbon dioxide emissions 10 percent below the company's 1990 level, thereby cutting its energy bills $650 million over 10 years. And just this past May, General Electric vowed to raise its energy efficiency 30 percent by 2012 to enhance the company's shareholder value. These sharp-penciled firms, and dozens like them, know that energy efficiency improves the bottom line and yields even more valuable side benefits: higher quality and reliability in energy-efficient factories, 6 to 16 percent higher labor productivity in efficient offices, and 40 percent higher sales in stores skillfully designed to be illuminated primarily by daylight.

The U.S. now uses 47 percent less energy per dollar of economic output than it did 30 years ago, lowering costs

BURNING FOSSIL FUELS not only contributes to global warming—it wastes money. Improving the energy efficiency of factories, buildings, vehicles and consumer products would swiftly reduce the consumption of coal and oil, curbing the damage to Earth's climate while saving immense amounts of money for businesses and households.

CARY WOLINSKY (*photography*); JEN CHRISTIANSEN (*photoillustration*)

by $1 billion a day. These savings act like a huge universal tax cut that also reduces the federal deficit. Far from dampening global development, lower energy bills accelerate it. And there is plenty more value to capture at every stage of energy production, distribution and consumption. Converting coal at the power plant into incandescent light in your house is only 3 percent efficient. Most of the waste heat discarded at U.S. power stations—which amounts to 20 percent more energy than Japan uses for everything—could be lucratively recycled. About 5 percent of household electricity in the U.S. is lost to energizing computers, televisions and other appliances that are turned off. (The electricity wasted by poorly designed standby circuitry is equivalent to the output of more than a dozen 1,000-megawatt power stations running full-tilt.) In all, preventable energy waste costs Americans hundreds of billions of dollars and the global economy more than $1 trillion a year, destabilizing the climate while producing no value.

CROSSROADS FOR

ENERGY

THE PROBLEM

- The energy sector of the global economy is woefully inefficient. Power plants and buildings waste huge amounts of heat, cars and trucks dissipate most of their fuel energy, and consumer appliances waste much of their power (and often siphon electricity even when they are turned off).
- If nothing is done, the use of oil and coal will continue to climb, draining hundreds of billions of dollars a year from the economy as well as worsening the climate, pollution and oil-security problems.

THE PLAN

- Improving end-use efficiency is the fastest and most lucrative way to save energy. Many energy-efficient products cost no more than inefficient ones. Homes and factories that use less power can be cheaper to build than conventional structures. Reducing the weight of vehicles can double their fuel economy without compromising safety or raising sticker prices.
- With the help of efficiency improvements and competitive renewable energy sources, the U.S. can phase out oil use by 2050. Profit-seeking businesses can lead the way.


Rooftop solar array

S. STRONG *Solar Design Associates, Inc.*

If energy efficiency has so much potential, why isn't everyone pursuing it? One obstacle is that many people have confused efficiency (doing more with less) with curtailment, discomfort or privation (doing less, worse or without). Another obstacle is that energy users do not recognize how much they can benefit from improving efficiency, because saved energy comes in millions of invisibly small pieces, not in obvious big chunks. Most people lack the time and attention to learn about modern efficiency techniques, which evolve so quickly that even experts cannot keep up. Moreover, taxpayer-funded subsidies have made energy seem cheap. Although the U.S. government has declared that bolstering efficiency is a priority, this commitment is mostly rhetorical. And scores of ingrained rules and habits block efficiency efforts or actually reward waste. Yet relatively simple changes can turn all these obstacles into business opportunities.

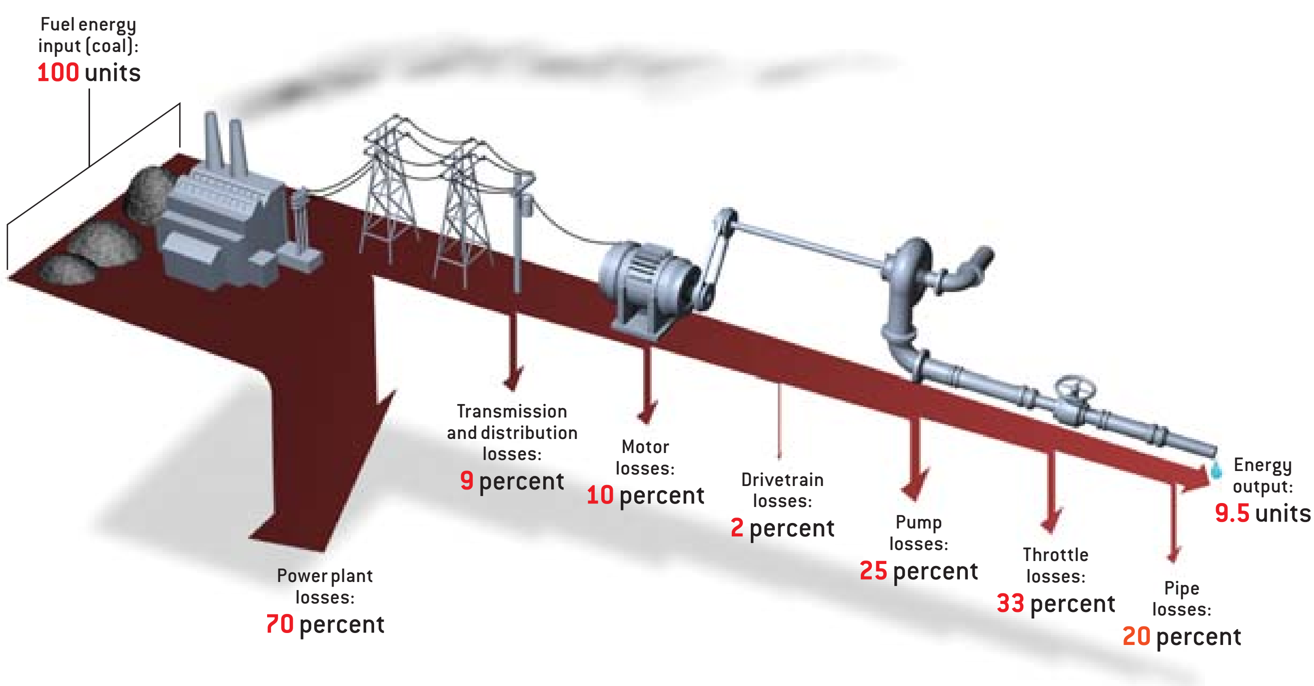
Enhancing efficiency is the most vital step toward creating a climate-safe energy system, but switching to fuels that emit less carbon will also play an important role. The world economy is already decarbonizing: over the past two centuries, carbon-rich fuels such as coal have given way to fuels with less carbon (oil and natural gas) or with none (renewable sources such as solar and wind power). Today less than one third of the fossil-fuel atoms burned are carbon; the rest are climate-safe hydrogen. This decarbonization trend is reinforced by greater efficiencies in converting, distributing and using energy; for example, combining the production of heat and electricity can extract twice as much useful work from each ton of carbon emitted into the atmosphere. Together these advances could dramatically reduce total carbon emissions by 2050 even as the global economy expands. This article focuses on the biggest prize: wringing more work from each unit of energy delivered to businesses and consumers. Increasing end-use efficiency can yield huge savings in fuel, pollution and capital costs because large amounts of energy are lost at every stage of the journey from production sites to delivered services [*see box on opposite page*]. So even small reductions in the power used at the downstream end of the chain can enormously lower the required input at the upstream end.

The Efficiency Revolution

MANY ENERGY-EFFICIENT PRODUCTS, once costly and exotic, are now inexpensive and commonplace. Electronic speed controls, for example, are mass-produced so cheaply that some suppliers give them away as a free bonus with each motor. Compact fluorescent lamps cost more than $20 two decades ago but only $2 to $5 today; they use 75 to 80 percent less electricity than incandescent bulbs and last 10 to 13 times longer. Window coatings that transmit light but reflect heat cost one fourth of what they did five years ago. Indeed, for many kinds of equipment in competitive markets—motors, industrial pumps, televisions, refrigerators—some highly energy-efficient models cost no more than inefficient ones. Yet far more important than all these better and cheaper technologies is a hidden revolution in the design that combines and applies them.

COMPOUNDING LOSSES

From the power plant to an industrial pipe, inefficiencies along the way whittle the energy input of the fuel—set at 100 arbitrary units in this example—by more than 90 percent, leaving only 9.5 units of energy delivered as fluid flow through the pipe. But small increases in end-use efficiency can reverse these compounding losses. For instance, saving one unit of output energy by reducing friction inside the pipe will cut the needed fuel input by 10 units, slashing cost and pollution at the power plant while allowing the use of smaller, cheaper pumps and motors.



For instance, how much thermal insulation is appropriate for a house in a cold climate? Most engineers would stop adding insulation when the expense of putting in more material rises above the savings over time from lower heating bills. But this comparison omits the capital cost of the heating system—the furnace, pipes, pumps, fans and so on—which may not be necessary at all if the insulation is good enough. Consider my own house, built in 1984 in Snowmass, Colo., where winter temperatures can dip to –44 degrees Celsius and frost can occur any day of the year. The house has no conventional heating system; instead its roof is insulated with 20 to 30 centimeters of polyurethane foam, and its 40-centimeter-thick masonry walls sandwich another 10 centimeters of the material. The double-pane windows combine two or three transparent heat-reflecting films with insulating krypton gas, so that they block heat as well as eight to 14 panes of glass. These features, along with heat recovery from the ventilated air, cut the house's heat losses to only about 1 percent more than the heat gained from sunlight, appliances and people inside the structure. I can offset this tiny loss by playing with my dog (who generates about 50 watts of heat, adjustable to 100 watts if you throw a ball to her) or by burning obsolete energy studies in a small woodstove on the coldest nights.

Eliminating the need for a heating system reduced construction costs by $1,100 (in 1983 dollars). I then reinvested this money, plus another $4,800, into equipment that saved half the water, 99 percent of the water-heating energy and 90 percent of the household electricity. The 4,000-square-foot structure—which also houses the original headquarters of Rocky Mountain Institute (RMI), the nonprofit group I cofounded in 1982—consumes barely more electricity than a single 100-watt lightbulb. (This amount excludes the power used by the institute's office equipment.) Solar cells generate five to six times that much electricity, which I sell back to the utility. Together all the efficiency investments repaid their cost in 10 months with 1983 technologies; today's are better and cheaper.

In the 1990s Pacific Gas & Electric undertook an experiment called ACT^2 that applied smart design in seven new and old buildings to demonstrate that large efficiency improvements can be cheaper than small ones. For example, the company built a new suburban tract house in Davis, Calif., that could stay cool in the summer without air-conditioning. PG&E estimated that such a design, if widely adopted, would cost about $1,800 less to build and $1,600 less to maintain over its lifetime than a conventional home of the same size. Similarly, in 1996 Thai architect Soontorn Boonyatikarn built a house near steamy Bangkok that required only one-seventh

DON FOLEY

the air-conditioning capacity usually installed in a structure of that size; the savings in equipment costs paid for the insulating roof, walls and windows that keep the house cool [*see box on opposite page*]. In all these cases, the design approach was the same: optimize the whole building for multiple benefits rather than use isolated components for single benefits.

Such whole-system engineering can also be applied to office buildings and factories. The designers of a carpet factory built in Shanghai in 1997 cut the pumping power required for a heat-circulating loop by 92 percent through two simple changes. The first change was to install fat pipes rather than thin ones, which greatly reduced friction and hence allowed the system to use smaller pumps and motors. The second innovation was to lay out the pipes before positioning the equipment they connect. As a result, the fluid moved through short, straight pipes instead of tracing circuitous paths, further reducing friction and capital costs.

This isn't rocket science; it's just good Victorian engineering rediscovered. And it is widely applicable. A practice team at RMI has recently developed new-construction designs offering energy savings of 89 percent for a data center, about 75 percent for a chemical plant, 70 to 90 percent for a supermarket and about 50 percent for a luxury yacht, all with capital costs lower than those of conventional designs. The team has also proposed retrofits for existing oil refineries, mines and microchip factories that would reduce energy use by 40 to 60 percent, repaying their cost in just a few years.

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Vehicles of Opportunity

TRANSPORTATION CONSUMES 70 percent of U.S. oil and generates a third of the nation's carbon emissions. It is widely considered the most intractable part of the climate problem, especially as hundreds of millions of people in China and India buy automobiles. Yet transportation offers enormous efficiency opportunities. *Winning the Oil Endgame,* a 2004 analysis written by my team at RMI and co-sponsored by the Pentagon, found that artfully combining lightweight materials with innovations in propulsion and aerodynamics could cut oil use by cars, trucks and planes by two thirds without compromising comfort, safety, performance or affordability.

Despite 119 years of refinement, the modern car remains astonishingly inefficient. Only 13 percent of its fuel energy even reaches the wheels—the other 87 percent is either dissipated as heat and noise in the engine and drivetrain or lost to idling and accessories such as air conditioners. Of the energy delivered to the wheels, more than half heats the tires, road and air. Just 6 percent of the fuel energy actually accelerates the car (and all this energy converts to brake heating when you stop). And, because 95 percent of the accelerated mass is the car itself, less than 1 percent of the fuel ends up moving the driver.

Yet the solution is obvious from the physics: greatly reduce the car's weight, which causes three fourths of the energy losses at the wheels. And every unit of energy saved at the wheels by lowering weight (or cutting drag) will save an additional seven units of energy now lost en route to the wheels. Concerns about cost and safety have long discouraged attempts to make lighter cars, but modern light-but-strong materials—new metal alloys and advanced polymer composites—can slash a car's mass without sacrificing crashworthiness. For example, carbon-fiber composites can absorb six to 12 times as much crash energy per kilogram as steel does, more than offsetting the composite car's weight disadvantage if it hits a steel vehicle that is twice as heavy. With such novel materials, cars can be big, comfortable and protective without being heavy, inefficient and hostile, saving both oil *and* lives. As Henry Ford said, you don't need weight for strength; if you did, your bicycle helmet would be made of steel, not carbon fiber.

Advanced manufacturing techniques developed in the past two years could make carbon-composite car bodies competitive with steel ones. A lighter body would allow automakers to use smaller (and less expensive) engines. And because the assembly of carbon-composite cars does not require body or paint shops, the factories would be smaller and cost 40 percent less to build than conventional auto plants. These savings would offset the higher cost of the carbon-composite materials. In all, the introduction of ultralight bodies could nearly double the fuel efficiency of today's hybrid-electric vehicles—which are already twice as efficient as conventional cars—without raising their sticker prices. If composites prove unready, new ultralight steels offer a reliable backstop. The competitive marketplace will sort out the winning materials, but, either way, superefficient ultralight vehicles will start pulling

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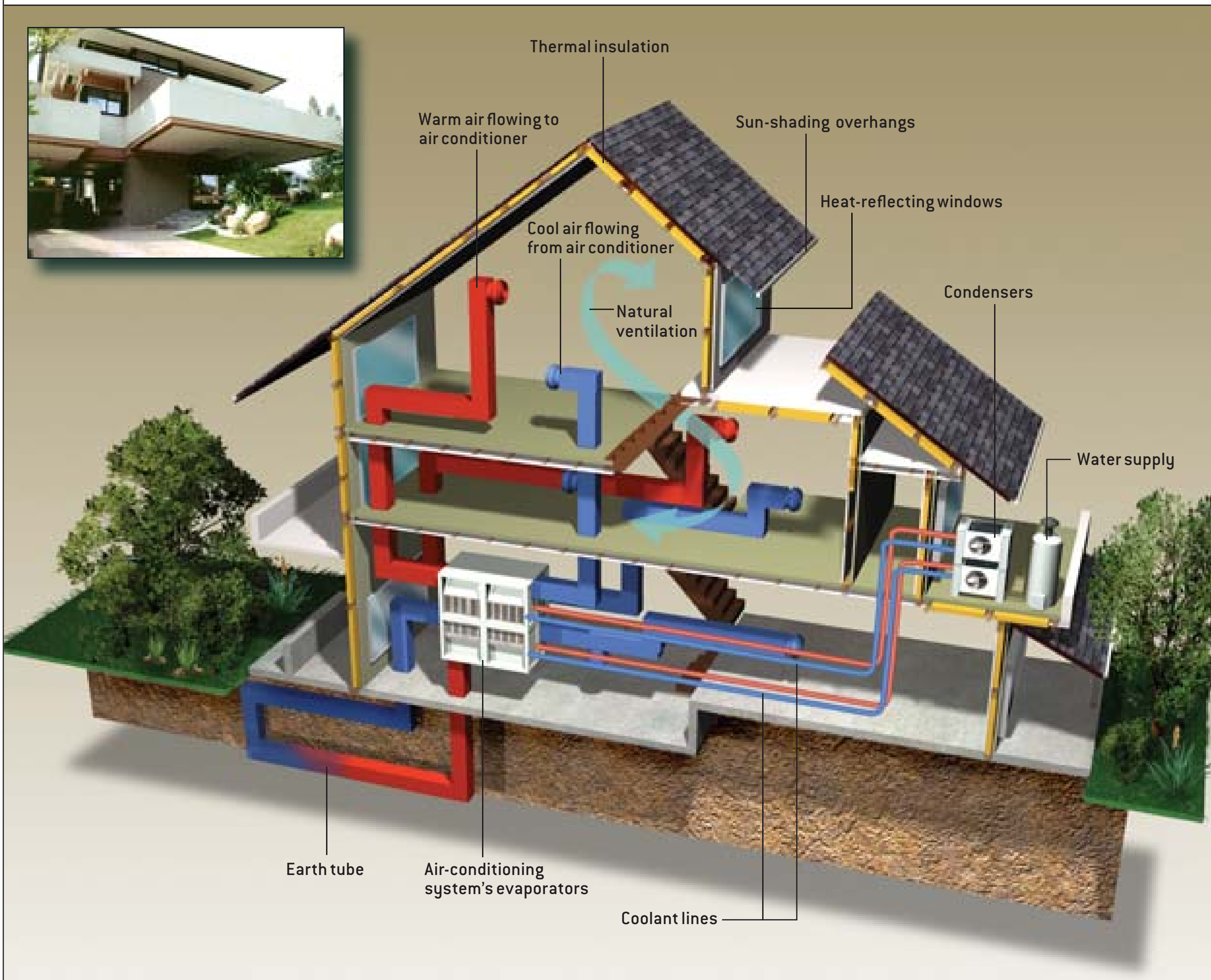
SAVING ENERGY BY DESIGN

How can you keep cool in tropical Thailand while minimizing power usage? Architect Soontorn Boonyatikarn of Chulalongkorn University used overhangs and balconies to shade his 350-square-meter home in Pathumthani, near Bangkok. Insulation, an airtight shell and infrared-reflecting windows keep heat out of the house while letting in plenty of daylight. An open floor plan and central stairwell promote ventilation, and indoor air is cooled as it flows through an underground tube. As a result, the house needs just one seventh of the typical air-conditioning capacity for a structure of its size. To further reduce energy bills, the air-conditioning system's condensers heat the house's water.



DON FOLEY (*schematic*); SOONTORN BOONYATIKARN *Chulalongkorn University* (*photograph*)

away from the automotive pack within the next decade.

What is more, ultralight cars could greatly accelerate the transition to hydrogen fuel-cell cars that use no oil at all [see "On the Road to Fuel-Cell Cars," by Steven Ashley; Scientific American, March]. A midsize SUV whose halved weight and drag cut its needed power to the wheels by two thirds would have a fuel economy equivalent to 114 miles per gallon and thus require only a 35-kilowatt fuel cell—one third the usual size and hence much easier to manufacture affordably [*see box on page 81*]. And because the vehicle would need to carry only one third as much hydrogen, it would not require any new storage technologies; compact, safe, off-the-shelf carbon-fiber tanks could hold enough hydrogen to propel the SUV for 530 kilometers. Thus, the first automaker to go ultralight will win the race to fuel cells, giving the whole industry a strong incentive to become as boldly innovative in materials and manufacturing as a few companies now are in propulsion.

RMI's analysis shows that full adoption of efficient vehicles, buildings and industries could shrink projected U.S. oil use in 2025—28 million barrels a day—by more than half, lowering consumption to pre-1970 levels. In a realistic scenario, only about half of these savings could actually be captured by 2025 because many older, less efficient cars and trucks would remain on the road (vehicle stocks turn over slowly). Before 2050, though, U.S. oil consumption could be phased out altogether by doubling the efficiency of oil use and substituting alternative fuel supplies [*see illustration on page 83*]. Businesses can profit greatly by making the transition, because saving each barrel of oil through efficiency improvements costs only $12, less than one fifth of what petroleum sells for today. And two kinds of alternative fuel supplies could compete robustly with oil even if it sold for less than half the current price. The first is ethanol made from woody, weedy plants such as switchgrass and poplar. Corn is currently the main U.S. source of ethanol, which is blended with gasoline, but the woody plants yield twice as much ethanol per ton as corn does and with lower capital investment and far less energy input.

The second alternative is replacing oil with lower-carbon natural gas, which would become cheaper and more abundant as efficiency gains reduce the demand for electricity at peak periods. At those times, gas-fired turbines generate power so wastefully that saving 1 percent of electricity would cut U.S. natural gas consumption by 2 percent and its price by 3 or 4 percent. Gas saved in this way and in other uses could then replace oil either directly or, even more profitably and efficiently, by converting it to hydrogen.

The benefits of phasing out oil would go far beyond the estimated $70 billion saved every year. The transition would lower U.S. carbon emissions by 26 percent and eliminate all the social and political costs of getting and burning petroleum—military conflict, price volatility, fiscal and diplomatic distortions, pollution and so on. If the country becomes oil-free, then petroleum will no longer be worth fighting over. The Pentagon would also reap immediate rewards from raising energy efficiency because it badly needs to reduce the costs and risks of supplying fuel to its troops. Just as the U.S. Department of Defense's research efforts transformed civilian industry by creating the Internet and the Global Positioning System, it should now spearhead the development of advanced ultralight materials.

The switch to an oil-free economy would happen even faster than RMI projected if policymakers stopped encouraging the perverse development patterns that make people drive so much. If federal, state and local governments did not mandate and subsidize suburban sprawl, more of us could live in neighborhoods where almost everything we want is within a five-minute walk. Besides saving fuel, this New Urbanist design builds stronger communities, earns more money for developers and is much less disruptive than other methods of limiting vehicle traffic (such as the draconian fuel and car taxes that Singapore uses to avoid Bangkok-like traffic jams).

ADDICTED TO OIL

28 million

Barrels of oil that will be consumed each day in the U.S. by 2025 if current trends continue

13 percent

The proportion of a car's fuel energy that reaches its wheels

$70 billion

Annual savings (by 2025) from improving the efficiency of oil use and finding substitutes for oil

Renewable Energy

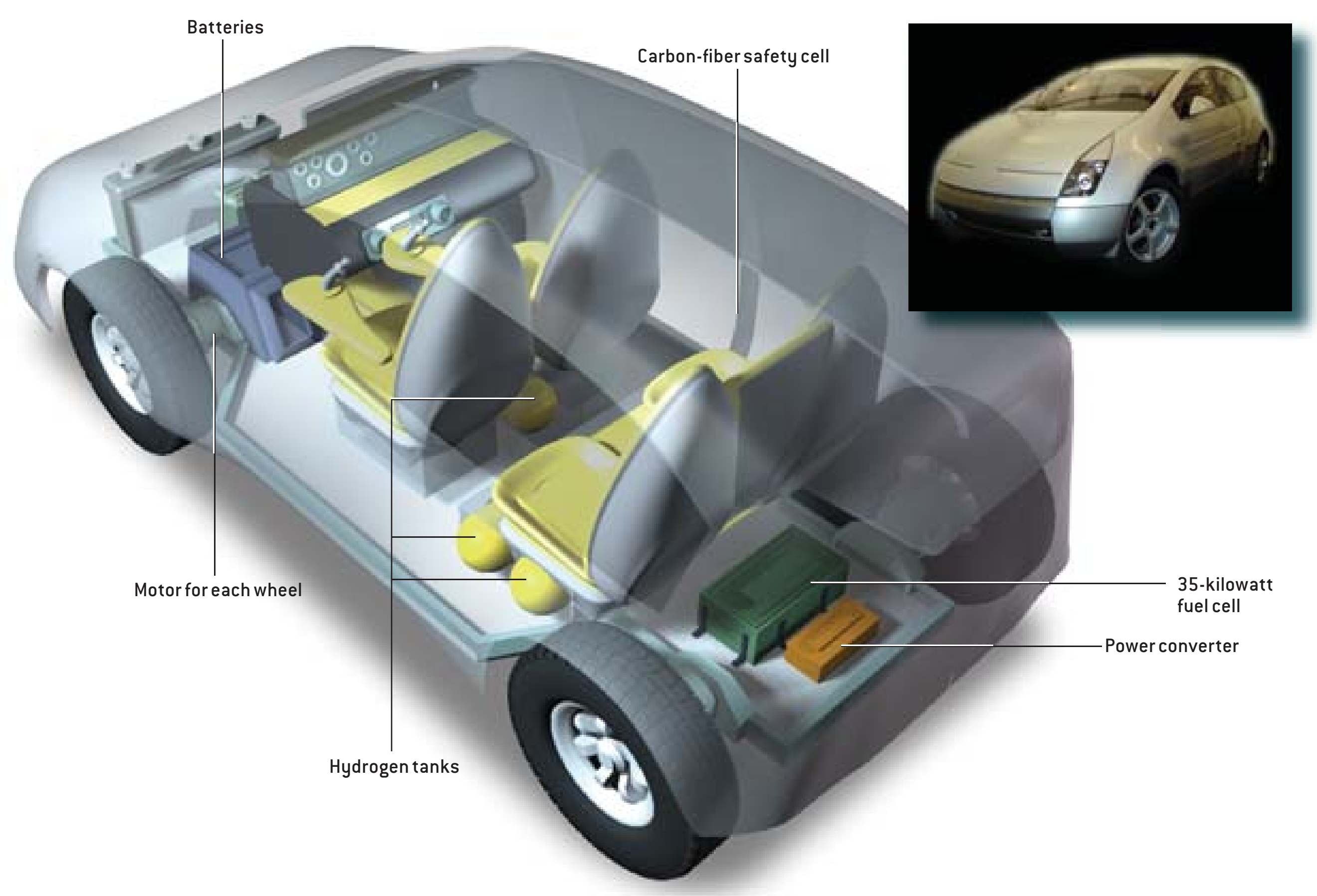
EFFICIENCY IMPROVEMENTS that can save most of our electricity also cost less than what the utilities now pay for coal, which generates half of U.S. power and 38 percent of its fossil-fuel carbon emissions. Furthermore, in recent years alternatives to coal-fired power plants—including renewable sources such as wind and solar power, as well as decentralized cogeneration plants that produce electricity and heat together in buildings and factories—have begun to hit their stride. Worldwide the collective generating capacity of these sources is already greater than that of nuclear power and growing six times as fast [*see illustration on page 82*]. This trend is all the more impressive because decentralized generators face many obstacles to fair competition and usually get much lower subsidies than centralized coal-fired or nuclear plants.

Wind power is perhaps the greatest success story. Mass production and improved engineering have made modern wind turbines big (generating two to five megawatts each), extremely reliable and environmentally quite benign. Denmark already gets a fifth of its electricity from wind, Germany a tenth. Germany and Spain are each adding more than 2,000 megawatts of wind power each year, and Europe aims to get 22 percent of its electricity and 12 percent of its total energy from renewables by 2010. In contrast, global nuclear generating capacity is expected to remain flat, then decline.

The most common criticism of wind power—that it produces electricity too intermittently—has not turned out to be a serious drawback. In parts of Europe that get all their power from wind on some days, utilities have overcome the problem by diversifying the locations of their wind turbines, incorporating wind forecasts into their generating plans and integrating wind power with hydroelectricity and other energy sources. Wind and solar power work particularly well together, partly because the conditions that are bad for wind (calm, sunny weather) are good for solar, and vice versa. In fact, when properly combined, wind and solar facilities are more reliable than conventional power stations—they come in smaller modules (wind turbines, solar cells) that are less likely to fail all at once, their costs do not swing wildly with the prices of fossil fuels, and terrorists are much more likely to attack a nuclear

A LEAN, MEAN DRIVING MACHINE

Ultralight cars can be fast, roomy, safe and efficient. A concept five-seat midsize SUV called the Revolution, designed in 2000, weighs only 857 kilograms—less than half the weight of a comparable conventional car—yet its carbon-fiber safety cell would protect passengers from high-speed collisions with much heavier vehicles. A 35-kilowatt fuel cell could propel the car for 530 kilometers on 3.4 kilograms of hydrogen stored in its tanks. And the Revolution could accelerate to 100 kilometers per hour in 8.3 seconds.



DON FOLEY (*schematic*); HYPERCAR, INC. (*photograph*)

reactor or an oil terminal than a wind farm or a solar array.

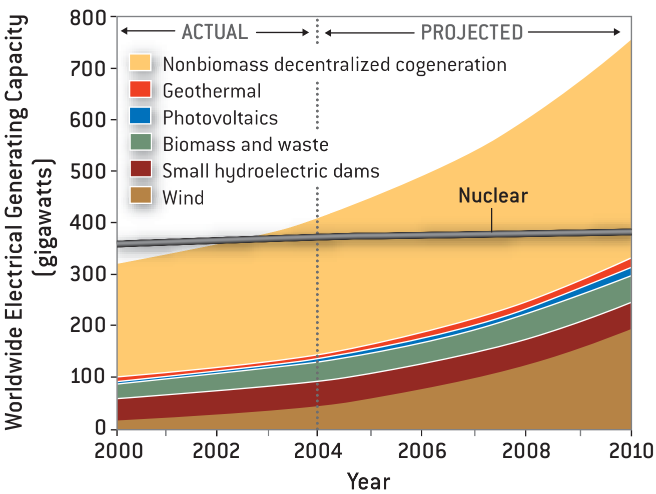
Most important, renewable power now has advantageous economics. In 2003 U.S. wind energy sold for as little as 2.9 cents a kilowatt-hour. The federal government subsidizes wind power with a production tax credit, but even without that subsidy, the price—about 4.6 cents per kilowatt-hour—is still cheaper than subsidized power from new coal or nuclear plants. (Wind power's subsidy is a temporary one that Congress has repeatedly allowed to expire; in contrast, the subsidies for the fossil-fuel and nuclear industries are larger and permanent.) Wind power is also abundant: wind farms occupying just a few percent of the available land in the Dakotas could cost-effectively meet all of America's electricity needs. Although solar cells currently cost more per kilowatt-hour than wind turbines do, they can still be profitable if integrated into buildings, saving the cost of roofing materials. Atop big, flat-roofed commercial buildings, solar cells can compete without subsidies if combined with efficient use that allows the building's owner to resell the surplus power when it is most plentiful and valuable—on sunny afternoons. Solar is also usually the cheapest way to get electricity to the two billion people, mostly in the developing world, who have no access to power lines. But even in rich countries, a house as efficient as mine can get all its electricity from just a few square meters of solar cells, and installing the array costs less than connecting to nearby utility lines.

Cheaper to Fix

INEXPENSIVE EFFICIENCY improvements and competitive renewable sources can reverse the terrible arithmetic of climate change, which accelerates exponentially as we burn fossil fuels ever faster. Efficiency can outpace economic growth if we pay attention: between 1977 and 1985, for example, U.S. gross domestic product (GDP) grew 27 percent, whereas oil use fell 17 percent. (Over the same period, oil imports dropped 50 percent, and Persian Gulf imports plummeted 87 percent.) The growth of renewables has routinely outpaced GDP; worldwide, solar and wind power are doubling every two and three years, respectively. If both efficiency and renewables grow faster than the economy, then carbon emissions will fall and global warming will slow—buying more time to develop even

Wind turbines in Germany

ELECTRICITY ALTERNATIVES



DECENTRALIZED SOURCES of electricity—cogeneration (the combined production of electricity and heat, typically from natural gas) and renewables (such as solar and wind power)—surpassed nuclear power in global generating capacity in 2002. The annual output of these low- and no-carbon sources will exceed that of nuclear power this year.

better technologies for displacing the remaining fossil-fuel use, or to master and deploy ways to capture combustion carbon before it enters the air [see "Can We Bury Global Warming?" by Robert H. Socolow; SCIENTIFIC AMERICAN, July].

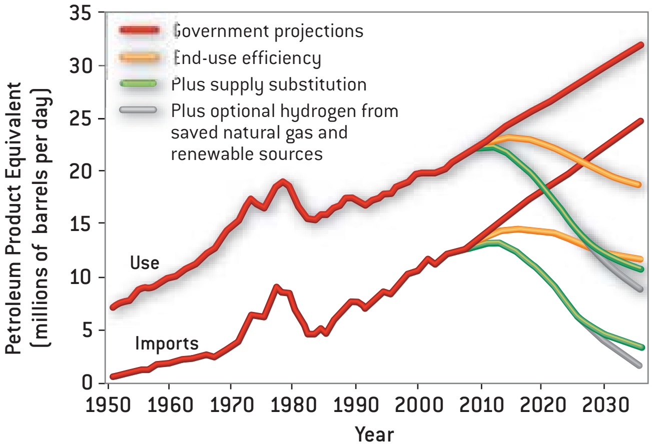
In contrast, nuclear power is a slower and much more expensive solution. Delivering a kilowatt-hour from a new nuclear plant costs at least three times as much as saving one through efficiency measures. Thus, every dollar spent on efficiency would displace at least three times as much coal as spending on nuclear power, and the efficiency improvements could go into effect much more quickly because it takes so long to build reactors. Diverting public and private investment from market winners to losers does not just distort markets and misallocate financial capital—it worsens the climate problem by buying a less effective solution.

The good news about global warming is that it is cheaper to fix than to ignore. Because saving energy is profitable, efficient use is gaining traction in the marketplace. U.S. Environmental Protection Agency economist Skip Laitner calculates that from 1996 to mid-2005 prudent choices by businesses and consumers, combined with the shift to a more information- and service-based economy, cut average U.S. energy use per dollar of GDP by 2.1 percent a year—nearly three times as fast as the rate for the preceding 10 years. This change met 78 percent of the rise in demand for energy services over the past decade (the remainder was met by increasing energy supply), and the U.S. achieved this progress without the help of any technological breakthroughs or new national policies. The climate problem was created by millions of bad decisions over decades, but climate stability can be restored by millions of sensible choices—buying a more efficient lamp or car, adding insulation or caulk to your home, repealing subsidies for waste and rewarding desired outcomes (for example, by paying architects and engineers for savings, not expenditures).

The proper role of government is to steer, not row, but for years officials have been steering our energy ship in the wrong direction. The current U.S. energy policy harms the economy and the climate by rejecting free-market principles and playing favorites with technologies. The best course is to allow every method of producing or saving energy to compete fairly, at honest prices, regardless of which kind of investment it is, what technology it uses, how big it is or who owns it. For example, few jurisdictions currently let decentralized power sources such as rooftop solar arrays "plug and play" on the electric grid, as modern technical standards safely permit. Although 31 U.S. states allow net metering—the utility buys your power at the same price it charges you—most artificially restrict or distort this competition. But the biggest single obstacle to electric and gas efficiency is that most countries, and all U.S. states except California and Oregon, reward distribution utilities for selling more energy and penalize them for cutting their customers' bills. Luckily, this problem is easy to fix: state regulators should align incentives by decoupling profits from energy sales, then letting utilities keep some of the savings from trimming energy bills.

JEN CHRISTIANSEN; SOURCE: ROCKY MOUNTAIN INSTITUTE *(graph)*; ANDREAS RENTZ *Getty Images (photograph)*

AN OIL-FREE AMERICA



U.S. OIL CONSUMPTION AND IMPORTS can be profitably slashed by doubling the efficiency of vehicles, buildings and industries (*yellow lines in graph*). The U.S. can achieve further reductions by replacing oil with competitive substitutes such as advanced biofuels and saved natural gas (*green lines*) and with hydrogen fuel (*gray lines*).

JEN CHRISTIANSEN; SOURCE: RMI (*graph*); PROJECTIONS TO 2025 FROM U.S. ENERGY INFORMATION ADMINISTRATION; ESTIMATES AFTER 2025 FROM RMI

Superefficient vehicles have been slow to emerge from Detroit, where neither balance sheets nor leadership has supported visionary innovation. Also, the U.S. lightly taxes gasoline but heavily subsidizes its production, making it cheaper than bottled water. Increasing fuel taxes may not be the best solution, though; in Europe, stiff taxes—which raise many countries' gasoline prices to $4 or $5 a gallon—cut driving more than they make new cars efficient, because fuel costs are diluted by car owners' other expenses and are then steeply discounted (most car buyers count only the first few years' worth of fuel savings). Federal standards adopted in the 1970s helped to lift the fuel economy of new cars and light trucks from 16 miles per gallon in 1978 to 22 miles per gallon in 1987, but the average has slipped to 21 mpg since then. The government projects that the auto industry will spend the next 20 years getting its vehicles to be just 0.5 mile per gallon more efficient than they were in 1987. Furthermore, automakers loathe the standards as restrictions on choice and have become adept at gaming the system by selling more vehicles classified as light trucks, which are allowed to have lower fuel economy than cars. (The least efficient light trucks even get special subsidies.)

The most powerful policy response is "feebates"—charging fees on inefficient new cars and returning that revenue as rebates to buyers of efficient models. If done separately for each size class of vehicle, so there is no bias against bigger models, feebates would expand customer choice instead of restricting it. Feebates would also encourage innovation, save customers money and boost automakers' profits. Such policies, which can be implemented at the state level, could speed the adoption of advanced-technology cars, trucks and planes without mandates, taxes, subsidies or new national laws.

In Europe and Japan, the main obstacle to saving energy is the mistaken belief that their economies are already as efficient as they can get. These countries are up to twice as efficient as the U.S., but they still have a long way to go. The greatest opportunities, though, are in developing countries, which are on average three times less efficient than the U.S. Dreadfully wasteful motors, lighting ballasts and other devices are freely traded and widely bought in these nations. Their power sector currently devours one quarter of their development funds, diverting money from other vital projects. Industrial countries are partly responsible for this situation because many have exported inefficient vehicles and equipment to the developing world. Exporting inefficiency is both immoral and uneconomic; instead the richer nations should help developing countries build an energy-efficient infrastructure that would free up capital to address their other pressing needs. For example, manufacturing efficient lamps and windows takes 1,000 times less capital than building power plants and grids to do the same tasks, and the investment is recovered 10 times faster.

China and India have already discovered that their burgeoning economies cannot long compete if energy waste continues to squander their money, talent and public health. China is setting ambitious but achievable goals for shifting from coal-fired power to decentralized renewable energy and natural gas. (The Chinese have large supplies of gas and are expected to tap vast reserves in eastern Siberia.) Moreover, in 2004 China announced an energy strategy built around "leapfrog technologies" and rapid improvements in the efficiency of new buildings, factories and consumer products. China is also taking steps to control the explosive growth of its oil use; by 2008 it will be illegal to sell many inefficient U.S. cars there. If American automakers do not innovate quickly enough, in another decade you may well be driving a superefficient Chinese-made car. A million U.S. jobs hang in the balance.

Today's increasingly competitive global economy is stimulating an exciting new pattern of energy investment. If governments can remove institutional barriers and harness the dynamism of free enterprise, the markets will naturally favor choices that generate wealth, protect the climate and build real security by replacing fossil fuels with cheaper alternatives. This technology-driven convergence of business, environmental and security interests—creating abundance by design—holds out the promise of a fairer, richer and safer world. SA

MORE TO EXPLORE

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