Efficient Use of Electricity

Advanced technologies offer an opportunity to meet the world's future energy needs while minimizing the environmental impact. Both suppliers and consumers of electricity can benefit from the savings.

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Electricity is fundamental to the quality of modern life. It is a uniquely valuable, versatile and controllable form of energy, which can perform many tasks efficiently. In little over 100 years electricity has transformed the ways Americans and most peoples of the world live. Lighting, refrigeration, electric motors, medical technologies, computers and mass communications are but a few of the improvements it provides to an expanding share of the world's growing population.

Many analysts believe that regional electricity shortages could occur in the U.S. within the next 10 years, perhaps as early as 1993. Given the importance of electricity to all sectors of the economy, such shortages would have severe consequences. Yet financing large-scale power plant construction could push America's $170-billon-a-year electricity costs higher: a large (one billion watts) power plant costs more than $1 billion and may entail lengthy regulatory and environmental approvals. Thus there is growing pressure for utilities to provide needed generating capacity or to reduce electricity demand, or both.

A kilowatt-hour of electricity can light a 100-watt lamp for 10 hours or lift a ton 1,000 feet into the air or melt enough aluminum for a six-pack of soda cans or heat enough water for a few minutes' shower. To save money and ease environmental pressures, can more mechanical work or light, more aluminum or a longer shower be wrung from that same kilowatt-hour?

The answer is clearly yes. Yet estimates as to how much more range from 30 to 75 percent. Also at issue is how fast efficiency can be improved, and at what cost.

Since the oil embargo of 1973, energy intensity—the amount of energy required to produce a dollar of U.S. gross national product—has fallen by 28 percent. Plugged steam leaks, caulk guns, duct tape, insulation and cars whose efficiency has increased by seven miles per gallon have helped to extract more work from each unit of fuel. Applications of electricity, too, have made important contributions to productivity and to a more information-based economy. Electricity accounts for a growing fraction of energy demand, and its relation to the gross national product has held relatively steady in recent years. It is not clear, however, that electricity and economic growth must continue to march in lock step. Technologies and implementation techniques now exist for using electricity more efficiently while actually improving services. Harnessing this potential could get society off the present treadmill of ever higher financial and environmental risks and could make affordable the electric services that are vital to global development.

Historical patterns are already starting to change. California reduced its electric intensity by 18 percent from 1977 to 1986 and expects the trend to continue. Nevertheless, in such major industries as cars, steel and paper, Japan's electric use per ton is falling while the U.S.'s is rising—chiefly because American companies are still adopting new fuel-saving "electrotechnologies" already common in Japan. But companies there are improving their efficiency at a faster rate. The resultant widening efficiency gap contributes to Japanese competitiveness.

Other industrialized nations are also setting higher standards for efficiency. Sweden has outlined ways to double its electricity efficiency. Denmark has vowed to cut its carbon dioxide output to half the 1988 level by 2030 and West Germany to 75 percent of the 1987 level by 2005; both nations emphasize efficiency.

These encouraging developments reflect rapid progress on four separate but related fronts: advanced technologies for using electricity more productively; new ways to finance and deliver those technologies to customers; expanded and reformulated roles for electric utilities; and innovative regulation that rewards efficiency.

The technological revolution is most dramatic. The 1980's created a flood of more powerful yet cost-effective electricity-saving devices. If anything, progress seems to be accelerating as developments in materials, electronics, computer design and manufacturing converge. Rocky Mountain Institute estimates that in the past five years the potential to save electricity has about doubled, whereas

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the average cost of saving a kilowatt-hour has fallen by about two thirds. The institute has also found that most of the best efficient technologies are less than a year old.

Of course, while some innovations are saving electricity, others will use electricity in new ways in those areas where electricity has an advantage over other forms of energy. For example, electricity can be environmentally beneficial and cost-effective in ultraviolet curing of finishes, microwave heating and drying, induction heating and several other industrial uses. Such electrotechnologies save money and fuel and reduce pollution overall. The Electric Power Research Institute (EPRI) estimates that by 2000 these new technologies will save as much as half a quadrillion British thermal units (Btu'S) of fuel per year yet wfll Increase electricity use in the U.S. only slightly.

How much electricity could be saved if we did everything, did it right and fully applied the best technologies for efficiency? Agreement is growing that an astonishing amount of electricity—far more than the 5 to 15 percent cited a few years ago—could be saved in the U.S. According to a 1990 report by EPW, it is technically feasible to save from 24 to 44 percent of U.S. electricity by 2000—some of it rather expensively—in addition to the 9 percent already included in utility forecasts. Thus, theoretically, aggressive efficiency efforts might capture as much as three to five times the savings that EPRI forecasts to happen spontaneously, about four to seven times as much as current utility programs plan to capture (80 billion watts before 2000). Rocky Mountain Institute estimates a long-term potential to save about 75 percent of electricity at an average cost of .6 cent per kilowatt-hour—several times lower than just the cost of fuel for a coal or nuclear plant. Even more could be saved at higher costs. The differences between these estimates are less important than their agreement that substantial amounts of electricity can be saved in a cost-effective manner.

How do potential electricity savings in the U.S. compare with analyses for other countries? Potential savings vary, mainly because of differences in climate, in use of appliances and in price and economic structure. Western Europeans and the Japanese have already captured more of the potential electricity savings, and, as these nations continue to progress, they will pay more for less electricity savings than Americans, but the differences are probably not substantial. Studies have found potential savings of 50 percent in Sweden at an average cost of 1.3 cents per kilowatt-hour, 75 percent in Danish buildings at 1.3 cents per kilowatt-hour and 80 percent in West German households at a cost repaid in 2.6 years.

Strong anecdotal evidence suggests that in most developing and socialist countries, many electric devices are several times less efficient than in the U.S. Improved devices are often costly there today because they require electronics or special materials that are not readily available. But as global markets for these devices expand, lowering their international prices, it is reasonable to expect that the potential electricity savings will be even greater in the countries that are the least efficient today. The U.S. potential may therefore prove to be not a bad surrogate for the global average.

To understand the pitfalls involved and the effort required to move toward a more efficient economy, consumers and suppliers of electricity must understand how major savings can be achieved. Electricity, like other forms of energy, can be saved by demanding fewer or inferior services—warmer beer, colder showers, dimmer lights. No such options are considered here. If technology is applied intelligently, electricity can be saved without sacrificing the quality of services, in fact, many new devices actually function better than the equipment they replace: they provide more pleasing light, more reliable production and higher standards of comfort and control.

The biggest savings in electricity can be attained in a few areas: lights, motor systems and the refrigeration of food and rooms. In the U.S. lighting consumes about a quarter of electricity—about 20 percent directly, plus another 5 percent in cooling equipment to compensate for the unwanted heat that lights emit. In a typical existing commercial building, lighting uses about two fifths of all electricity directly or more than half including the cooling load. Converting to today's best hardware could save some 80 to 90 percent of the electricity used for lighting, according to Lawrence Berkeley Laboratory, EPRI suggests that as much as 55 percent could be saved through cost-effective means.

Compact fluorescent lamps, for instance, consume 75 to 85 percent less electricity than do incandescent ones. They typically last four to five times longer than incandescent floodlamps and nine to 13 times longer than ordinary incandescent bulbs. If one balances the higher initial cost of the lamps against the reduction in replacement lamps and installation labor (longer-life bulbs do not need to be changed so often), one can recover the cost of the fluorescent lamps and still save many dollars over the life of each lamp. One can thus make money without even counting the savings in electricity. This is not a free lunch; it is a lunch you are paid to eat.

Efficient lighting hardware is now available for almost any application. Most devices provide the same amount of light as older systems do, with less glare, less noise, more pleasant color and no flicker. These aesthetic improvements can unlock even bigger savings: improving productivity by 1 or 2 percent is usually worth more to an office's bottom line than eliminating electric bills.

Together the lighting innovations that are commercially available can potentially save one seventh to one fifth of all the electricity now used in the U.S. These innovations would cost about one cent per kilowatt-hour to install. The reduced maintenance costs, Rocky Mountain Institute calculates, would save the user an additional 2.4 cents per kilowatt-hour saved. The savings in electricity would reduce the need for about 70 to 120 billion watts of power plants that would cost from $85 to $200 billion to build and from $18 to $30 billion per year to operate. Thus, lighting innovations may be the biggest gold mine in the entire economy.

After lights, electric motors offer the best opportunity to effect major savings. Motors consume 65 to 70 percent of industrial electricity and more than half the electricity generated in the U.S. The annual electricity bill for motors exceeds $90 billion, or about 2 percent of the gross national product.

A typical large industrial motor consumes electricity that costs some 10 to 20 times its total capital cost per year: its capital cost is only about 1 to 3 percent of its total life-cycle cost. Over a motor's life, a one-percentage point gain in efficiency typically adds upward of $10 per horsepower to the bottom line. Multiplying the many percentage points of available savings by the hundreds or thousands of horsepower for each big motor reveals very large potential savings. And one industrial processing plant can have hundreds of such motors.

Many machines, especially pumps and fans, need to vary their output to accommodate changing process needs. This is often done by running the pump or fan at full speed while "throttling" its output with a partly closed valve or damper, like driving with one foot on the gas and the other on the brake. Electronic adjustable-speed drives can reduce this waste. When you need only half the flow from a pump, you can in principle save seven eighths of its power and in practice nearly that much, because electronic drives are very efficient. Savings can range from 10 to 40 percent, with typical applications reducing total U.S. motor energy by about 20 percent. Paybacks range from six months to three years, averaging one year.

A new breed of high-efficiency motors represents another important advance. These motors are better designed and better made from higher-quality materials than conventional motors are, thereby squeezing down their magnetic, resistive and mechanical losses to less than half the levels of a decade ago. Although such motors are widely found in North America, Western Europe and Japan, they are not available in some industrialized countries, Such as Australia, or in much of the socialist or developing world, where motor efficiencies are of-ten very low.

Most engineers think only in terms of adjustable-speed drives and high' efficiency motors. Although both are important, they account for only half of the total potential electricity savings in U.S. motor systems. The other half comes from 33 other improvements in the choice, maintenance and sizing of motors, three further kinds of controls and the efficiency with which electricity is supplied to the motor and torque is transmitted to the machine. Improved motor systems can run on about half the electricity, which amounts, in principle, to electricity savings equivalent in the U.S. to about 80 to 190 billion watts of power plants. Furthermore, the cost of the new motors can usually be recovered in about 16 months, because after a company pays for only seven of the 35 improvements (including adjustable-speed drives and high-efficiency motors), the other improvements are free by-products.

Progress in motor and lighting technologies is matched by advances in super-efficient appliances. Refrigerators and freezers can now consume 80 to 90 percent less electricity than conventional models; commercial refrigeration systems can save 50 percent, televisions 75 percent, photocopiers 90 percent and computers 95 percent. Rocky Mountain Institute, for example, installed efficient lights and appliances in its 4,000-square-foot headquarters, decreasing consumption of electricity tenfold, to only $5 a month. The institute also lowered its water consumption by 50 percent and eliminated 99 percent of the energy it needed to heat space and water. (The building is so well insulated that even though it is located in the subarctic climate of the Colorado mountains it needs no furnace.) Moreover, all of this seven-year-old technology paid for itself within a year.

Exploiting the full menu of efficiency opportunities can double the quantity and more than halve the cost of savings, because saving electricity is like eating a lobster: if you extract only the large chunks of meat from the tail and claws and throw away the rest, you will miss a comparable amount of tasty morsels tucked in crevices. To capture major electricity savings cheaply, one must not only install new technologies but also rethink the engineering of whole systems, paying meticulous attention to detail.

Such rethinking will require a new infrastructure to deliver integrated packages of modern technologies. Only a handful of firms provide comprehensive, up-to-date lighting retrofits; few if any provide similar services for motors. Yet retrofits that save electricity represent a global business opportunity ultimately worth perhaps hundreds of billions of dollars a year—an ample prize to elicit entrepreneurship.

The potential to save electricity will not be realized until—like power plants—electricity-saving programs are planned, designed, financed, built, commissioned and maintained. Just as one might extract a mineral resource from the ground, one must determine how much electricity can be profitably saved employing existing technology and how to convert that reserve to actual production.

Efficient technologies are often underused because of the lack of customer demand (market pull) or the lack of a sufficient distribution channel (market push), or both. If electricity consumers want efficient appliances and ask retailers to provide them, retailers will then ask wholesalers to supply them, and wholesalers in turn will seek manufacturers to produce those products. If consumers fail to act, then the whole string of potential benefits unravels.

To create market pull, energy planners must understand how consumers make energy choices. Most planners are puzzled to find that customers sometimes shun efficiency even when it is accompanied by attractive economic incentives. In the past, manufacturers and retailers have not considered efficiency to be an important feature in new products, because they have found that consumers rarely decide to make a purchase based on efficiency. The factors that most consistently affect their choices are appearance; safety; comfort, convenience and control; economy and reliability; high-technology features; the need to have the latest equipment; the desire to avoid hassles; and resistance to having utilities control energy use. Because human nature is diverse, the weighing of these factors varies enormously, and retailers must adjust their marketing strategies accordingly. Businesses have analogous concerns, including product quality, production reliability, fuel flexibility, environmental cleanliness, a clean workplace and low risk.

If efficient technologies are to be widely deployed, a third party, such as the electric utility or government, may need to assume responsibility for both market push and market pull. As we shall see, utilities have a special interest in influencing customers' demand—treating it not as fate but as choice—in order to provide better service at lower cost while increasing their own profits and reducing their business risks. Utilities can choose from a wide range of market push and pull methods designed to influence consumer adoption and reduce barriers. These include rebates or other financing options, direct contact with their customers, special tariffs, advertising, education, and cooperative ventures with architects, engineers and suppliers of efficient technology. Collectively, such efforts are part of demand-side management, which seeks to change the demand for electricity while stiil meeting customers' needs.

More than 60 utilities serving almost half of all Americans now offer rebate programs to promote the buying or selling of efficient devices. The overwhelming majority (92 percent) pay rebates to purchasers to create market pull; about 24 percent pay appliance dealers to create market push.

Utility rebate programs can rapidly stimulate market development. Efficient lighting equipment was unavailable in Las Vegas, for instance, until Nevada Power Company started offering rebates, whereupon within six months, 20 wholesale and retail outlets were competing in the price and breadth of efficient lighting systems.

Many utilities have begun to pay consumers for each kilowatt-hour saved, no matter how it is done. They have also tried to reward "trade allies" who remove old, inefficient equipment or who sell, specify or install electricity-saving devices. Utilities sometimes offer rebates to consumers who beat a government performance standard, thus eliciting better technologies so the standard can be raised until cost-effectiveness limits are reached.

Other financial incentives complement rebates: low- or no-interest loans, gifts and leases. Southern California Edison Company, for example, has given away more than 800,000 compact fluorescent lamps. The Taunton Municipal Lighting Plant in Massachusetts leases such lamps for 20 cents each per month and replaces them for free. Thus, customers can pay for efficiency over time, just as they would otherwise pay for power plants. The makers of compact fluorescent lamps have relied on both their own and utilities' marketing strategies to achieve annual U.S. sales of about 20 million units. Those sales are doubling or tripling each year, and such lamps already dominate the West German market.

These well-established methods are so effective that when Southern California Edison Company had a peak load of 15 billion watts, in 1983-1984, it was able to reduce its forecast of peak demand by more than 500 million watts in a single year. At the same time, California's appliance and building standards increased electricity savings even more. Annual savings represented 8.6 percent of the utility's peak demand at the time and cost the utility only about 1 percent as much as building and running a new power station. If all Americans saved electricity as fast as those 10 million did, the U.S. economy could grow by several percent every year while total electricity use decreased.

Such success stories are now spreading in the U.S. and abroad. In some instances, skillful and imaginative marketing has captured 70 to 90 percent of specific efficiency markets, such as housing insulation, in just a year or two. Some utilities, such as the Bonneville Power Administration, are saving businesses money through commercial efficiency programs whose cost is about .5 cent per kilowatt-hour.

Utilities such as North Carolina's Duke Power Company offer lower rates to efficient customers. Others require minimum efficiency levels as a condition of service; Atlantic Electric in New Jersey, for example, has such an air conditioner standard. Several states are now trying or considering a sliding-scale hookup fee: when a utility connects a new building to the power grid, it charges a fee that is tied to the building's efficiency. Consideration is also being given to using such fees to pay rebates ("feebates") for the most efficient buildings.

Still further savings may be achieved by methods that seek not merely to market "negawatts" (saved electricity) but to make markets in negawatts: saved electricity can be treated as a commodity just like copper or sowbellies. This strategy can maximize competition among means of savings and among providers of savings and so drive down the cost. For example, some utilities run competitive bidding processes in which all ways to make or save electricity compete.

Saved electricity can be converted to money and traded between utilities or between customers. Some utilities may even want to become "negawatt brokers" and make spot, futures and options markets in saved electricity. Others are considering buying contracts from their customers to stabilize or reduce demand. The contracts could be resold in secondary markets, just as some brokers already buy and sell air pollution rights.

Some aggressive utilities compering in the emerging negawatt market even sell efficiency in the territories of other utilities. Puget Sound Power and light Company sells electricity in one state, but its subsidiary sells efficiency in nine states.

Even though some utilities and consumers have taken the lead in electricity efficiency, most of the potential savings remain untapped. Customers use very different financial criteria to assess ways to save electricity than utilities use to assess new power plants. On the one hand, if customers invest money to save electricity in their home or business, they will probably want to recoup their investment within about two years—perhaps as long as five years for a few far-sighted industries and less than one year for low-income renters. On the other hand, if utilities build plants to increase capacity, their technical and financial strength lets them recover costs over a 20-year period.

The gap between the payback horizon of consumers and utilities tends to make society buy too little efficiency and too much supply. The result in the U.S. alone is the $60 billion per year now spent in expanding electricity supplies that could be partly displaced by investments in efficiency. The payback gap also dilutes price signals. If customers can avoid a tariff of six cents per kilowatt-hour by saving electricity, then without other incentives they will buy efficiency costing up to .6 cent per kilowatt-hour—about a tenth of the tariff, because the tariff is calculated at the utility's payback horizon of 20 years, but the customer invests on the basis of a two-year horizon. Just getting the prices right will therefore not necessarily induce people to buy as much efficiency as would benefit society at large. However, correct pricing is important: only prices that tell the truth can inform customers about how much is enough. Prices should be adjusted to the time and season of use—perhaps ultimately with sophisticated new kinds of electronic meters—and reflect real-time spot prices in order to provide the most accurate signals.

Utilities around the world are reexamining their purpose. Is their mission the production and sale of electricity, or is it the profitable production of customer satisfaction? Utilities that take the latter view believe that if electricity costs more than efficiency, then customers will eventually realize they can save kilowatt-hours and money and still get hot showers and cold beer with high-performance shower heads and superefficient refrigerators. The only relevant question, then, is who will sell efficiency? If efficiency is cheaper than electricity, customers will buy less electricity and more efficiency. It is generally a sound business strategy to satisfy customer needs before someone else does.

Utilities are the logical organizations to expedite the use of energy-efficient products: they have technical skill, permanence, credibility, close ties to customers, a relatively low cost of capital and a fairly steady cash flow. At present, however, they have little motive to expedite energy efficiency. The conflict is obvious: Why spend money to reduce sales?

In principle, utilities can profit in several ways from making their customers more efficient. They can avoid operating costs in the short run, construction costs of new power plants in the medium run and replacement costs of old power plants in the long run. They can also earn a spread on financing efficiency, just as a bank would. Legislation such as the amended U.S. Clean Air Act may allow utilities to use efficiency to generate pollution rights, which they can resell. And finally, under new regulations now being adopted in some states in the U.S., utilities may be able to receive exemplary financial rewards for money-saving investments.

A major breakthrough occurred in 1989 when new regulations were accepted in principle nationwide for consideration by state regulators. The proposed rules would uncouple utilities' profits from their sales, removing a utility's disincentive to invest in efficiency. In effect, the utilities will be compensated for the revenue they would otherwise lose by selling less electricity—and will get to keep part of the savings.

Such rules have already proved effective in a few cases. Pacific Gas & Electric Company in California and a group of environmentalists, government administrators and consumers recently agreed that the utility should keep 15 percent of any money saved by certain new efficiency programs. Customers will benefit by getting 85 percent rather than all of nothing.

In New York Niagara Mohawk Power Corporation has proposed another way to profit from efficiency services. Under the plan, the utility's 12 efficiency programs, which cost $30 million to implement in 1990, will be allowed to recover costs and clear a $1 million profit if the utility's 12 programs achieve the state's goal of saving 133 million kilowatt-hours, which is worth about $10 million a year in reduced energy cost for participating customers. By 1992 the programs should save 240 million kilowatt-hours per year. Where does the money come from? Prices per kilowatt-hour will rise by as much as 1.4 percent, yet participating customers will still pay lower bills because they will consume less.

Niagara's residential low-cost measures program, for example, provides each participating household with a low-flow shower head, a compact fluorescent light bulb and insulation to wrap their electric water heaters and pipes. The equipment should save 960 kilowatt hours per participating household per year. For each household, the utility loses about $72 in annual energy sales but saves about $40 on fuel and capacity costs. The difference ($32 a year) is charged to the residential customers each year for eight years and includes a $5 profit for the utility. For the equipment, each participating household pays 56 a year for eight years. Therefore, each household will save $272 over eight years.

As efficient technologies and implementation techniques spread, how will they change the economics of our businesses, the services we receive and the health of our environment? Consider first the effect of efficiency on local business, in Osage, Iowa (population 4,000), a utility manager launched a nine-year program to weatherize homes and control electricity loads at peak periods. These initiatives saved the utility enough money to prepay all its debt, accumulate a cash surplus and cut inflation-corrected rates by a third (thereby attracting two factories to town). Furthermore, each household received more than $1,000 of savings a year, boosting the local economy and making shops noticeably more prosperous than in comparable towns nearby. If other communities in the U.S. followed the lead of Osage, they could create economic vitality that would reverberate from Main Street to Wall Street.

Electric efficiency can also enhance industrial competitiveness. When the rod, wire and cable business fell on hard rimes around 1980, for example, the biggest independent U.S. firm, Southwire, responded by saving, over eight years, about 60 percent of its gas and 40 percent of its electricity per ton of product. The savings yielded virtually all the company's profits during a tough period. The efforts of two engineers may have saved 4,000 jobs at 10 Southwire plants in six states.

Electric efficiency could also break a major logjam in global development. In developing nations, electricity generation already consumes a fourth of global development capital, and in the next few decades the utilities of those nations are projected to need about eight times more capital than is expected to be available—a prescription for power shortages. But efficiency can be the key to saving the capital desperately needed for other development tasks.

Electric efficiency can also ease environmental pressures. If a consumer replaces a single 75-watt bulb with an 18-watt compact fluorescent lamp that lasts 10,000 hours, the consumer can save the electricity that a typical U.S. power plant would make from 770 pounds of coal. As a result, about 1,600 pounds of carbon dioxide and 18 pounds of sulfur dioxide would not be released into the atmosphere, reducing the contribution of these gases to global warming and acid rain. Alternatively, an oil-fired electric plant would save 62 gallons of oil—enough to fuel an American car for a 1,500-mile journey. Yet far from costing extra, the lamp generates net wealth and saves as much as $100 of the cost of generating electricity. Since saving the fuel is cheaper than burning it, environmental problems can be abated at a profit. (Power plants that run on fossil fuel use three units of fuel to make one unit of electricity, where as in socialist and developing countries they often use five to six units to do the same.)

No matter how electric efficiency is used to reduce emissions, consumers and suppliers of electricity will achieve the biggest reduction at the lowest cost in the shortest time only if they choose the best buys first. Suppose a government wants to reduce carbon dioxide emissions by reducing the amount of electricity generated by coal-fired power plants. To replace that electricity, the government should invest in low-cost efficiency options such as lighting or motor retrofits before considering alternative high-cost technologies such as solar or nuclear power. Otherwise each dollar spent will replace less coal burning than it could have. As we compete for limited resources, the order of environmental priority should be the order of economic priority.

The best-buys-first sequence can be determined either by "least-cost utility planning" or "integrated resource planning"—a formal procedure now required by utility regulators in most of the U.S. or by an equivalent market process in which all ways to make or save electricity compete fairly for marginal investment.

Electric efficiency, wisely bought today, can go far to stretch the electricity supply. It can also provide time to perfect and deploy renewable energy resources such as solar power, an area where recent progress has been so encouraging. If efficiency decreases the demand for electricity, then renewable resources can be deployed more easily and provide more electricity to more people. Both in the broad sense and in detailed design, electric efficiency and renewable resources are natural partners.

The electric utility is only one of many organizations that should be encouraging energy efficiency. State and local agencies can be particularly helpful in educating customers. Federal support for such programs, which were largely abandoned over the past decade, should be restored.

America's largest landlord—the U.S. government—can take the lead by starting a massive, modern retrofit program in federally owned buildings. The government could be the key to developing market push in certain technologies. It could provide funds to help underwrite the high initial manufacturing costs that penalize new technologies, in addition, state and federal authorities could encourage manufacturers to make more efficient products and broaden performance labeling. Governments could also do more to assist in the research and development of efficient technology. Investments in efficiency are far out of line with potential benefits. Not only do consumers and suppliers of electricity need more and better hardware choices, but they also need better ways to help designers choose from the bewilderingly large array of technologies that are already available.

A formidable challenge to electric utilities and governments, then, as well as to customers, design professionals and many other stakeholders, is to integrate the technical, economic, cultural, marketing and policy innovations into coherent efforts to capture the efficiency potential. It is encouraging that many are rising to this challenge. The seriousness of some U.S. utilities' effort, such as that of the New England Electric System, is indicated by their commitment to allocate as much as 4 percent of their gross revenues to improving customers' end-use efficiency. In recent weeks, five U.S. utilities have added nearly $1 billion to their efficiency budgets. Some utilities in Western Europe and Japan, too, have undertaken similarly impressive programs. With such efforts, electric and economic growth need not march in lock step—if we choose to use electricity to a way that saves money and the environment.

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