The Negawatt Revolution: Electric Efficiency and Asian Development

BY AMORY B. LOVINS AND ASHOK GADGIL

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In the 1980s, Chinese officials had a nifty plan to boost household refrigerator ownership in Beijing from 6% to 60%: just buy and run castoff Japanese refrigerator factories. But they overlooked the refrigerators' obsolete and inefficient design until too late—after their needlessly high electrical use had committed China to upwards of a half-billion unavailable dollars' worth of electric capacity, plus decades of coal-burning and pollution. Thus a well-meant development effort created shortages of both power and capital vital for development.

Today in Taiwan, back-alley operators are melting down unrefined scrap copper and drawing it into impure, high-resistance wire. It's then used not only domestically, causing most Taipei house fires, but also in apparently cheap but very inefficient motors and lamp ballasts for export. From Bangkok to Cairo, those devices are being installed every day. Such a 75-kW motor looks as much as a few thousand dollars cheaper to its buyer (though it's actually not, since its inefficiency so derates it that a severalfold bigger motor is needed to deliver the same torque without burning up). But its inefficiency typically costs the country installing it more than $30,000 in extra electric capacity—tens of times the "bargain" motor's capital cost.

Those inefficient refrigerators and motors are the tip of a very expensive iceberg on which Asian development threatens to founder. Despite herculean plant-building efforts, the region's growth is bumping up against electrical supply limits, shrinking power reserves until whole national economies balance on the knife-edge of the next boiler tube or turbine bearing to fail. Millions are already being asked or forced to curtail air conditioning and other services. Most Asian utilities know no other option: after all, they think they're in the business of selling more and more kilowatt-hours. Many use subsidized or promotional tariffs (the more you use, the less you pay per unit). Almost none seriously help customers to use electricity more efficiently. The utilities' goal is to increase sales, revenues, and capacity; how efficiently customers use the electricity is their own business.

But outside Asia, a very different pattern is emerging. Across the Pacific, northern California, one of America's fastest-growing high-tech areas, is served by the nation's largest investor-owned utility—which, for the first time in 40 years, has not a single conventional power plant in planning or construction. In fact, Pacific Gas & Electric Co. doubts it'll ever build another central power plant. While making its existing fossil and nuclear plants last longer, the company now plans to get all of its new power in the '90s from two other resources scarcely considered in Asia: at least three-fourths from improved customer efficiency, and the rest from the next best buy—diverse, mainly customer-owned, renewable sources (sun, wind, water, and biomass). PG&E is convinced that these options cost less, work better, carry fewer and more tractable risks, and provide better service than building more power plants.

Why do Asia's utilities supply more electricity and ask their customers to do less with it, while many U.S. utilities seek to supply less and help their customers do more with it? Utilities on both sides of the Pacific have equally talented engineers and similar economic motives—but very different concepts of what business they're in.

In striking contrast to their Asian peers' desire to sell more of a bulk commodity called electricity, many U.S. utilities realize they're in the business of profitably producing customer satisfaction. Many use tariffs that correctly signal long-run marginal cost (thereby generally discouraging costly growth), and many—by year-end, probably most—also include environmental costs in investment decisions. Most are required by regulators to choose the best buys first: to meet customers' needs for light, comfort, shaftpower, and other services in the cheapest way, whether by supplying more electricity or using it more efficiently.

Some U.S. utilities are already, and most soon will be, directly rewarded for cost-cutting, *e.g.*, by being allowed to keep as extra profit part of whatever they save their customers. Thus PG&E is spending $150 million this year to help make its customers more efficient, and will keep 15% of the resulting savings, boosting its 1990 profits by $40–50 million. Regulatory reform also decouples profits from sales, so utilities will no longer be rewarded for selling more electricity nor penalized for selling less.

The result: U.S. utilities increasingly focus on the bottom line, not the top line. They make money on margin, not volume. Since electricity is costly while efficiency is cheap, they know customers will want to buy less electricity and more efficiency—and that it's sound business strategy to sell customers what they want before someone else does. U.S. utilities, therefore, increasingly accept, even welcome, lower sales and revenues, so long as costs drop even more. That will occur whenever it's cheaper to save electricity than to make it; and nowadays that's virtually always.

A veritable revolution in new technologies for wringing more work out of each kilowatt-hour, and new ways to finance and deliver them, is sweeping North America and much of Europe. Together, these commercially available technologies, many of the best less than a year old, can yield electric savings twice as big, yet only a third as costly, as five years ago. Yet it's in Asia that hot economies and climates threaten the gravest power shortages, and capital shortages provide the most urgent incentive for marketing efficiency instead of building power plants.

Consider, for example, a modern factory to produce quadrupled-efficiency compact-fluorescent lamps. The output of such a $7 1/2-million lamp factory saves as much electricity as a billion-dollar, 700-megawatt power plant makes. But the lamp factory needs 140 times less capital investment than the power plant, and avoids its fuel cost and pollution. (Compared with coal-fired generation, each compact fluorescent lamp, over its 10,000-hour life, keeps roughly a ton of $C0_2$ out of the air, plus acid gas.) Since incandescent lamps normally contribute to peak loads late on summer days, it's more valid to compare efficient lamps with the *peak* generating capacity they displace: in India, the $7 1/2-million lamp factory would displace 3,700 megawatts of onpeak capacity costing at least $2.2-5.6 billion (using gas turbines or intermediate-load-factor coal plants)—300–750 times as much. World Bank cost estimates applicable to many developing countries would put the tab at $9.4 billion, or over 1,200 times as much as the lamp factory.

Another example: thin-film coatings inside modern windows can let in over half the visible light to displace electric lighting and the heat it releases, but reflect away nearly all the unwanted solar heat radiation. Outdoor heat is also blocked by cheap insulating-gas fillings, usually argon. Such "superwindows" make new Asian offices *cheaper* to build, because the windows cost less extra than they save by displacing cooling equipment. The output of one $10-million superwindow plant in, say, Bangkok could produce more comfort than the air conditioners run by 3,000 megawatts of generating plants costing about 185-460 times as much (plus their fuel and pollution), or, at World Bank costs, about 770 times as much.

Thus highly efficient use of electricity, far from being a luxury of the rich, is a necessity especially of the poor. It's a practice they can't hope to get rich without, because today's spot shortages of power are a small taste of what lies ahead if inefficient use persists: utilities, and nations, will simply run out of capital.

"Business-as-usual" expansion of electrical supply would require investments consuming approximately the *entire* economic growth of the developing world. Specifically, power investments in developing countries (including eastern Europe) are projected at nearly $70 billion a year to 2000, twice that thereafter; but power-sector lending by the World Bank, multilateral, and bilateral sources totals less than $10 billion a year. The shortfall is a recipe for non-development.

In contrast, making rapidly growing stocks of buildings and equipment highly efficient in the first place can not only boost competitiveness, but also free up enormous amounts of capital—tens of percent of total national budgets now, more later—for other development needs.

This is most vital in the poorest countries, where unneeded power-plant investments to run those inefficient lights, motors, and appliances diverts capital from such basic needs as clean water, infant vaccination, female literacy. Could the inefficient equipment being sold to developing countries be causing about as much human misery as the drug trade? To get huge development leverage, shouldn't we all strive in international commerce to make efficient equipment easier to get and inefficient equipment harder to get—and to label equipment so buyers can tell the difference?

Some developing countries already make superlatively efficient equipment, but not for their home markets: all the efficient refrigerator compressors made in Brazil, and 95% of the compact fluorescent lamps made in Mexico, are exported to the U.S. Nor is there any shortage of developing-country engineering and entrepreneurial talent: arguably the world's best space-cooling and air-handling engineering firm is in Singapore. But until governments realign utilities' missions to meeting customers' needs at least cost, most of the available capital and talent will continue to be misdirected.

How could Asian utilities do better? Most American utilities already finance customers' efficiency improvements, via concessionary loans, gifts, rebates, or leases, whenever efficiency costs less than supply. Customers can then compare ways to save or make electricity on an equal footing. Otherwise, customers want *their* money back at least ten times as fast from their own investments in efficiency as utilities want their money back from power plants, and this tenfold "payback gap" dilutes price signals tenfold, misallocating each year, in the U.S. alone, about $60 billion—more than total investment in durable manufactures.

In the best 1983-85 U.S. utility efficiency programme (for ten million customers in hot, fast-growing Southern California), even such simple tools as rebates to the buyers and sellers of efficient equipment, plus government efficiency standards for buildings and appliances, cut the ten-year forecast of peak electric demand by over 8% of current demand *per year*—fast enough to cut actual electric use even with several percent annual economic growth. The cost to the utility: about *one percent* the cost of a new power plant.

Today, newer implementation methods can do even better by making saved electricity into a fungible commodity. Eight states make all ways to produce or save electricity compete at open auction. Some utilities trade saved electricity, and are considering rewarding customers for going bounty-hunting and saving other customers' electricity. There is talk of spot, futures, and options markets in saved electricity (Britain just launched an electricity futures market). Some electric utilities sell electric efficiency in other utilities' territories, and gas utilities are about to. Some jurisdictions are trying a self-financing combination of fees charged to connect inefficient buildings to the grid, and rebates paid for connecting efficient buildings, both on an open-ended sliding scale.

Whatever the means of implementation, electric efficiency offers canny industrialists and developers a big competitive edge, even in existing facilities. For example, roughly half of industrial motor-system energy can be saved, with typical payback just over a year, by 35 kinds of improvements to the choice, sizing, and maintenance of motors and to their controls, electric supplies, and mechanical drivetrains. Motors use about three-fourths of industrial electricity and more than half of most countries' total electricity.

Similarly, in standard office fluorescent lighting, advanced reflectors, lamps, dimmable electronic ballasts, and controls can save 70–90+% of the lighting energy (plus a one-third or greater "bonus" in smaller cooling loads), with a payback under two years. In both cases, these retrofits provide higher-quality service: more reliable and controllable torque for better production quality, and the same amount of light with less glare, no flicker or hum, and more pleasant and accurate colour.

Even bigger and cheaper savings come from properly integrating different kinds of efficiency. For example, ASEAN commercial buildings consume over a third of all electricity, costing several billion dollars per year. But they could apply virtually the same techniques proposed by five engineering firms to retrofit a 1,900-m^2 section of PG&E's research headquarters—an office one-third more efficient than the U.S. norm to start with. Those five cost-effective conceptual designs were predicted to save 67–87% of the office's energy, using off-the-shelf equipment and with greatly improved comfort and aesthetics.

One of the five firms predicted an 86% electric saving at one-fourth the cost of a new power plant—a payback of about 4 1/2 years—by five main means, all relevant to Asian offices too: lightshelves to bounce daylight 8-14 m into the core; a lighting retrofit delivering 300 lux with only 3–4 W/m^2; replacing the heat-absorbing tinted windows with "superwindows" tuned differently for each side of the building; choosing better computers, printers, and photocopiers (saving two-thirds of their energy, but the full potential saving is about *96%* at zero or negative marginal cost); and making the space-conditioning equipment at least three times as efficient, but paying half its extra cost by making it severalfold smaller. Predicted energy costs would fall by $14 per m^2-y, and working conditions would become far nicer, presumably yielding an even more valuable gain in productivity.

Until Asian businesses capture such striking opportunities—with or without utilities' help—development will continue to be stunted, opportunities wasted, and electricity scarce. But harnessing the "negawatt revolution" in countries with rapidly growing infrastructure can help create far more prosperous and sustainable Asian societies. The next time you choose ordinarily inefficient equipment or buildings, ask yourself: If you can't afford to do it right the first time, how come you can afford to do it twice? And can't you think of investments much better for your nation's development than buying unnecessary power plants?

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Amory B. Lovins directs research at Rocky Mountain Institute (Snowmass CO 81654-9199, USA), a nonprofit resource policy center that supports electric efficiency efforts by 200+ utilities, industries, and governments in 32 countries. Dr. Ashok Gadgil, a Pew Scholar formerly with the Tata Energy Research Institute, is a researcher at Lawrence Berkeley Laboratory (Berkeley C4 94720, USA), where he helps to coordinate RMI's support of Indian partner organizations' Bombay Efficient Lighting Large-Scale Experiment.