An Efficient

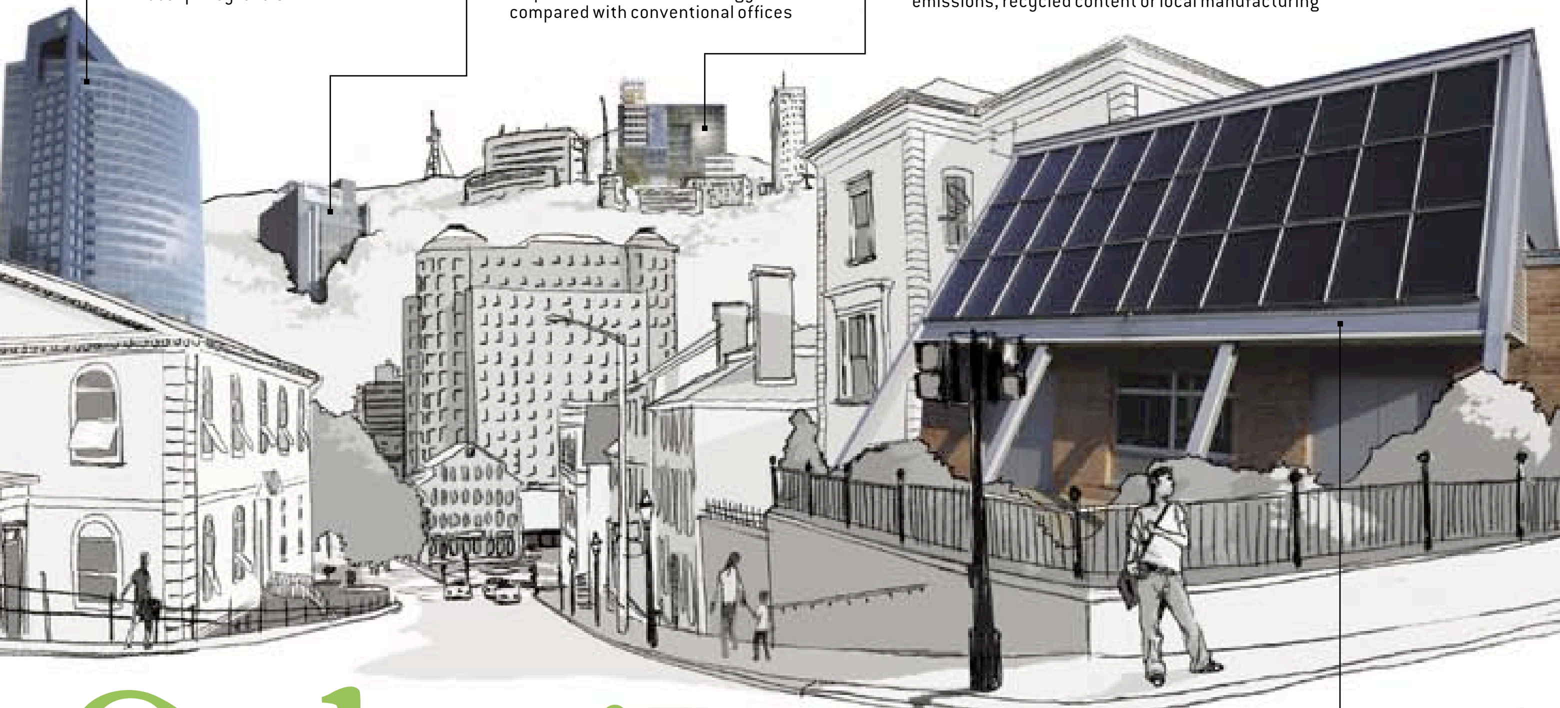
Wasting less energy is the quickest, least expensive way to stem carbon emissions BY EBERHARD K. JOCHEM

OVERVIEW

- Two thirds of all energy is lost during its conversion into forms used in human activities; most of this energy comes from carbon-emitting fossil fuels.
- The quickest, easiest way to reduce carbon emissions is to avoid as many of these losses as possible.
- Improving the energy efficiency of buildings, appliances and industrial processes offers impressive savings.

The huge potential of energy efficiency measures for mitigating the release of greenhouse gases into the atmosphere attracts little attention when placed alongside the more glamorous alternatives of nuclear, hydrogen or renewable energies. But developing a comprehensive efficiency strategy is the fastest and cheapest thing we can do to reduce carbon emissions. It can also be profitable and astonishingly effective, as two recent examples demonstrate.

From 2001 through 2005, Procter & Gamble's factory in Germany increased production by 45 percent, but the energy needed to run machines and to heat, cool and ventilate buildings rose by only 12 percent, and carbon emissions remained at the 2001 level. The major pillars supporting this success include highly efficient illumination, compressed-air systems, new designs for heating and air conditioning, funneling heat losses from compressors into heating buildings, and detailed energy measurement and billing.



Solution

In some 4,000 houses and buildings in Germany, Switzerland, Austria and Scandinavia, extensive insulation, highly efficient windows and energy-conscious design have led to enormous efficiency increases, enabling energy budgets for heating that are a sixth of the requirement for typical buildings in these countries.

Improved efficiencies can be realized all along the energy chain, from the conversion of primary energy (oil, for example) to energy carriers (such as electricity) and finally to useful energy (the heat in your toaster). The annual global primary energy demand is 447,000 petajoules (a petajoule is roughly 300 gigawatt-hours), 80 percent of which comes from carbon-emitting fossil fuels such as coal, oil and gas. After conversion these primary energy sources deliver roughly 300,000 petajoules of so-called final energy to customers in the form of electricity, gasoline, heating oil, jet fuel, and so on.

The next step, the conversion of electricity, gasoline, and the like to useful energy in engines, boilers and lightbulbs, causes further energy losses of 154,000 petajoules. Thus, at present almost 300,000 petajoules, or two thirds of the primary energy, are lost during the two stages of energy conversion. Furthermore, all useful energy is eventually dissipated as heat at various temperatures. Insulating buildings more effectively, changing industrial processes and driving lighter, more aerodynamic cars [see "Fueling Our Transportation Future," by John B. Heywood, on page 60] would reduce the demand for useful energy, thus substantially reducing energy wastage.

Given the challenges presented by climate change and the high increases expected in energy prices, the losses that occur

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all along the energy chain can also be viewed as opportunities—and efficiency is one of the most important. New technologies and know-how must replace the present intensive use of energy and materials.

Room for Improvement

BECAUSE CONSERVATION MEASURES, whether incorporated into next year's car design or a new type of power plant, can have a dramatic impact on energy consumption, they also have an enormous effect on overall carbon emissions. In this mix, buildings and houses, which are notoriously inefficient in many countries today, offer the greatest potential for saving energy. In countries belonging to the Organization for Economic Cooperation and Development (OECD) and in the megacities of emerging countries, buildings contribute more than one third of total energy-related greenhouse gas emissions.

Little heralded but impressive advances have already been made, often in the form of efficiency improvements that are invisible to the consumer. Beginning with the energy crisis in the 1970s, air conditioners in the U.S. were redesigned to use less power with little loss in cooling capacity and new U.S. building codes required more insulation and double-paned windows. New refrigerators use only one quarter of the power of earlier models. (With approximately 150 million refrigerators and freezers in the U.S., the difference in consumption between 1974 efficiency levels and 2001 levels is equivalent to avoiding the generation of 40 gigawatts at power plants.) Changing to compact fluorescent lightbulbs yields an instant reduction in power demand; these bulbs provide as much light as regular incandescent bulbs, last 10 times longer and use just one fourth to one fifth the energy.

> **65 percent** of primary energy—that in the natural resources we harness for power—is lost during conversion to the useful energy that makes our lives more comfortable
>
> **80 percent** of primary energy comes from carbon-emitting fossil fuels
>
> Almost **35 percent** of greenhouse gas emissions come from buildings

Despite these gains, the biggest steps remain to be taken. Many buildings were designed with the intention of minimizing construction costs rather than life-cycle cost, including energy use, or simply in ignorance of energy-saving considerations. Take roof overhangs, for example, which in warm climates traditionally measured a meter or so and which are rarely used today because of the added cost, although they would control heat buildup on walls and windows. One of the largest European manufacturers of prefabricated houses is now offering zero-net-energy houses: these well-insulated and intelligently designed structures with solar-thermal and photovoltaic collectors do not need commercial energy, and their total cost is similar to those of new houses built to conform to current building codes. Because buildings have a 50- to 100-year lifetime, efficiency retrofits are essential. But we need to coordinate changes in existing buildings thoughtfully to avoid replacing a single component, such as a furnace, while leaving in place leaky ducts and single-pane windows that waste much of the heat the new furnace produces.

One example highlights what might be done in industry: although some carpet manufacturers still dye their products at 100 to 140 degrees Celsius, others dye at room temperature using enzyme technology, reducing the energy demand by more than 90 percent.

The Importance of Policy

TO REALIZE THE FULL BENEFITS of efficiency, strong energy policies are essential. Among the underlying reasons for the crucial role of policy are the dearth of knowledge by manufacturers and the public about efficiency options, budgeting methods that do not take proper account of the ongoing benefits of long-lasting investments, and market imperfections such as external costs for carbon emissions and other costs of energy use. Energy policy set by governments has traditionally underestimated the benefits of efficiency. Of course, factors other than policy can drive changes in efficiency—higher energy prices, new technologies or cost competition, for instance. But policies—which include energy taxes, financial incentives, professional training, labeling, environmental legislation, greenhouse gas emissions trading and international coordination of regulations for traded products—can make an enormous difference. Furthermore, rapid growth in demand for energy services in emerging countries provides an opportunity to implement energy-efficient policies from the

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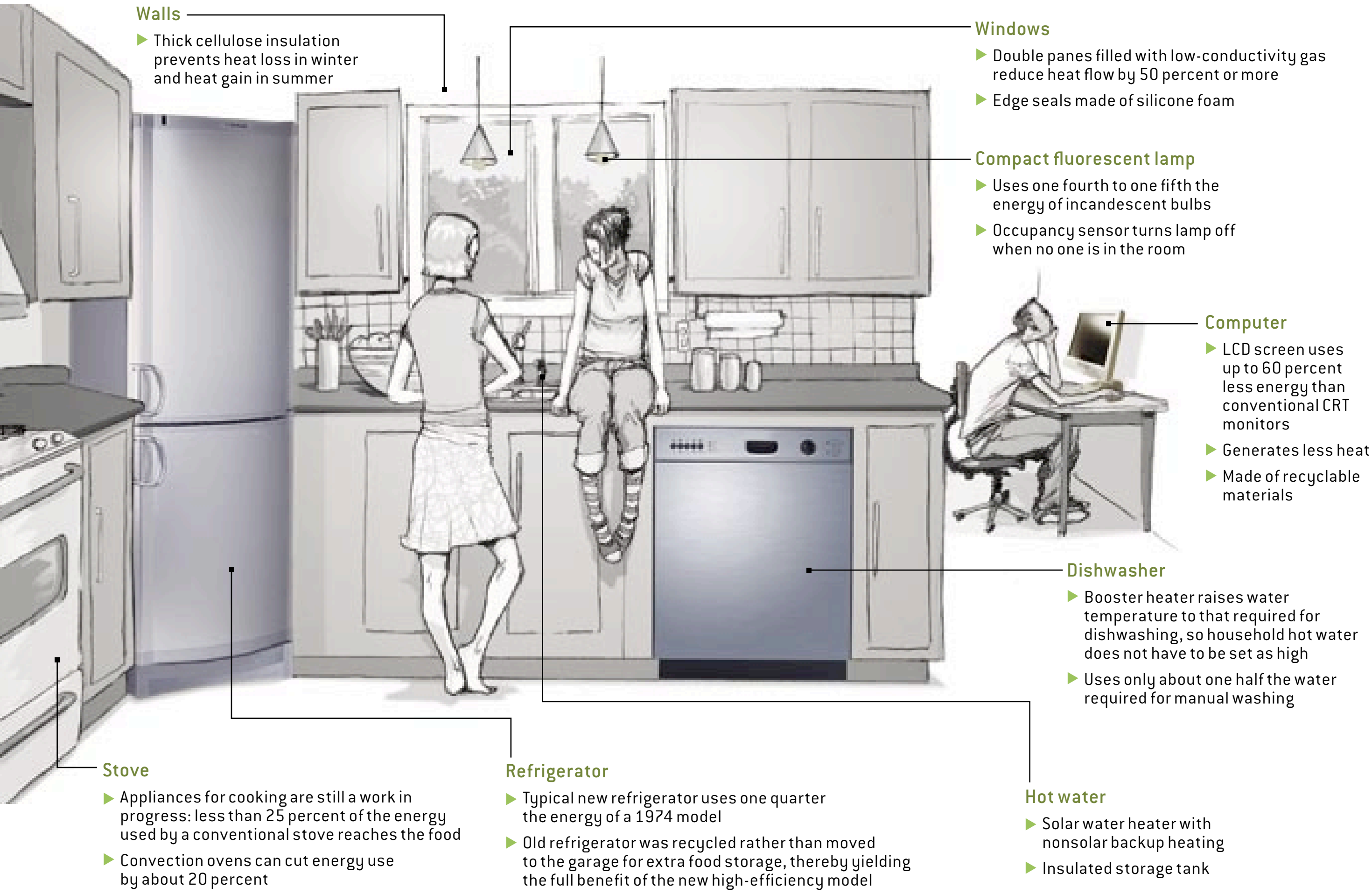

MATT VINCENT ILLUSTRATION; THE GREEN CULTURE/SOLARGOODS.COM (*refrigerator and dishwasher*); NEC CORPORATION OF AMERICA (*computer*); LUCY READING-IKKANDA (*lightbulbs*)

outset as infrastructure grows: programs to realize efficient solutions in buildings, transport systems and industry would give people the energy services they need without having to build as many power plants, refineries or gas pipelines.

Japan and the countries of the European Union have been more eager to reduce oil imports than the U.S. has and have encouraged productivity gains through energy taxes and other measures. But all OECD countries except Japan have so far failed to update appliance standards. Nor do gas and electric bills in OECD countries indicate how much energy is used for heating, say, as opposed to boiling water or which uses are the most energy-intensive—that is, where a reduction in usage would produce the greatest energy savings. In industry, compressed air, heat, cooling and electricity are often not billed by production line but expressed as an overhead cost.

Nevertheless, energy efficiency has a higher profile in Europe and Japan. A retrofitting project in Ludwigshafen, Germany, serves as just one example. Five years ago 500 dwellings were equipped to adhere to low-energy standards (about 30 kilowatt-hours per square meter per year), reducing the annual energy demand for heating those buildings by a factor of six. Before the retrofit, the dwellings were difficult to rent; now demand is three times greater than capacity.

Other similar projects abound. The Board of the Swiss Federal Institutes of Technology, for instance, has suggested a technological program aimed at what we call the 2,000-Watt Society—an annual primary energy use of 2,000 watts (or 65 gigajoules) per capita. Realizing this vision in industrial countries would reduce the per capita energy use and related carbon emissions by two thirds, despite a two-thirds increase in GDP, within the next 60 to 80 years. Swiss scientists, including myself, have been evaluating this plan since 2002, and we have concluded that the goal of the 2,000-watt per capita society is technically feasible for industrial countries in the second half of this century.

To some people, the term "energy efficiency" implies reduced comfort. But the concept of efficiency means that you get the same service—a comfortable room or convenient travel from home to work—using less energy. The EU, its member states and Japan have begun to tap the substantial—and profitable—potential of efficiency measures. To avoid the rising costs of energy supplies and the even costlier adaptations to climate change, efficiency must become a global activity. SA

MORE TO EXPLORE

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