CHAPTER 2

Making Better Energy Choices

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Nestled among the rolling green hills of southern West Virginia lie old towns like Clear Creek, Duncan Fork, Superior Bottom, and White Oak. The Appalachian Mountains of this region are home to some of the poorest people in the United States. For generations, residents have relied on coal mining for jobs and as a way of life. But many believe that "Appalachia is under assault" and that the industry that has sustained them for generations is now impoverishing them. Mountaintops are being blasted off to reach coal that lies within. In the process, mountains become wasteland, hardwood forests are lost, streams fill with toxic sludge, wells dry up, and entire communities are being driven away.[1]

Miles away from these barren mountain tops, someone arrives home and flips a switch, wanting only light in the darkness and not thinking about what this involves beyond the walls of the house. For most people, electricity is an invisible force that flows in magically and silently to brighten a room, cool a refrigerator, heat a stovetop, or bring a television to life. Between monthly utility bills, most people give it little thought.

Yet the moment someone flips a light switch or turns on a computer, a chain reaction is set in motion. Current flows into the building from transmission lines that stretch across open land and city streets to bring electricity from distant power plants. Along the way, much of this energy is lost to resistance in the transmission lines and dissipates as heat.

To create electricity, in much of the world enormous piles of coal move by conveyor belt to be pulverized into a fine powder and then fed into a blazing fire in the power plant's furnace. The fire produces steam from water, which turns a generator to produce an electrical current. In the process, the plant emits pollutants that cause acid rain and smog, as well as mercury and carbon dioxide (CO_2), a global warming gas. At most, 35 percent of the coal's energy converts to electricity, meaning that nearly two thirds of it is lost as waste heat, benefiting no one and often harming surrounding ecosystems. And all this coal must be transported to the power plant, by rail or barge, from places like the Appalachian Mountains of southern West Virginia.[2]

Everything we consume or use—our homes, their contents, our cars and the roads we travel, the clothes we wear, and the food we eat—requires energy to produce and package, to distribute to shops or front doors, to operate, and then to get rid of. We rarely consider where this energy comes from or how much of it we use—or how much we truly need.

Whether in the form of gasoline to fuel a car or uranium to generate electricity, the energy required to support our economies and lifestyles provides tremendous convenience and benefits. But it also exacts enormous costs on human health, ecosystems, and even security. Energy consumption affects everything from a nation's foreign debt (due to fuel imports) to the stability of the Middle East. From the air we breathe to the water we drink, our energy use affects the health of current and future generations. Inefficient and unsustainable use of biomass in poor nations leads to deforestation and desertification, while unsustainable use of fossil fuels is altering the global climate. And as we seek out more-remote sources of fuel, we endanger the culture and way of life of indigenous peoples from the Amazon to the Arctic.

The energy intensity—that is, the energy input per dollar of output—of the global economy is declining, and recent decades have seen continuing improvements in energy efficiency. Yet these encouraging developments are being offset by an ever-increasing level of consumption worldwide. Of course, it is not surprising that energy use is rising in developing countries, where most people have never driven a car, turned on an air conditioner, or cooked with anything other than wood or animal dung. As their lives improve, their use of energy increases, and vice versa.

More surprising is the dramatic surge in energy use in many industrial countries. Compared with just 10 years ago, for example, Americans are driving larger and less efficient cars and buying bigger homes and more appliances. As a result, U.S. oil use has increased over the decade by nearly 2.7 million barrels a day—more oil than is used daily in total in India and Pakistan, which together contain more than four times as many people as the United States does. Is this ever-growing demand sustainable? And is a fundamental shift required in the way we produce and use energy?[3]

The type and amount of energy that people use is influenced by a number of factors, including income, climate, available resources, and corporate and government policies. Through taxes and subsidies, regulations and standards, and investments in infrastructure, governments influence how, where, how much, and what form of energy we use. But we as consumers are not powerless bystanders. We are the ones who buy vehicles, appliances, clothing, homes, and other goods and services, based on features such as price, fashion, and values. Ultimately, within the limits of availability and affordability, it is consumers who choose what to buy and how to use it, and thus it is consumers who can drive change.

Global Energy Use Trends

Between 1850 and 1970, the number of people living on Earth more than tripled and the energy they consumed rose 12-fold. By 2002, our numbers had grown another 68 percent and fossil fuel consumption was up another 73 percent. Energy use has driven economic growth and vice versa, but they are not as closely linked as once believed. Before the first global oil crisis, many economists thought that using more energy was a prerequisite for economic growth. But when oil prices suddenly leaped skyward in the early 1970s, governments and consumers reacted by setting efficiency standards and conserving fuel. Between 1970 and 1997, global energy intensity declined 28 percent as economic output continued to rise.[4]

The more efficiently we produce and use energy, the less energy we require for the same services. If the United States used as much energy per dollar of gross domestic product in 2000 as it did in 1970, energy consumption would have totaled 177 quads rather than the 98.5 quads actually used. According to energy analyst Amory Lovins, energy efficiency measures enacted since the mid-1970s saved the United States an estimated $365 billion in 2000 alone.[5]

With only 2 percent of global reserves and 4.5 percent of total population, the United States remains the world's largest oil consumer.

The potential for future savings in the United States and elsewhere remains enormous. We still waste huge amounts of energy. Consider the path from coal mine to light switch, and imagine those energy losses throughout the entire economy, and in every country. In the United States, for example, for every 100 units of energy fed into power plants, buildings, vehicles, and factories, no more than 37 units emerge as useful services such as heat, electricity, and mobility. Globally, the average efficiency of converting primary energy into useful energy is 28 percent. And losses vary greatly from one use or country to the next: for example, Lovins estimates that only 14 percent of oil at the wellhead reaches the wheels of a typical modern car.[6]

Consumption of energy, particularly oil, has increased steadily, with only a brief slowdown during the oil crises of the 1970s. Only Eastern Europe and the former Soviet states have experienced declines in energy consumption. Industrial countries continue to use the largest share of global oil—62 percent. U.S. oil use has doubled since 1960. Although the nation's share of global consumption has declined considerably since 1960, during the 1990s it began to inch up again. With only 2 percent of global reserves and 4.5 percent of total population, the United States remains the world's largest oil consumer.[7]

Today the world's richest people use on average 25 times more energy per person than the poorest ones do. In fact, almost a third of the people in the world have no access to electricity or other modern energy services, while another third have only limited access. About 2.5 billion people, most in Asia, have only wood or other biomass for energy. The average American consumes five times more energy than the average global citizen, 10 times more than the average Chinese, and nearly 20 times more than the average Indian. (See Table 2–1.)[8]

Extreme inequalities exist within the developing world as well, where energy consumption is rising fastest and petroleum use alone has quadrupled since 1970. For example, India has a rapidly growing consumer class that is accumulating cars and home appliances, while 48 percent of Indian families live without permanent housing. The same can be said for countries from Ghana to Viet Nam.[9]

More and more people in the South are using as much energy as people in the North do on average, and studies suggest that their incomes are rising faster than anything experienced by the industrial world. (See Box 2–1.) China is already the world's number one coal consumer and the third largest oil user, while Brazil is the sixth largest oil consumer, India ranks eighth, and Mexico tenth.[10]

Table 2–1. Annual Energy Consumption and Carbon Dioxide Emissions, Selected Countries

Country	Commercial Energy	Oil	Electricity	Carbon Dioxide Emissions
	(tons of oil equivalent per person)	(barrels per day per thousand population)	(kilowatt-hours per person)	(tons per person)
United States	8.1	70.2	12,331	19.7
Japan	4.1	42.0	7,628	9.1
Germany	4.1	32.5	5,963	9.7
Poland	2.4	10.9	2,511	8.1
Brazil	1.1	10.5	1,878	1.8
China[1]	0.9	4.2	827	2.3
India	0.5	2.0	355	1.1
Ethiopia	0.3	0.3	22	0.1

[1]Excluding Hong Kong.
SOURCE: See endnote 8.

BOX 2–1. SURGING ENERGY DEMAND IN CHINA AND INDIA

Although more than a third of the world's people live in China and India, they now account for only 13 percent of global energy consumption. But their energy use is rising rapidly, and these two nations both rely heavily on coal—China for more than 70 percent of its commercial energy and India for over 50 percent. The International Energy Agency projects that rising energy demand in China and India will account for more than two thirds of the expected global increase in coal use between now and 2030. These population giants will thus have enormous impacts on the global energy market and the environment in the decades ahead.

Income levels have risen rapidly in both countries thanks to declining population growth rates and surging economic growth. China's economy has more than quadrupled in size since 1980. During the 1980s, electricity demand in China increased more than 400 percent because of appliance purchases. In India, the number of "affluent" households—those earning $220 per month or more—grew sixfold in just five years, while the number of low-income families declined significantly. Such trends promise to accelerate, feeding a growing consumer class that wants access to the conveniences of home appliances, lighting, gas-powered cooking, and increased mobility.

Demand for oil will grow rapidly too, as more and more people obtain private cars. Domestic oil currently meets about two thirds of China's needs, but consumers will soon rely far more on imports if demand doubles by 2025 as expected—causing China to overtake Japan as the world's second largest oil consumer, behind the United States. Car sales in China grew by 82 percent during the first half of 2003 relative to the same period the previous year. At projected growth rates, China's private vehicle fleet could swell from just over 5 million in 2000 to nearly 24 million by the end of 2005, adding substantially to already congested streets and polluted air. Growth in purchases of sport-utility vehicles (SUVs), which have poor fuel economy, has exceeded even manufacturers' expectations. In India, SUV sales now represent 10 percent of vehicle purchases, and they could soon surpass car sales.

—*Tawni Tidwell*

SOURCE: See endnote 10.

To date, energy use in the South has been limited primarily by income and infrastructure—lack of access to roads and electricity has restrained use of cars and appliances, for example, even among the growing middle and upper classes. In the future, however, people in the developing world will be more constrained by depleting resources and environmental realities. Earth cannot provide enough for today's global population to live like the average American, or even the average European. (See Chapter 1.) For example, if the average Chinese consumer used as much oil as the average American uses, China would require 90 million barrels per day—11 million more than the entire world produced each day in 2001. In the future, population growth, climate change, and other environmental challenges could stress natural systems to their limits, while conventional fuels cannot meet projected energy demand growth. In fact, many analysts predict that even at current consumption rates world oil production will peak before 2020. This has enormous implications for the way people live and get around.[11]

Energy That Moves Us

During the twentieth century, humans became a vastly more mobile species. In industrial countries today, it is not unusual for someone to travel 10,000 or even 50,000 kilometers in a year. And a good deal of what we use as consumers, from our personal computers to the food we eat, crosses continents and oceans to reach us. Just 150 years ago, movement was limited to the distance a person or animal could travel on foot. For roughly a third of humanity, of course, this is still true. For the other two thirds, however, increased mobility of people and property has had profound impacts, altering everything from work to family to the nature and design of our cities.

Today transportation accounts for nearly 30 percent of world energy use and 95 percent of global oil consumption. The United States is by far the world's largest consumer of energy for transport, devouring more than a third of the global total. Starting from a low base, however, transport energy use is currently increasing most rapidly in Asia, the Middle East, and North Africa.[12]

In fact, transport is the world's fastest-growing form of energy use, driven in part by a shift of people and freight to more flexible but more energy-intensive transport modes. Although more passengers travel by rail than air, and more freight by ship than other means, even relatively small shifts in transport choices have significant impacts. Only 0.5 percent of the total distance people travel each year is done by air, yet planes use up about 5 percent of transportation energy. And trucks require four to five times more energy than railroads or ships do for the same weight and distance shipped.[13]

But the most significant driver of rising energy consumption for transportation is growing reliance on the private car. Some 40.6 million passenger vehicles rolled off the world's assembly lines in 2002, five times as many as in 1950. The global passenger car fleet now exceeds 531 million, growing by about 11 million vehicles annually.[14]

About one fourth of those cars are found on U.S. roads, where cars and light trucks account for 40 percent of the nation's oil use and contribute about as much to climate change as all economic activity in Japan does. The total distance traveled by Americans exceeds that of all other industrial nations combined—not only because the country is larger, but also because Americans opt to drive when others bike or walk. As a U.S. transportation consultant recently noted, "The automobile has gotten like TV sets:

There are more of them in the house than eyes to look at them." Today there are more cars than Americans licensed to drive them, and most households own two or more vehicles.[15]

On a per capita basis, car ownership in Western Europe and Japan is comparable to ownership levels in the United States in the early 1970s, while Eastern Europe is more like the United States in the 1930s. But rising incomes, lifestyle changes, women entering the work force, national policies that encourage mobility, and declining fuel costs have all spurred significant growth. Per-person car ownership in Japan quadrupled from 1975 to 1990, and Poland saw a 15-fold increase from the early 1970s to 2001. Only about 20 percent of the world's vehicles are in Asia and the Pacific region, but the numbers there are growing by 10–15 percent a year. (See Table 2–2.)[16]

The size and weight of vehicles are expanding as well—a trend that has wiped out more than 20 years of efficiency improvements gained in the United States through federally mandated fuel efficiency standards. In fact, the fuel economy of U.S. vehicles would be one third higher than it is today if weight and performance had remained constant since 1981. Ironically, Ford Motor Company's Model T got better gas mileage nearly a century ago than the average vehicle Ford puts on the roads today (albeit with a top speed of 45 miles per hour). Nearly half the vehicles that Americans buy now are gas-guzzling SUVs and light trucks. And the yearning for larger vehicles is contagious. If current trends continue, by 2030 half of the world's passenger vehicles will be SUVs or other light trucks.[17]

People are also driving greater distances. Between 1952 and 1992, while the number of people in the United Kingdom increased 15 percent, the distance they drove tripled. And from 1970 to 2000, the kilometers traveled in European Union (EU) countries more than doubled. In the United States, the number of trips per household rose 46 percent between 1983 and 1995, while average trip length increased more than 5 percent.[18]

Although mobility contributes to economic and social well-being, there are high external costs associated with the extent and nature of our travel. Worldwide, nearly a million people—most of them pedestrians—are killed in traffic accidents each year, and the number of deaths from vehicular air pollution is higher. As vehicle use increases, roads

Table 2–2. Private and Commercial Vehicle Fleets, Selected Countries and Total, 1950–99

Country	1950	1960	1970	1980	1990	1999
			(million vehicles)			
United States	49.2	73.9	108.4	155.8	188.8	213.5
Japan	–	1.3	17.3	37.1	56.5	71.7
Germany	–	5.6	15.5	24.6	32.2	45.8
China	–	–	–	1.7	5.8	12.8
India	–	0.5	1.1	1.9	4.2	8.2
Argentina	–	0.9	2.3	4.3	5.9	6.6
South Africa	0.6	1.2	2.1	3.4	5.1	6.6
Czech and Slovak Reps.	0.2	0.4	1.0	2.6	3.7	5.1
World	70.4	126.9	246.4	411.0	583.0	681.8

SOURCE: See endnote 16.

become congested, wasting productive hours and reducing vehicle efficiency. The costs of road transport not covered by drivers—air pollution, noise, congestion, accidents, and road damage—start at 5 percent of gross domestic product in industrial countries and go higher in some developing-country cities. And money we invest in road-based infrastructure means less invested elsewhere, which worsens existing social inequities for those who cannot use the predominant means of transport. Even in the United States, about a third of the population is too poor, too old, or too young to drive a car.[19]

West Europeans now use public transit for 10 percent of all urban trips, and Canadians for 7 percent, compared with Americans at only 2 percent.

The choices people make about how to move around are greatly influenced by government policies, such as vehicle and fuel taxes, land use rules, and support for air and car transport versus public transit and bicycle use. A century ago, the United States led the world in public transit. In 1910, almost 50 times more Americans commuted to work by rail than by car, and a decade later almost every major U.S. city had a rail system. But following World War II, the government emphasized construction of roads and freeways. Today U.S. commuters receive subsidies for parking while those who use public transit receive considerably less, and bicyclists get nothing. Thus it is not surprising that public transit ridership is lower today than it was 50 years ago, despite a doubling in U.S. population. An exception to this trend is New York City, where due to high density and a proliferation of taxis and public transit options, only 25 percent of residents are licensed to drive. And in cities such as Denver, Colorado, where services are improving or expanding, the use of mass transit is again on the rise.[20]

In contrast, many countries have devoted significant resources to public transport while discouraging the use of private vehicles through traffic policies and user fees. In Japan and Europe, much of the investment in transportation infrastructure after World War II focused on passenger trains and transit systems. Today nearly 92 percent of downtown Tokyo travelers commute by rail, and the Japanese do only 55 percent of their traveling by car. West Europeans now use public transit for 10 percent of all urban trips, and Canadians for 7 percent, compared with Americans at only 2 percent. This is significant because for every kilometer people drive by private vehicle, they consume two to three times as much fuel as they would by public transit.[21]

Differences in transport trends are also explained by prices. The most rapid growth in private vehicle ownership and use typically occurs in countries with the lowest fuel and car prices. Cars and gas are cheaper in the United States than in Europe, for example, because they are not taxed as heavily. In fact, some of the worst gas guzzlers are subsidized: in 2003 the U.S. Congress passed legislation that effectively tripled a federal business tax credit for SUV purchases, to $75,000 each, compared with a $2,000 deduction for hybrid-electric vehicles.[22]

Despite U.S. policies and low fuel prices, some Americans are opting to pay more in order to consume less. While today's internal combustion engine is only about 20 percent efficient, hybrid cars can go much farther on a liter of fuel. By January 2003, some 150,000 drivers around the world had bought a hybrid car; many of these new owners are in the United States, where monthly sales of the

Toyota Prius were quadruple the figure in Japan. (See Box 2–2.)[23]

Growing awareness of air pollution, safety, and congestion problems associated with cars have motivated strong measures to reduce traffic growth, particularly in developing countries. In 1999, a group of citizens in Santiago, Chile, joined with the environmental group Greenpeace on a year-long campaign to upgrade that city's public transit system. As a result, Santiago now has special corridors for buses, the largest streets are restricted to public transit on high pollution days, and public transit usage has risen considerably.[24]

The municipal government in Bogotá, Colombia, began shifting roadways from cars to bicycles in the late 1980s and plans to ban private car use during peak hours by 2015. Former Mayor Enrique Peñalosa, the driving force behind this movement, believes that cars are "the most powerful instrument of social differentiation and alienation that we have in society" as they divert money away from education and other social services. Today, Bogotá has a good public transit system, pollution levels have declined, and commuting times during rush hours have been cut in half. Numerous other cities, from Zurich in Switzerland to Portland in Oregon, have lowered pollution levels while increasing public transport use by reorganizing urban areas and improving transport efficiencies.[25]

"Congestion charges" on vehicles entering city centers, combined with investments in public transit, have also reduced car use and pollution. London drivers used to spend half their time stuck in traffic, traveling the same speed as Londoners a century ago. But in response to a toll enacted in early 2003, traffic levels dropped by an average of 16 percent in the first few months, and most former car users began commuting by public transit. Central-city congestion charges were established years ago in Singapore and in Trondheim, Norway, and more recently in Toronto and Melbourne, with similar results.[26]

Elsewhere people have chosen to share fleets of vehicles rather than owning them, and in some places people are moving away from cars completely. A joint EUROCITIES-European Commission network is now promoting a "new mobility culture" throughout the EU, aiming to improve quality of life and shift reliance from cars to public transit, cycling, and walking. Zermatt, Switzerland, uses its long-time car-free status as a selling point for tourists, and 280 households in Freiburg, Germany, were the first of more than 40 German communities to commit to living without cars. It seems that once people have alternatives that are safe, comfortable, and reliable, more of them choose to live car-free.[27]

BOX 2–2. EFFICIENCY IS NOT ENOUGH

Numerous studies have concluded that over the next 10–15 years, the fuel economy of new U.S. cars and light trucks can increase by as much as one third with existing technologies. In the longer term, the use of light but strong space-age composite material, based on carbon fibers, advanced design, and hybrid or fuel-cell technology, could at least triple fuel economy. However, improvements in efficiency will only begin to resolve the problems associated with our transportation choices. And efficiency advances, in isolation, can actually encourage people to use more energy, increasing their travel and vehicle purchases because energy costs represent a smaller share of total expenses.

SOURCE: See endnote 23.

Energy Where We Live and Work

Worldwide, people use about a third of all energy in buildings—for heating, cooling, cooking, lighting, and running appliances. Building-related energy demand is rising rapidly, particularly within our homes.[28]

But there are large differences in household energy use from one country to the next. People in the United States and Canada consume 2.4 times as much energy at home as those in Western Europe. The average person in the developing world uses about one ninth as much energy in buildings as the average person in the industrial world, even accounting for noncommercial fuels. Yet a much higher share of total energy in developing countries is used at home because available fuels and technologies are so inefficient. In China, households use about 40 percent of the nation's energy, in India the figure is 50 percent, and in most of Africa it is even higher, compared with 15–25 percent in the industrial world.[29]

Although perhaps one fourth of the world's inhabitants have inadequate shelter or no house at all, for many other people home sizes are expanding even as the number of people per household shrinks. The United States represents the extreme case, where average new homes grew nearly 38 percent between 1975 and 2000, to 210 square meters (2,265 square feet)—twice the size of typical homes in Europe or Japan and 26 times the living space of the average person in Africa.[30]

As homes become bigger, largely due to low energy prices, each individual house has more space to heat, cool, and light, as well as room for bigger appliances and more of them. And as the number of people per household contracts, due to a variety of social trends, the number of houses needed for a given population rises. Each additional home requires construction materials, lighting, heating and cooling, appliances, and often more cars and roads—all of which require energy to produce and to operate. Between 1973 and 1992, shrinking household size in industrial countries alone accounted for a 20-percent increase in energy use per person.[31]

Home appliances are the world's fastest-growing energy consumers after automobiles, accounting for 30 percent of industrial countries' electricity consumption and 12 percent of their greenhouse gas emissions. Saturation in the ownership of large appliances in these nations is continually offset by the diffusion of new ones, including computers and other forms of information technology (IT), while efficiency gains made since the 1970s are being squandered in exchange for more and larger amenities. (See Box 2–3.) The average size of refrigerators in U.S. households, for example, increased by 10 percent between 1972 and 2001, and the number per home rose as well. Air conditioning has taken a similar path: in 1978, 56 percent of American homes had cooling systems, most of which were small window units; 20 years later, three quarters of U.S. homes had air conditioners, and nearly half were large central systems.[32]

Between 2000 and 2020, electricity use for appliances in the industrial world could rise 25 percent. Standby power—the electricity consumed when televisions, computers, fax machines, stereos, and many other appliances are turned "off" but are not unplugged—will likely be the fastest-growing consumer. By 2020, it could represent 10 percent of total electricity use in these countries, requiring almost 400 additional 500-megawatt power plants that will emit more than 600 million tons of carbon dioxide annually.[33]

In developing countries, most building-related energy needs are for cooking, water

BOX 2–3. THE BANE AND BOON OF INFORMATION TECHNOLOGY

The information technology age held the promise of a clearer path to sustainable development and a paperless economy. Yet it appears to have delivered neither. To date the impacts of IT on global energy consumption present a complex picture.

Americans use 2 percent of their electricity just to run computers and Internet equipment, while lifecycle consumption of the entire Internet infrastructure in Germany takes 3–4 percent of national energy. Much of the increase in energy use is attributable to new industries (such as Internet service providers), methods of communication (such as cell phones), and new forms of information management created through the use of IT. Rather than reducing paper consumption, electronic mail has actually increased it by 40 percent, with dramatic impacts on associated energy use—from running printers to supporting one of the most energy-intensive industries in the world, the paper industry. And although ordering products electronically would intuitively seem to require less energy than driving to different stores, this has turned out not to be true. One study of "tele-shopping" showed no net transport savings, while another found it took 55 percent more fuel to deliver groceries purchased online.

By some accounts, however, consumers in industrial nations are reducing their energy use with IT through changes in product inventories and through telecommuting, which cuts the amount of energy used to construct and occupy new buildings. IT has also been credited with driving much of the dramatic economic growth that some countries experienced in the late 1990s—a trend not matched by similar increases in energy consumption due to expansion of less energy-intensive industries like banking and financing.

Other benefits of IT include:

- A new computer chip and equipment design can reduce standby power requirements up to 90 percent.
- Toyota's newest hybrid-electric vehicle has an electronic control and software system that continuously optimizes the operation of key components, ensuring that the car always performs in its most efficient mode.
- Researchers at the Pacific Northwest National Laboratory are developing a "smart grid" that will prompt consumers to vary their energy loads as electricity prices change. This will increase the operating efficiency of existing plants by reducing the need for additional grid capacity and by enabling advanced controls and sensors to improve the efficiency of appliances. It will also provide renewable energy with easier access to the grid and energy markets.

—*Tawni Tidwell*

SOURCE: See endnote 32.

heating, and space heating—life's essentials—and most of this energy is derived from noncommercial, traditional fuels. For example, nearly three fourths of India's population relies on traditional biomass for cooking. Even so, demand for modern appliances is rising across the developing world as well. (See Table 2–3.)[34]

In fact, most of the growth in electricity demand since 1990 has occurred in the developing world, where per capita consumption has risen faster than income and where energy use for buildings tripled between 1971 and 1996. Television ownership increased fivefold in East Asia and the Pacific between 1985 and 1997. But appliance penetration rates are still relatively low in developing countries, so the potential for growth is enormous. In India, sales of frost-free refrigerators are projected to grow nearly 14 percent annu-

Table 2–3. Appliance Ownership in Industrial and Developing Countries, Selected Years

Country	Year	Refrigerator	Clothes Washer	Dishwasher	Air Conditioner
		(number per 100 households)			
United States	1973	100	70	25	47
	1992	118	77	45	69
	1998	115[1]	77	50	72
Japan	1973	104	96	0	16
	1992	117	99	0	131
Western Europe[2]	1973	91	69	5	0
	1992	111	89	24	1
India	1994	7	2	–	–
	1996	9	4	–	–
	1999	12	6	–	–
China rural/urban	1981	0/0	0/6	–	0/0
	1992	2/53	12/83	–	0/0
	1998	9/76	23/91	–	1/20

[1]Other sources show continued increases to 2000. [2]United Kingdom, West Germany, France, and Italy.
SOURCE: See endnote 34.

ally. The International Energy Agency expects that, based on current policies, world electricity demand will double between 2000 and 2030, with the greatest demand increase in the developing world and the most rapid growth in people's homes.[35]

Yet the same needs could be met with far less energy. Efficiency programs have proved highly effective to date, and continued improvements could take us a long way toward meeting this rising demand. The United States established national standards in 1987 after a proliferation of state-level programs. In response, manufacturers achieved major savings in appliance energy use, nearly tripling the efficiency of new refrigerators between 1972 and 1999 while saving consumers money. In Europe, higher energy prices combined with standards and labels, such as the German Blue Angel, have influenced consumer choice and have led manufacturers to produce more-efficient products in order to compete, thereby transforming entire markets. (See Chapter 5.) Still, much more could be done. Technologies available today could advance appliance efficiency by at least an additional 33 percent over the next decade, and further improvements in dryers, televisions, lighting, and standby power consumption could avoid more than half of projected consumption growth in the industrial world by 2030.[36]

In developing countries, people could save as much as 75 percent of their energy through improvements in building insulation, cooking, heating, lighting, and electrical appliances. Unfortunately, diffusion of more-efficient technologies is extremely slow due to high initial costs, the lack of modern fuels such as piped gas, and failures of existing distribution systems. Experiences in Thailand and Brazil show what is possible, however. In the early 1990s, facing a 14-percent annual increase in demand for electricity, the Thai government initiated a partnership with manufacturers to improve the efficiency of buildings, lighting, and cold appliances (such as refrigerators and air conditioners). By 2000, Thailand had exceeded its energy savings and CO_2 reduction targets by at least 200 percent. Between 1996 and 1998 alone, the market share of efficient refrigerators skyrocketed from 12 to 96 percent. And in Brazil, thanks greatly to labeling and voluntary standards, consumers lowered refrigerator-related energy use by 15 percent from 1985 to 1993.[37]

Improvements in the design and construction of buildings could also yield significant energy savings. According to energy analyst Donald Aitken, "Buildings remain the most underrated aspect of energy economics, and the most unexploited opportunity for improving efficiency." Potential savings in existing buildings are enormous, and consumers have already begun making improvements. In the EU, building construction is responsible for more than 12 percent of economic activity, and over half of this is for retrofitting existing buildings. But new buildings offer the greatest potential for savings, and the numbers are not insignificant—Americans alone erected 1.7 million new private homes in 2002.[38]

Because many buildings stand for at least 50–100 years—and some last for centuries—it is essential to get them right the first time. Even in cold climates, people can reduce the heating needs of new buildings by 90 percent through a combination of design and material improvements, while lighting and other energy needs can be lowered as well. As most people do not build their own homes or offices, efficiency of building design and materials generally rests on government regulations. California's buildings are far more efficient than the U.S. average because the state's building code is updated regularly, based on current technologies. Perhaps most telling is the fact that while per capita electricity use has doubled over the past 30 years in the rest of the country, it has remained constant in California.[39]

The energy demands of buildings can be dramatically reduced without increasing construction costs by using an integrated approach to the building "envelope" (the walls, roofs, foundations, and so on) and the mechanical and electrical systems. Many new buildings in Europe and the Asia-Pacific region were built incorporating this approach, including the European Parliament building in Strasbourg in France, Potsdamer Platz in Berlin, and Aurora Place in Sydney, Australia.[40]

Around the world, people are erecting "green" buildings that include additional energy-saving features such as daylighting, natural cooling, high performance windows, superior insulation, and photovoltaics (PVs). According to the Rocky Mountain Institute, lighting consumes up to 34 percent of U.S. electricity, including energy requirements for offsetting waste heat. Full use of advanced lighting technologies alone could eliminate the need for 120 1,000-megawatt power plants in the United States, saving money and improving human health and productivity as well.[41]

Encouraged by the U.S. Leadership in Energy and Environmental Design (LEED) program—a voluntary standard for green buildings—developers built the world's first green "high-rise" in New York City. These Battery Park City apartments will use 35 percent less energy and 65 percent less electricity than an average building during peak hours, with PVs meeting at least 5 percent of the demand. And on Earth Day in May 2003, Toyota opened a new California building complex constructed with steel from recycled automobiles, including efficient design and lighting and boasting one of North America's largest commercial PV systems.[42]

From California to Kenya to Germany, consumers are installing minute to megawatt-sized PV systems on the rooftops of houses and businesses. In 2002, more than 40,000 Japanese homeowners added 140 megawatts of PV installations, thanks to supportive government policies. Generating power locally with solar or wind energy is not only cleaner than conventional electricity, it also reduces or eliminates transmission and distribution losses, which range from 4–7 percent in industrial nations to more than 40 percent in parts of the developing world.[43]

Elsewhere people are painting roofs and planting rooftop gardens to reduce their energy consumption by 10–50 percent. Germans developed modern green roof technology, inspired by the sod roofs and walls in Iceland. Replacing dark, heat-absorbing surfaces of rooftops with plants lowers ambient temperatures and reduces energy use for heating and cooling. Examples of green roofs can be seen around the world, from Chicago's City Hall to Amsterdam's Schiphol Airport and Ford Motor Company's Rouge River Plant in Michigan—all 4.2 hectares (10.4 acres) of it.[44]

Energy in Everything We Buy

Everything we use has associated and compounding energy inputs, and the largest share of global energy consumption goes into producing our vehicles, appliances, buildings, and even our clothes and food. In the 1970s, manufacturing such products required 25–70 percent of total energy (varying widely by country). This share has declined steadily in all countries as the transportation and building sectors have grown even more rapidly, but energy use in manufacturing is still rising as we buy and use more and more stuff.[45]

Many manufactured goods cross borders and oceans to reach us, where the energy required to make and move them is omitted from national accounts. As a result, some experts argue that energy intensity is actually increasing in some nations, because they effectively import energy inputs from overseas. For example, by one estimate, the energy embodied in Australia's imports exceeds that of its exports.[46]

The energy invested in a particular thing during its life, from cradle to grave, is called the "embodied energy" of that object. The amount of embodied energy that an item contains depends greatly on the technology used to create it, the degree of automation, the fuel used by and the efficiency of a particular machine or power plant, and the distance the item travels from inception to purchase. The value differs considerably from place to place, and even from house to house.

By some estimates, people can live in a typical house for 10 years before the energy they use in it exceeds what went into its components—steel beams, cement foundation, window glass and frames, tile floors and carpeting, drywall, wood paneling or stairs—and its construction. And the embodied energy in the structure is rarely static. As people remove old materials and install new ones, add another room or a new deck, the embodied energy in the house increases.[47]

As with houses, large amounts of energy are required to assemble our automobiles, to construct and operate the manufacturing plants, and to fabricate the various inputs that make up a car. Most of the energy use associated with making a vehicle is for the manufacture of steel, plastic, glass, rubber, and other material inputs. The larger a vehicle, the more energy required, adding further significance to the trend toward larger cars and SUVs. And once we take a car on the road, its requirements extend to all the energy needed to construct and maintain the highways and bridges we travel, the parking lots, the auto dealers and parts stores, and the many fueling stations needed to keep it running. In total, the energy use associated with a car can be 50–63 percent higher than the direct fuel consumption of the vehicle over its lifetime, and the environmental impacts are also enormous.[48]

But the largest share of energy use associated with vehicles is driving them. To run our vehicles we extract petroleum from the earth, transport it to convenient locations, and refine it into useful fuel. Petroleum refining is one of the world's most energy-demanding industries—and the most energy-intensive in the United States. In 1998, petroleum refining accounted for 8 percent of total U.S. energy consumption.[49]

In many countries, an increasing share of fuel use for household transport is to reach enormous out-of-town "hypermarkets" that are replacing neighborhood food stores. Today many people use almost as much energy to collect some foods as producers do to get them to market. And the farther food travels, the higher its embodied energy, not only because it requires more transport fuel but also because it needs more preservatives and additives, refrigeration, and packaging. In much of the world, food transportation to local stores and then to our homes is among the largest and fastest-growing sources of greenhouse gas emissions.[50]

Producing our food also requires massive amounts of energy. While much comes from the sun, nearly 21 percent of the fossil energy we use goes into the global food system. David Pimentel of Cornell University estimates that the United States devotes about 17 percent of its fossil fuel consumption to the production and consumption of food: 6 percent for crop and livestock production, 6 percent for processing and packaging, and 5 percent for distribution and cooking.[51]

The question of whether embodied energy consumption is rising in some nations is open for debate, and depends greatly on the energy intensity of countries manufacturing the goods consumed. For example, South Korea has the most energy-efficient steel industry in the world, and transporting by ship is relatively energy-efficient. So exporting Korean cars to countries that manufacture steel less efficiently, such as the United States, can actually reduce the embodied energy of vehicles on U.S. roads.[52]

In 1998, petroleum refining accounted for 8 percent of total U.S. energy consumption.

In fact, there are extreme differences in the energy intensity of manufacturing industries from one country to another. In the early 1990s, the Japanese and Germans used less than half as much energy per unit of output in their heavy industries as Canadians and Americans did, due primarily to differences in energy prices. Japan, South Korea, and countries in Western Europe have the most efficient manufacturing sectors, whereas developing countries, the former Soviet bloc, and a few industrial countries—particularly the United States and Australia—have the least efficient. Yet some developing countries have taken the opportunity to leapfrog to modern technologies, rivaling Japan and Europe in manufacturing efficiency.[53]

By supporting items and processes that have lower embodied energy, as well as the companies that produce them, consumers can significantly reduce society's energy use. Unfortunately, labeling programs so far report only direct energy consumption of products, not their full embodied energy, making it difficult to compare one product to another. In spite of this, many consumers have already saved large amounts of energy by recycling and by purchasing recycled materials rather than relying on virgin resources. Producing aluminum from recycled material, for example, requires 95 percent less energy than manufacturing it from raw materials would.[54]

Policy and Choice

We are constantly making choices that affect our energy use. In fact, the amount and type of energy we consume is a result of two kinds of choices: those we make as a society and those we make as individuals and families. Society's decisions to tax or subsidize activities—such as driving and road building, for example—encourage people to adopt certain lifestyles, both extending and limiting their choices. But as individual consumers we still have important choices to make, from how much we drive to whether we insulate our homes. Two individuals with the same incomes, living in the same societies and in similar climates, often use very different amounts of energy as a result of personal choices.

If we are to meet the energy needs of the billions of people who now lack modern energy services, and at the same time bring energy use into balance with the natural world, new energy choices will be required—both at the individual level and at the societal level. Government policies are one way that societies make energy choices, and policies that affect the price of energy are among the most important.

As economies develop, factors such as climate, population density, and rate of urbanization become less important, and energy prices become the fundamental factors determining a nation's energy intensity. In fact, countries with higher energy prices—like Japan and Germany—also have lower energy intensities, while those with lower prices are generally quite energy-intensive, such as the United States for gas and oil, Australia for coal, and Scandinavia for electricity.[55]

When prices are low, energy use for individuals represents a smaller share of the cost of doing business, manufacturing a product, or running a home; consequently, investments in energy savings are low. Over the long term, prices affect what we choose to own, the size of our homes, how much we use our cars and appliances, and even the goods and technologies available to us. However, government policy plays a large role, sometimes propping up or undercutting energy prices. Through subsidies, taxes, standards, and other measures, government policies have a direct impact on energy supplies, demand, and the efficiency of our homes, appliances, cars, and factories.[56]

Auto and fuel taxes in many countries, in conjunction with investments in public transit and bicycle infrastructure, affect ownership trends and distance traveled by car and even the characteristics of the vehicle fleet, and they can encourage the use of public transportation, bikes, and rail. Where governments or companies subsidize public transit, people are more apt to commute by bus or subway than by car. In Denmark, where the tax on auto registrations exceeds a car's retail price, and where rail and bike infrastructure are well developed, more than 30 percent of families do not even own cars—mostly because they do not want them rather than because they cannot afford them. Congestion charges, such as those recently introduced in London, can also encourage commuters to make more-efficient energy choices.[57]

Even choice of home size and location is influenced by taxes, housing policies, and standards. The United States offers a full tax deduction on home mortgage interest, which enables people to buy homes of all sizes but also encourages large homes in sprawling communities. Sweden's tax policy also favors home ownership, but because housing policy has focused for decades on apartments, most people choose apartment living, and cities are more compact as a result. Homes and their contents are more efficient in places like California and Japan, where building codes and appliance standards are becoming increasingly stringent as technologies improve.[58]

And governments can influence the amount of embodied energy in the products people use and the waste left behind. At least 28 countries—from Brazil and Uruguay to China and throughout Europe—now require manufacturers to take back products for reuse and recycling. As a result, companies become more interested and invested in the disassembly and recycling of their goods, increase the quality and lifetime of their products, and thus reduce the amount of energy that goes into making them.[59]

Still, most countries favor auto and air travel over less energy-intensive alternatives, and they are biased toward conventional energy over renewable energy and toward new supplies over efficiency measures. In the mid-1990s, governments worldwide were handing out $250–300 billion annually to subsidize fossil fuels and nuclear power. Since then, several transitioning and developing countries have reduced energy subsidies significantly, but global subsidies for conventional energy remain many magnitudes higher than those for alternatives such as renewables and efficiency. And countries the world over invest enormous amounts of money in large transport infrastructure and energy-intensive manufacturing instead of less intensive, less damaging alternatives.[60]

Because subsidies artificially reduce the price of energy, they can lead to overconsumption. South Korean policies have suppressed electricity prices, undermining national objectives to improve efficiency. By the late 1990s, per capita household energy consumption there exceeded average levels in Europe. And subsidies are often of greatest benefit to those who do not need them. Up until 2003, for example, the Nigerian government provided annually more than $2 billion in fuel subsidies that benefited the rich at least as much as the poor. The subsidies also encouraged the smuggling of cheap fuel out of the country, requiring Nigeria to import fuel at higher cost.[61]

At least 28 countries now require manufacturers to take back products for reuse and recycling.

Combined with billions of dollars provided each year by the World Bank and export-credit agencies for carbon-intensive fossil fuel projects, national subsidies also forestall possible alternatives such as efficiency and renewable energy technologies, encourage energy-intensive industries to move to developing countries, and amount to lost opportunities for those nations to leapfrog to new technologies.[62]

Failure to internalize the full costs of energy acts as a subsidy as well because consumers do not pay directly for the environmental, social, or security impacts of their energy choices—whether the choice is for the source of the energy or for the amount they decide to use. For decades, government attempts to resolve energy problems and associated challenges have focused almost entirely on reducing intensity of production rather than tackling the motivations and problems associated with our ever-rising consumption. Unfortunately, the energy efficiency improvements made on the production end have been more than offset by rising levels of energy use on the consumer end.

But several countries have begun promoting sustainable consumption through green taxes, shifting the tax burden from labor to energy and other resources, often due to concerns about environmental problems such as climate change. As part of its effort to dramatically reduce national greenhouse gas emissions, for instance, Germany enacted new taxes on conventional energy in 1999, providing financial incentives for energy conservation and renewable energy technologies and a reduction in payroll taxes.[63]

While government policy acts to influence energy consumption in many ways, consumers' own decisions also have a major impact. Around the globe, consumers are making a difference, for better or worse. Whether people buy a new hybrid vehicle or a "Hummer," whether they travel by plane, train, or bicycle, or whether they decide not to go somewhere at all are choices that make a difference. Unfortunately, more and more consumers are choosing larger appliances, bigger homes, and tank-like vehicles for single-person trips on urban roads to malls or hypermarkets. As a counterbalance, though not a large one, other consumers are purchasing efficient hybrid cars, choosing locally grown produce, installing PVs, and buying green power. (See also Chapter 6.)

In much of Germany and Denmark, individuals singly and as part of cooperatives have installed wind turbines to provide local power for their communities. Elsewhere, people are tapping into renewable energy through green power markets. By the end of 2002, more than 980 megawatts of new renewable energy capacity had been added to meet the demand of green power customers in the United States, and another 430 megawatts were planned or under construction. And as the result of a student-run campaign calling for national leadership in environmental stewardship, the University of California campuses and Los Angeles College District committed to reducing energy consumption, purchasing green power, and installing photovoltaics on campus buildings. These two university systems together could increase U.S. grid-connected PV installations by 30 percent.[64]

Some consumers are going even further. Local authorities and representatives of municipalities from all over Europe have signed the Brussels Declaration for a Sustainable Energy Policy in Cities, committing to work for sustainable energy use in Europe and encouraging the creation of a legal framework to support the effort. In 1992, people in more than 30 Dutch municipalities voted to eliminate cars from their inner cities, while all over the Netherlands parking for bicycles far exceeds spaces for cars at railway stations as a result of customer demand. The Germans and Swiss started car sharing in the 1980s, and the concept has since spread to more than 550 communities in eight European countries with at least 70,000 members. Car sharing is now catching on in North America as well, with programs in more than 40 U.S. cities, from Seattle to Washington, D.C.[65]

Communities of people in more than 40 countries have created "ecovillages," working to achieve sustainable lifestyles through ecological design and construction, renewable and passive energy use, community building spaces, and local, organic agriculture. But it is not necessary to live in an ecovillage to reduce overall energy use and impact on the natural environment. Californians proved this when the energy crisis of 2001 led them, through behavioral and technological changes, to use 7.5 percent less electricity than in the previous summer. And in London a new community—Zero Emissions Development (ZED), whose housing units were sold out before its completion—

was built to minimize pollution and energy use through a combination of green technologies and designs, proximity to public transit, a shared fleet of electric vehicles, and prominently displayed meters that enable residents to track their resource consumption. Architect Bill Dunster, inspired by the fact that most energy is wasted through everyday choices, asserts that "you can get a better quality of life through making these changes, so why not do it?"[66]

It is widely assumed that quality of life and energy consumption are inextricably linked. Energy can improve lives by providing services that meet basic needs and lift people out of sickness, hunger, cold, and poverty. And the desire for a "better quality of life"—still too often defined as a larger home and more vehicles, appliances, and possessions—drives further energy consumption. But does there come a point beyond which more energy use provides only small marginal benefits? How much do we really need to achieve a good quality of life?

To answer these questions, it is useful to look at the relationship between perceived quality of life in various nations and their use of energy. The Human Development Index (HDI) was created by the United Nations to emphasize people rather than economic growth alone as the focus of development. It measures knowledge, longevity, and living standards. Energy analyst Carlos Suárez has mapped out the correlation between HDI and energy consumption. For the poorest people, even small increases in energy use can bring about dramatic improvements in the quality of their lives, both directly and indirectly. For example, electric lighting reduces eye strain and lengthens hours available for education, modern fuels for cooking lower health risks, and powered pumps reduce time spent collecting water. Improvements in energy services can also provide opportunities for increased income, and thus for further quality-of-life improvements. According to Suárez, the additional benefit per unit of energy drops as energy consumption approaches 1,000 kilograms of oil equivalent (kgoe) per person per year, and at 1,000–3,000 kgoe per person the benefits of additional energy use begin to decline significantly. Beyond this point, even tripling a country's per-person energy consumption does not correlate with an increase in that nation's HDI number. Countries that are nearing 3,000 kgoe per person include Italy, Greece, and South Africa; in contrast, Americans use nearly three times as much energy per person.[67]

Germany enacted new taxes on conventional energy in 1999, providing financial incentives for energy conservation and renewable energy technologies.

In a different attempt to measure quality of life, researcher Robert Prescott-Allen has developed the Wellbeing Index. (See Chapter 8.) This is a numerical ranking of 180 countries based on 87 indicators of human and ecosystem well-being, including health, education, wealth, and individual rights and freedoms, as well as diversity and quality of ecosystems, air and water quality, and resource use. According to the index, Sweden ranks first in well-being in the world while the United Arab Emirates (UAE) is nearly last, and yet the average person in the UAE consumes nearly twice as much energy as the average Swede does. (See Table 2–4.) Austrians, on the other hand, use about 61 percent as much energy as Swedes, yet still rank near the top for well-being. Thus there is no fixed relationship between energy use and

Table 2–4. Energy Use and Well-being, Selected Countries

Country	Well-being Rank[1]	Per Capita Energy Use Rank[2]	Share of Sweden's Per Capita Energy Use
			(percent)
Sweden	1	10	100
Finland	2	6	112
Norway	3	8	104
Austria	5	26	61
Japan	24	19	70
United States	27	4	140
Russian Federation	65	17	71
Kuwait	119	3	162
United Arab Emirates	173	2	190

[1]Out of 180 countries. [2]Based on total primary energy supply.
SOURCE: See endnote 68.

perceived well-being, and there is potential for great advances on the consumption front while improving quality of life.[68]

This is encouraging news because the status quo is not sustainable—socially, economically, or environmentally. There is growing evidence worldwide that current patterns of energy consumption are actually degrading the quality of life for many people—worsening air and water pollution, increasing health problems, raising economic and security costs associated with fuel extraction and use, and weakening the natural systems on which we rely for our very existence, including the global climate. Many developing nations, with huge populations in densely settled areas, are rapidly realizing these limits and starting to address them. For example, severe congestion and pollution problems in Shanghai have forced the city to limit the number of new vehicle registrations each month.[69]

Can Earth sustain our growing energy needs in the twenty-first century, even with a rapid and dramatic shift to more efficient technologies and the heavy use of renewable energy? No one knows for sure, but it certainly will not be easy. Increasing populations and growing levels of per capita consumption—particularly in the developing countries, where 75 percent of the world now lives—have the potential to overwhelm even the most ambitious energy technology efforts.[70]

By 2050, global population is projected to increase more than 40 percent, to 8.9 billion people. If everyone in the developing world were to consume the same amount of energy as the average person in high-income countries does today—a level significantly below per capita consumption in the United States—energy use in the developing world would increase more than eightfold between 2000 and 2050. If everyone on Earth consumed at this rate, total global energy use would increase fivefold over this period.[71]

Although this rate of growth is highly improbable, conventional sources of fossil fuels are unlikely to meet rising demand over the next century. And increasing our use of conventional fuels and technologies will further threaten the natural environment, public health, and international stability, with significant implications for our quality of life. We will be hard-pressed to meet global energy needs even with renewable energy and major improvements in efficiency if current consumption trends continue. Consumption patterns will have to change as well. We will have to find new ways to satisfy the needs of mind and body while reducing consumption of energy for transportation and in our buildings, and while minimizing the energy embodied in all that we buy.

The Secretary-General of the Organisation for Economic Co-operation and Development, which represents the world's wealthiest nations, recently acknowledged that around the world "there is growing consensus that energy use patterns need to be radically altered." Governments can help to shape energy use through measures such as infrastructure investments, regulation, incentives, and energy pricing. Political will and effective, appropriate policies are essential for driving change.[72]

But it is also up to us as individuals—both as consumers and as members of diverse communities—to recognize the links between our consumption choices and the impacts we have on the world around us. We must come to grips with the limits we face and change the way we use energy.