from *Plan B 3.0: Mobilizing to Save Civilization*, by Lester R. Brown

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Raising Energy Efficiency

As noted in Chapter 3, the Himalayan glaciers that feed the major rivers in Asia during the dry season are melting, and some of them could disappear entirely in a matter of decades, shrinking the region's grain harvest. We also noted that if the Greenland and West Antarctic ice sheets melt, sea level will rise 12 meters (39 feet).

The ice melting effects of climate change alone could increase the number of failing states to a point where civilization would begin to unravel. We are faced with civilization-threatening climate change and a need to massively reduce carbon emissions—and to do it quickly. We do not need to wait for future temperature rises to see that we are in trouble. The melting just described warrants a crash program to cut carbon emissions.

One of the goals of Plan B is to reestablish a balance between carbon emissions and nature's capacity to sequester carbon by cutting net carbon dioxide (CO_2) emissions 80 percent by 2020. This will halt the rise in atmospheric CO_2, stabilizing it below 400 parts per million (ppm), up only modestly from the 384 ppm in 2007. It will also help keep future temperature rise to a minimum. Such a basic economy restructuring in time to avoid catastrophic climate disruption will be challenging, but how can we face the next generation if we do not try?[1]

Our plan to cut net CO_2 emissions 80 percent by 2020 includes stopping deforestation and an even more ambitious effort to cut fossil fuel use. The latter has two major components—raising energy efficiency to offset all projected demand growth, as discussed in this chapter, and developing the earth's rich array of renewable energy resources in order to close down all coal- and oil-fired power plants, as discussed in the next chapter.

In laying out Plan B, we exclude the oft-discussed option of CO_2 sequestration at coal-fired power plants. Given the costs and the lack of investor interest in the technology, there is reason to doubt that carbon sequestration will be economically viable on a meaningful scale by 2020.

And similarly, we do not count on a buildup in nuclear power. Our assumption is that new openings of nuclear power plants worldwide will simply offset the closing of aging plants, with no overall growth in capacity. If we use full-cost pricing—requiring utilities to absorb the costs of disposing of nuclear waste, of decommissioning the plant when it is worn out, and of insuring the reactors against possible accidents and terrorist attacks—building nuclear plants in a competitive electricity market is simply not economical.

Beyond the economic costs are the political questions. If we say that expanding nuclear power is an important part of our energy future, do we mean for all countries or only for some countries? If the latter, who makes the A-list and the B-list of countries? And who enforces the listings?

For reference, world electricity generation totaled 18.5 trillion kilowatt-hours in 2006. Of this, two thirds came from fossil fuels (40 percent from coal, 6 percent from oil, and 20 percent from natural gas), 15 percent from nuclear, 16 percent from hydropower, and 2 percent or so from other renewables. (The average U.S. home uses roughly 10,000 kilowatt-hours of electricity per year, so 1 billion kilowatt-hours is enough to supply 100,000 U.S. homes).[2]

Since coal supplies 40 percent of the world's electricity but accounts for over 70 percent of the electrical sector's CO_2 emissions, the first priority is to reduce demand enough to avoid constructing any new coal-fired power plants. In the next chapter we focus on phasing out coal-fired power plants. This may appear to be a novel idea, particularly to energy planners in countries such as China and India, but it is not, for example, in Europe. Germany has cut coal use 37 percent since 1990 through efficiency gains and by substituting wind-generated electricity for that from coal. The United Kingdom has cut coal use 43 percent, largely by replacing it with North Sea natural gas.[3]

In early 2007, some 150 new coal-fired power plants were planned in the United States. Then public opposition began to mount. California, which imports 20 percent of its electricity, prohibited the signing of any new contracts to import electricity produced with coal. Several other states, including Florida, Texas, Minnesota, Washington, and Kansas, followed, refusing licenses for coal-fired power plants or otherwise preventing their construction.[4]

Coal's future took a telling blow in July 2007 when Citigroup downgraded coal company stocks across the board and recommended that clients switch to other energy stocks. In August, coal took another hit when U.S. Senate Majority Leader Harry Reid of Nevada, who had been opposing three coal-fired power plants planned for his own state, announced that he was extending his opposition to building coal-fired power plants anywhere in the world. Investment analysts and political leaders are now beginning to see what has been obvious for some time to scientists such as NASA's James Hansen, who says that it makes no sense to build coal-fired power plants when we will have to bulldoze them in a few years.[5]

Banning the Bulb

Perhaps the quickest, easiest, and most profitable way to reduce electricity use worldwide—thus cutting carbon emissions—is simply to change light bulbs. Replacing the inefficient incandescent light bulbs that are still widely used today with new compact fluorescents (CFLs) can reduce electricity use by three fourths. The energy saved by replacing a 100-watt incandescent bulb with an equivalent CFL over its lifetime is sufficient to drive a Toyota Prius hybrid car from New York to San Francisco.[6]

Over its lifetime, each standard (13 watt) CFL will reduce electricity bills by roughly $30. And though a CFL may cost twice as much as an incandescent, it lasts 10 times as long. Since it uses less energy, it also means fewer CO_2 emissions. Each one reduces energy use by the equivalent of 200 pounds of coal over its lifetime. Less coal burning means reduced air pollution, making lighting efficiency an obviously attractive option for fast-growing economies plagued with polluted air, such as China and India.[7]

The world may be moving toward a political tipping point away from inefficient light bulbs. In February 2007 Australia announced it would phase out the sale of incandescent light bulbs by 2010, replacing them with CFLs. Canada soon followed, saying it would phase out incandescents sales by 2012.[8]

In mid-March, a U.S. coalition of environmental groups joined with Philips Lighting to launch an initiative to shift to more-efficient bulbs in all of the country's estimated 4 billion light sockets by 2016.[9]

By mid-2007, some 15 states either had passed or were considering legislation to restrict or ban the sale of incandescent light bulbs. The proposed legislation in New York, for example, would phase out incandescents by 2012, four years ahead of the coalition's deadline. And with a dozen or so others restricting or proposing to restrict use in one way or another, pressure is building to pass legislation making this shift nationwide.[10]

The European Union (EU), with 27 member countries, announced in March 2007 that it plans to cut carbon emissions 20 percent by 2020, with part of the cut coming from replacing incandescent bulbs with CFLs. In the United Kingdom, the civic group Ban the Bulb has been vigorously pushing for a ban on incandescents since early 2006. Further east, the Moscow city government is urging its residents to switch to compact fluorescents.[11]

Brazil, hit by a nationwide electricity shortage in 2000–02, responded with an ambitious program to replace incandescents with CFLs. As a result, an estimated half of its light sockets now contain these efficient bulbs. In 2007, China—working with the Global Environment Facility—announced a plan to replace all its incandescents with more efficient lighting within a decade.[12]

Greenpeace is urging the government of India to ban incandescents in order to cut carbon emissions. Since roughly 640 million of the 650 million bulbs sold each year in this fast-growing economy are the old inefficient incandescents, the potential for cutting carbon emissions, reducing air pollution, lowering the frequency of blackouts, and saving consumers money is huge.[13]

At the industry level, Philips, the world's largest lighting manufacturer, is going to stop marketing incandescents in Europe by 2016. And the European Lamp Companies Federation (the bulb manufacturers' trade association) is supporting a rise in EU lighting efficiency standards that would lead to a phaseout of incandescent bulbs.[14]

Retailers are joining the switch too. Wal-Mart, the world's largest retailer, announced a marketing campaign in November 2006 to boost its sales of compact fluorescents to 100 million by the end of 2007, more than doubling its annual sales of such bulbs. And Currys, Britain's largest electrical retail chain, announced in 2007 that it would discontinue selling incandescent light bulbs.[15]

For office buildings, commercial outlets, and factories, where linear (tubular) fluorescents are widely used, the key to cutting electricity use is shifting to the most advanced models, which are even more efficient than CFLs. Since linear fluorescents are long-lasting, many of those now in use rely on an earlier, less energy-efficient technology.[16]

An even newer lighting technology—light-emitting diodes or LEDs—uses only one fifth as much electricity as the old-fashioned incandescent bulbs. Already, New York City has replaced traditional bulbs with LEDs in many of its traffic lights, cutting its annual bill for maintenance and electricity by $6 million. LED costs are still high, however, discouraging widespread consumer use.[17]

In addition to switching bulbs themselves, huge energy savings can be gained just by turning lights off when not in use. There are numerous technologies for reducing electricity used for lighting, including motion sensors that turn lights off when spaces are unoccupied, such as in washrooms, hallways, and stairwells. In cities, dimmers can be used to reduce street light intensity, and timers can turn off outside lights that illuminate monuments or other landmarks when people are asleep. Dimmers can also be used to take advantage of day lighting to reduce the intensity of interior lighting.

Shifting to CFLs in homes, to the most advanced linear fluorescents in office buildings, commercial outlets, and factories, and to LEDs in traffic lights would cut the world share of electricity used for lighting from 19 percent to 7 percent. This would save enough electricity to avoid building 705 coal-fired power plants. By way of comparison, today there are 2,370 coal-fired plants in the world.[18]

In a world facing new evidence almost daily of global warming and its consequences, a quick and decisive victory is needed in the battle to cut carbon emissions and stabilize climate. A rapid shift to the most energy-efficient lighting technologies would provide just such a victory—generating momentum for even greater advances in climate stabilization.

Energy-Efficient Appliances

Although many people know that CFLs use only one fourth as much electricity as incandescent light bulbs, considerably fewer know that a similar range of efficiencies exists for many household appliances, such as refrigerators.[19]

The U.S. Energy Policy Act of 2005 included a rise in efficiency standards that will reduce electricity demand enough to avoid building 29 coal-fired power plants. Other provisions in the act—such as tax incentives that encourage the adoption of energy-efficient technologies, a shift to more combined heat and power generation, and the adoption of real-time pricing of electricity (a measure that will discourage optional electricity use during peak demand periods)—would cut electricity demand enough to avoid building an additional 37 coal-fired power plants. Appliance efficiency standards and other measures in the bill will also reduce natural gas consumption substantially. Altogether, these measures will reduce consumer electricity and gas bills in 2020 by over $20 billion.[20]

Taking into account recent technological advances, the American Council for an Energy-Efficient Economy (ACEEE) proposed in March 2006 to raise the bar further for 15 appliances. Included in this group were residential furnaces, pool heaters, and DVD players. If these new standards were adopted in 2008, the ACEEE calculates that they would reduce 2020 electricity demand by 52 billion kilowatt-hours, which would be enough to avoid another 16 coal-fired power plants. The reduction in CO_2 emissions in 2020 from adoption of these standards would be equal to taking 8 million cars off the road. Better still, for every $1 invested in more-efficient appliances, consumers will save over $4 on their electricity and gas bills.[21]

With appliance efficiency, the big challenge now is China. In 1980 its appliance manufacturers produced only 50,000 refrigerators, virtually all for domestic use. In 2004 they produced 30 million refrigerators, 73 million color TVs, and 24 million clothes washers, many of which were for export.[22]

Market penetration of these modern appliances in urban China today is similar to that in industrial countries. For every 100 urban households there are 133 color TV sets, 96 washing machines, and 70 room air conditioners. In rural areas there are 75 color TVs and 40 washing machines for every 100 households. This phenomenal growth in household appliance use in China, along with the extraordinary growth of industry, raised China's electricity use sevenfold from 1980 to 2004. Although China had established standards for most appliances by 2005, the standards are not strictly enforced.[23]

The other major concentration of appliances is in the European Union, home to 490 million people. Greenpeace notes that even though Europeans on average use roughly half as much electricity as Americans or Canadians, they still have a large potential for reducing their usage. A refrigerator in Europe uses roughly half as much electricity as one in the United States, for example, but the most efficient refrigerators on the market today use only one fourth as much electricity as the average refrigerator in Europe—a huge opportunity for improvement.[24]

But this is not the end of the efficiency trail. There is still a wide gap between the most efficient appliances on the market and the efficiency standards just proposed. And advancing technology keeps raising the efficiency potential.

Among industrial countries, Japan's Top Runner Program is the most dynamic system for upgrading appliance efficiency standards. In this system, the most efficient appliances today set the standard for those sold tomorrow. With this program Japan planned to raise efficiency standards between the late 1990s and the end of 2007 for individual appliances by anywhere from 15 to 83 percent, depending on the appliance. This is an ongoing process that continually exploits advances in efficiency technologies.[25]

In an analysis of potential energy savings by 2030 by type of appliance, the Organisation for Economic Co-operation and Development (OECD) put the potential savings from reducing electricity for standby use—that consumed when the appliance is not being used—at the top of the list. As of 2007, the estimated share of electricity used by appliances in standby mode worldwide is up to 10 percent of total electricity consumption. At the individual household level in OECD countries, standby power ranged from a low of perhaps 30 watts to a high of over 100 watts in both U.S. and New Zealand households. Since this power is used around the clock, even though the wattage is relatively low, the cumulative use of electricity is substantial.[26]

Some governments are capping the amount of standby power used by TV sets, computers, microwaves, DVD players, and so on at 1 watt per appliance. South Korea, for example, is mandating a 1-watt limit on standby levels for many appliances by 2010. Australia is doing the same for nearly all appliances by 2012.[27]

A U.S. study estimates that roughly 5 percent of U.S. residential electricity use is consumed by appliances in standby mode. If this figure dropped to 1 percent, which could be done easily, it would reduce electricity use enough to avoid building 17 coal-fired power plants. If China were to lower its standby losses accordingly, it could avoid building an even larger number of power plants.[28]

Climate change is a global phenomenon requiring a global response. The time has come to set worldwide efficiency standards for all household appliances that are determined by the most efficient models on the market today, like Japan's Top Runner Program. The standards would be raised every few years to take advantage of the latest technological gains in efficiency.

The principal reason that consumers do not buy the most energy-efficient appliances is because the improved design and insulation increase the upfront costs. If, however, societies adopt a carbon tax reflecting the health care costs of breathing polluted air and the costs of climate change, the more efficient appliances would be economically much more attractive.

Although we lack sufficient data to make a detailed calculation of the electricity that can be saved by adopting the more advanced appliance efficiency standards, we are confident that a worldwide set of appliance efficiency standards keyed to the most efficient models on the market would lead to energy savings in the appliance sector approaching or exceeding the 12 percent of world electricity savings from more efficient lighting. This being the case, gains in lighting and appliance efficiencies alone would enable us to avoid building 1,410 coal-fired power plants—more than the 1,382 new coal-fired power plants projected by the International Energy Agency (IEA) to be built by 2020.[29]

More-Efficient Buildings

The building sector is responsible for a large share of world electricity consumption, raw materials use, and waste generation. In the United States, buildings—commercial and residential—account for 70 percent of electricity use and over 38 percent of CO_2 emissions. Worldwide, building construction accounts for 40 percent of materials use.[30]

Because buildings last for 50–100 years or longer, it is often assumed that increasing energy efficiency in the building sector is a long-term process. But that is not the case. An energy retrofit of an older inefficient building can cut energy use by 20–50 percent. The next step, shifting entirely to carbon-free electricity, either generated onsite or purchased, to heat, cool, and light the building completes the job. Presto! A zero-carbon building.[31]

The building construction and real estate industries are recognizing the value of green buildings. An Australian firm, Davis Langdon, notes there is a growing sense of "the looming obsolescence of non-green buildings," one that is driving a wave of reform in both construction and real estate. Further, Davis Langdon says, "going green is future-proofing your asset."[32]

In the United States, the private U.S. Green Building Council (USGBC)—well known for its certification and rating program called Leadership in Energy and Environmental Design (LEED)—heads the field. This voluntary certification program sets standards so high that it has eclipsed the U.S. government Energy Star certification program for buildings. LEED has four certification levels—Certified, Silver, Gold, and Platinum. A LEED-certified building must meet minimal standards in environmental quality, materials use, energy efficiency, and water efficiency. LEED-certified buildings are attractive to buyers because they have lower operating costs, higher lease rates, and happier, healthier occupants than traditional buildings do.[33]

The LEED certification standards for construction of new buildings were issued in 2000. Any builder who wants a building certified must request certification and pay for it. In 2004 the USGBC also began certifying the interiors of commercial buildings and tenant improvements of existing buildings. It was planning to begin issuing certification standards for home builders by the end of 2007.[34]

Looking at the LEED certification criteria and examples of LEED buildings provides an insight into the many ways buildings can become more energy-efficient. The certification process for new buildings begins with site selection, then moves on to energy efficiency, water efficiency, materials used, and indoor environmental quality. In site selection, certification points are awarded for locating the building close to public transport, such as light rail or buses. Beyond this, a higher certification depends on provision of bicycle racks and shower facilities for employees. To be certified, new buildings must maximize the exposure to daylight, with minimum daylight illumination for 75 percent of the occupied space.[35]

With energy, exceeding the high level of efficiency required for basic certification earns additional points. Further points are awarded for the use of renewable energy, including rooftop solar cells to generate electricity, rooftop solar water and space heaters, and the purchase of green power.[36]

Both membership in the USGBC and the number of building proposals being submitted for certification are growing fast. As of August 2007 the Council had 10,688 member organizations, including corporations, government agencies, environmental groups, and other nonprofits. Membership has grown 10-fold since 2000.[37]

Thus far LEED has certified 748 new buildings in the United States, with some 5,200 under construction that have applied for certification. Commercial building space that has been certified or registered for certification approval totals 2 billion square feet of floor space, or some 46,000 acres (think 46,000 football fields).[38]

The Chesapeake Bay Foundation's office building for its 100 staff members near Annapolis, Maryland, was the first to earn

a LEED platinum rating. Among its features are a ground source heat pump for heating and cooling, a rooftop solar heater for hot water, and sleekly designed composting toilets that produce a rich humus used to fertilize the landscape surrounding the building. Toyota's North American office in Torrance, California, which houses 2,000 employees, was one of the first large office buildings to earn a LEED gold rating. It is distinguished by a large solar-electric generating facility that provides much of its electricity. The combination of waterless urinals and rainwater recycling enable it to operate with 94 percent less water than a conventionally designed building of the same size. Less water means less energy.[39]

The 54-story Bank of America tower in New York, scheduled to open in early 2008, will be the first large building to earn a platinum rating. It will have its own co-generation power plant and will collect rainwater, reuse waste water, and use recycled materials in construction. The complex of new buildings at the World Trade Center site is being designed to achieve gold certification.[40]

A 60-story office building with a gold rating being built in Chicago will use river water to cool the building in summer, and the rooftop will be covered with plants to reduce runoff and heat loss. Energy-conserving measures will save the owner $800,000 a year in energy bills. The principal tenant, Kirkland and Ellis LLP, a Chicago-based law firm, insisted that the building be gold-certified and that this be incorporated into the lease.[41]

The state of California commissioned Capital E, a green building consulting firm, to analyze the economics of 33 LEED-certified buildings in the state. The study concluded that certification raised construction costs by $4 per square foot, but because operating costs as well as employee absenteeism and turnover were lower and productivity was higher than in non-certified buildings, the standard- and silver-certified buildings earned a profit over the first 20 years of $49 per square foot, and the gold- and platinum-certified buildings earned $67 per square foot.[42]

In 2001 a global version of the USGBC, the World Green Building Council, was formed. It initially consisted of Green Building Councils from six other countries. All told, as of August 2007 there were LEED certification projects in progress in some 41 countries, including Brazil, Canada, India, and Mexico.[43]

Also at the international level, the Clinton Foundation announced in May 2007 its Energy Efficiency Building Retrofit Program, a project of the Clinton Climate Initiative. This program, in cooperation with C40, a large-cities climate leadership group, brings together five of the world's largest banks and four of the leading energy service companies to work with an initial group of 16 cities to retrofit buildings, reducing their energy use by 20–50 percent. Among these cities are some of the world's largest, including Bangkok, Berlin, Karachi, London, Mexico City, Mumbai, New York, Rome, and Tokyo. Each of the banks—ABN AMRO, Citi, Deutsche Bank, JP Morgan Chase, and UBS—is committed to investing up to $1 billion in this effort, enough to easily double the current worldwide level of energy saving retrofits.[44]

The world's four largest energy service companies—Honeywell, Johnson Controls, Siemens, and Trane—will do the actual retrofitting. And, most important, they agreed to provide "performance guarantees," thus ensuring that all the retrofits will be profitable. Cutting energy use and carbon emissions can be highly profitable. At the launch of this program, former President Bill Clinton pointed out that banks and energy service companies would make money, building owners would save money, and carbon emissions would fall.[45]

On the architectural front, a climate-conscious architect from New Mexico, Edward Mazria, has launched the 2030 Challenge. Its principal goal is for the nation's architects to be designing buildings in 2030 that use no fossil fuels. Mazria observes that the buildings sector is the leading source of climate emissions, easily eclipsing transportation. Therefore, he says, "it's the architects who hold the key to turning down the global thermostat." To reach his goal, Mazria has organized a coalition consisting of several organizations, including the American Institute of Architects, the USGBC, and the U.S. Conference of Mayors.[46]

Mazria recognizes the need for faculty retraining in the country's 124 architectural schools to "transform architecture from its mindless and passive reliance on fossil fuels to an architecture intimately linked to the natural world in which we live." It is the responsibility of architects, Mazria believes, "to engage the environment in a way that significantly reduces or eliminates the need for fossil fuels." Today's architectural concepts and construction technologies enable architects to easily design new buildings with half the energy requirements of today's buildings. Among the design technologies are natural day-lighting, rooftop solar-electric cells, natural ventilation, glazed windows, reduced water use, more-efficient lighting technologies, and motion sensors for lighting.[47]

Restructuring the Transport System

Aside from the overriding need to stabilize atmospheric CO_2 levels, there are several other compelling reasons for countries everywhere to restructure their transport systems, including the need to prepare for falling oil production, to alleviate traffic congestion, and to reduce air pollution. The U.S. car-centered transportation model, with three cars for every four people, that much of the world aspires to will not likely be viable over the long term even for the United States, much less for everywhere else.[48]

The shape of future transportation systems centers around the changing role of the automobile. This in turn is being influenced by the transition from a predominantly rural global society to a largely urban one. By 2020 close to 55 percent of us will be living in cities, where the role of cars is diminishing. In Europe, where this process is well along, car sales in almost every country have peaked and are falling.[49]

With world oil output close to peaking, there will not be enough economically recoverable oil to support a world fleet expansion along U.S. lines or, indeed, to sustain the U.S. fleet. Oil shocks are now a major security risk. The United States, where 88 percent of the 133 million working people travels to work by car, is dangerously vulnerable.[50]

Mounting concern about climate change and the desire to restrict carbon emissions is beginning to permeate transportation policymaking at the urban, provincial, and national level. In addition to a daily $16 toll on cars entering central London, Mayor Ken Livingston proposed in 2007 a $50-per-day charge on sport utility vehicles entering the city because of their high CO_2 emissions. This staggering proposed tax enjoys the support of Londoners by a three to one margin. New York is also considering a tax on cars entering the city.[51]

The mayors of both New York and San Francisco have announced that all taxis in their cities will be hybrids by 2012, a move designed to reduce CO_2 emissions, fuel use, and local air pollution. The New York goal is to replace the 13,000 existing taxis that get roughly 14 miles per gallon with cars that will get 30–50 miles per gallon.[52]

Beyond the desire to stabilize climate, drivers almost everywhere are facing gridlock and worsening congestion that are raising both frustration and the cost of doing business. In the United States, the average commuting time for workers has increased steadily since the early 1980s. The automobile promised mobility, but after a point its growing numbers in an increasingly urbanized world offer only the opposite: immobility.[53]

While the future of transportation in cities lies with a mix of light rail, buses, bicycles, cars, and walking, the future of intercity travel over distances of 500 miles or less belongs to high-speed trains. Japan, with its high-speed bullet trains, has pioneered this mode of travel. Operating at speeds up to 190 miles per hour, Japan's bullet trains carry almost a million passengers a day. On some of the heavily used intercity high-speed rail lines, trains depart every three minutes.[54]

Beginning in 1964 with the 322-mile line from Tokyo to Osaka, Japan's high-speed rail network now stretches for 1,360 miles, linking nearly all its major cities.

One of the most heavily traveled links is the original line between Tokyo and Osaka, where the bullet trains carry 117,000 passengers a day. The transit time of two hours and 30 minutes between the two cities compares with a driving time of eight hours. High-speed trains save time as well as energy.[55]

Although Japan's bullet trains have carried billions of passengers over 40 years at high speeds, there has not been a single casualty. Late arrivals average 6 seconds. If we were selecting seven wonders of the modern world, Japan's high-speed rail system surely would be among them.[56]

While the first European high-speed line, from Paris to Lyon, did not begin operation until 1981, Europe has made enormous strides since then. As of early 2007 there were 3,034 miles (4,883 kilometers) of high-speed rail operating in Europe, with 1,711 more miles to be added by 2010. The goal is to have a Europe-wide high-speed rail system integrating the new eastern countries, including Poland, the Czech Republic, and Hungary, into a continental network by 2020.[57]

Once high-speed links between cities begin operating, they dramatically raise the number of people traveling by train between cities. For example, when the Paris-to-Brussels link, a distance of 194 miles that is covered by train in 85 minutes, opened, the share of those traveling between the two cities by train rose from 24 percent to 50 percent. The car share dropped from 61 percent to 43 percent, and CO_2-intensive plane travel virtually disappeared.[58]

Carbon dioxide emissions per passenger mile on Europe's high-speed trains are one third those of its cars and only one fourth those of its planes. In the Plan B economy, CO_2 emissions from trains will essentially be zero, since they will be powered by green electricity. In addition to being comfortable and convenient, these rail links reduce air pollution, congestion, noise, and accidents. They also free travelers from the frustrations of traffic congestion and long airport security check lines.

Existing international links, such as the Paris-Brussels link, are being joined by links between Paris and Stuttgart, Frankfurt and Paris, and a new link from the Channel Tunnel to London that cuts the London-Paris travel time to scarcely two hours and 20 minutes. On the newer lines, trains are operating at up to 200 miles per hour. As *The Economist* notes, "Europe is in the grip of a high speed rail revolution."[59]

There is a huge gap in high-speed rail between Japan and Europe on one hand and the rest of the world on the other. The United States has a "high-speed" Acela Express that links Washington, New York, and Boston, but unfortunately neither its speed nor its reliability come close to the trains in Japan and Europe.[60]

China is beginning to develop high-speed trains linking some of its major cities. The one introduced in 2007 from Beijing to Shanghai reduced travel time from 12 to 10 hours. China now has 3,750 miles of track that can handle train speeds up to 125 miles per hour. The plan is to double the mileage of high-speed track by 2020.[61]

In the United States, the need both to cut carbon emissions and to prepare for shrinking oil supplies calls for a shift in investment from roads and highways to railways. In 1956 U.S. President Dwight Eisenhower launched the interstate highway system, justifying it on national security grounds. Today the threat of climate change and the insecurity of oil supplies both argue for the construction of a high-speed electrified rail system, for both passenger and freight traffic. The relatively small amount of additional electricity needed could come from renewable sources, mainly wind farms.[62]

The passenger rail system would be modeled after those of Japan and Europe. A high-speed transcontinental line that averaged 170 miles per hour would mean traveling coast-to-coast in 15 hours, even with stops in major cities along the way. There is a parallel need to develop an electrified national rail freight network that would greatly reduce the need for long-haul trucks.

Any meaningful global effort to cut transport CO_2 emissions begins with the United States, which consumes more gasoline than the next 20 countries combined, including Japan, China, Russia, Germany, and Brazil. The United States—with 238 million vehicles out of the global 860 million, or roughly 28 percent of the world total—not only has the largest automobile fleet but is near the top in miles driven per car and near the bottom in fuel efficiency.[63]

Three initiatives are needed in the United States. One is a meaningful gasoline tax. Phasing in a gasoline tax of 40¢ per gallon per year for the next 12 years (for a total rise of $4.80 a gallon) and offsetting it with a reduction in income taxes would raise the U.S. gasoline tax to the $4–5 per gallon prevailing today in Europe and Japan. Combined with the rising price of gas itself, such a tax should be more than enough to encourage a shift to more fuel-efficient cars.

The second measure is raising the fuel-efficiency standard from the 22 miles per gallon of cars sold in 2006 to 45 miles per gallon by 2020. This would help move the U.S. automobile industry in a fuel-efficient direction. Third, reaching our CO_2 reduction goal depends on a heavy shift of transportation funds from highway construction to urban transit and intercity rail construction.[64]

A New Materials Economy

The production, processing, and disposal of material in our modern throwaway economy wastes not only material but energy as well. In nature, one-way linear flows do not survive long.

Nor, by extension, can they survive long in the expanding global economy. The throwaway economy that has been evolving over the last half-century is an aberration, now itself headed for the junk heap of history.

The potential for sharply reducing materials use was pioneered in Germany, initially by Friedrich Schmidt-Bleek in the early 1990s and then by Ernst von Weizsäcker, an environmental leader in the German Bundestag. They argued that modern industrial economies could function very effectively using only one fourth the virgin raw material prevailing at the time. A few years later, Schmidt-Bleek, who founded the Factor Ten Institute in France, showed that raising resource productivity even more—by a factor of 10—was well within the reach of existing technology and management, given the right policy incentives.[65]

In 2002, American architect William McDonough and German chemist Michael Braungart coauthored *Cradle to Cradle: Remaking the Way We Make Things*. They concluded that waste and pollution are to be avoided entirely. "Pollution," said McDonough, "is a symbol of design failure."[66]

Industry, including the production of plastics, fertilizers, steel, cement, and paper, accounts for more than 30 percent of world energy consumption. The petrochemical industry, which produces products such as plastics, fertilizers, and detergents, is the biggest consumer of energy in the manufacturing sector, accounting for about a third of worldwide industrial energy use. Since a large part of industry fossil fuel use is for feedstock, to manufacture plastics and other materials, increased recycling can reduce feedstock needs. Worldwide, increasing recycling rates and moving to the most efficient manufacturing systems in use today could reduce energy use in the petrochemical industry by 32 percent.[67]

The global steel industry, producing over 1.2 billion tons in 2006, is the second largest consumer of energy in the manufacturing sector, accounting for 19 percent of industrial energy use. Energy efficiency measures, such as adopting the most efficient blast furnace systems in use today and the complete recovery of used steel, could reduce energy use in the steel industry by 23 percent.[68]

Reducing materials use means recycling steel, the use of which dwarfs that of all other metals combined. Steel use is dominated by three industries—automobile, household appliances, and construction. In the United States, virtually all cars are recycled. They are simply too valuable to be left to rust in out-of-the-way junkyards. The U.S. recycling rate for household appliances is estimated at 90 percent. For steel cans it is 60 percent, and for construction steel it is 97 percent for steel beams and girders, but only 65 percent for reinforcement steel. Still, the steel discarded each year is enough to meet the needs of the U.S. automobile industry.[69]

Steel recycling started climbing more than a generation ago with the advent of the electric arc furnace, a technology that produces steel from scrap using only one fourth the energy it would take to produce it from virgin ore. Electric arc furnaces using scrap now account for half or more of steel production in more than 20 countries. A few countries, including Venezuela and Saudi Arabia, use electric arc furnaces for all of their steel production. While the present shortage of scrap limits the ability to switch entirely to electric arc furnaces, more scrap will be available in 2020 when developing economies begin retiring aging infrastructure. If three fourths of steel production were to switch to electric arc furnaces using scrap, energy use in the steel industry could be cut by almost 40 percent.[70]

The cement industry, turning out 2.3 billion tons in 2006, is another major player in industrial energy consumption, accounting for 7 percent of industrial energy use. China, at close to half of world production, manufactures more cement than the next top 20 countries combined, yet it does so with extraordinary inefficiency. If China used the same technologies as Japan, it could reduce its energy consumption for cement production by 45 percent. Worldwide, if all cement producers used the most efficient dry kiln process in use today, energy use in the cement industry could drop 42 percent.[71]

Restructuring the transportation system also has a huge potential for reducing materials use. For example, improving urban transit means that one 12-ton bus can replace 60 cars weighing 1.5 tons each, or a total of 90 tons, reducing material use by 87 percent. Every time someone decides to replace a car with a bike, material use is reduced by 99 percent.[72]

The big challenge in cities everywhere is to recycle the many components of garbage, since recycling uses only a fraction of the energy of producing the same items from virgin raw materials. Virtually all paper products can now be recycled, including cereal boxes, junk mail, and paper bags in addition to newspapers and magazines. So too can glass, most plastics, aluminum, and other materials from buildings being torn down. Advanced industrial economies with stable populations, such as those in Europe and Japan, can rely primarily on the stock of materials already in the economy rather than using virgin raw materials. Metals such as steel and aluminum can be used and reused indefinitely.[73]

One of the most effective ways to encourage recycling is to adopt a landfill tax. For a recent example, the state of New Hampshire adopted a "pay-as-you-throw" program that encourages municipalities to charge residents for each bag of garbage. This has dramatically reduced the flow of materials to landfills. In the town of Lyme, with nearly 2,000 people, adoption of a landfill tax raised the share of garbage recycled from 13 percent in 2005 to 52 percent in 2006.[74]

The quantity of recycled material in Lyme, which jumped from 89 tons in 2005 to 334 tons in 2006, included corrugated cardboard, which sells for $90 a ton; mixed paper, $45 a ton; and aluminum, $1,500 per ton. This program simultaneously reduces the town's landfill fees while generating a cash flow from the sale of recycled material.[75]

San José, California, already diverting 62 percent of its municipal waste from landfills for reuse and recycling, is now focusing on the large flow of trash from construction and demolition sites. This material is trucked to one of two dozen specialist recycling firms in the city. For example, at Premier Recycle up to 300 tons of building debris is delivered each day. It is skillfully separated into recyclable piles of concrete, scrap metal, wood, and plastics. Some materials the company sells, some it gives away, and some it pays someone to take.[76]

Before the program began, only about 100,000 tons per year of the city's mixed construction and demolition materials were reused or recycled. Now it is nearly 500,000 tons. The scrap metal that is salvaged goes to recycling plants, wood can be converted into mulch or wood chips for fueling power plants, and concrete can be recycled to build road banks. By deconstructing a building instead of simply demolishing it, most of the material in it can be reused or recycled, thus dramatically reducing energy use and carbon emissions. San José is becoming a model for cities everywhere.[77]

Germany and, more recently, Japan are requiring that products such as automobiles, household appliances, and office equipment be designed for easy disassembly and recycling. In May 1998, the Japanese Diet enacted a tough appliance recycling law, one that prohibits discarding household appliances, such as washing machines, TV sets, or air conditioners. With consumers bearing the cost of disassembling appliances in the form of a disposal fee to recycling firms, which can come to $60 for a refrigerator or $35 for a washing machine, the pressure to design appliances so they can be more easily and cheaply disassembled is strong.[78]

Closely related to this concept is that of remanufacturing. Within the heavy industry sector, Caterpillar has emerged as a leader. At a plant in Corinth, Mississippi, it recycles some 17 truckloads of diesel engines a day. These engines, retrieved from Caterpillar's clients, are disassembled by hand by workers who do not throw away a single component, not even a bolt or screw. Once the engine is disassembled, it is then reassembled with all worn parts repaired. The resulting engine is as good as new. Caterpillar's remanufacturing division is racking up $1 billion a year in sales and growing at 15 percent annually, contributing impressively to the company's bottom line.[79]

Another emerging industry is airliner recycling. Daniel Michaels writes in the *Wall Street Journal* that Boeing and Airbus, which have been building jetliners in competition for nearly 40 years, are now vying to see who can dismantle them most efficiently. The first step is to strip the plane of its marketable components, such as engines, landing gear, galley ovens, and hundreds of other items. For a jumbo jet, these key components can collectively sell for up to $4 million. Then comes the final dismantling and recycling of aluminum, copper, plastic, and other materials. The next time around the aluminum may show up in cars, bicycles, or another jetliner.[80]

The goal is to recycle 90 percent of the plane, and perhaps one day 95 percent or more. With more than 3,000 airliners already put out to pasture and many more to come, this retired fleet has become the equivalent of an aluminum mine.[81]

With computers becoming obsolete every few years as technology advances, the need to be able to quickly disassemble and recycle them is a paramount challenge in building an eco-economy. In Europe, information technology (IT) firms are going into the reuse of computer components big-time. Because European law requires that manufacturers pay for the collection, disassembly and recycling of toxic materials in IT equipment, manufacturers have begun to focus on how to disassemble everything from computers to cell phones. Nokia, for example, has designed a cell phone that will virtually disassemble itself.[82]

On the clothing front, Patagonia, an outdoor gear retailer, has launched a garment recycling program beginning with its polyester fiber garments. Working with Teijin, a Japanese firm, Patagonia is now recycling not only the polyester garments it sells but also those that are sold by its competitors. Patagonia estimates that a garment made from recycled polyester, which is indistinguishable from the initial polyester made from petroleum, uses less than one fourth as much energy. With this success behind it, Patagonia is beginning to work on nylon garments and plans also to recycle cotton and wool clothing.[83]

In addition to measures that encourage the recycling of materials, there are those that encourage the reuse of products such as beverage containers. Finland, for example, has banned the use of one-way soft drink containers. Canada's Prince Edward Island has adopted a similar ban on all nonrefillable beverage containers. The result in both cases is a sharply reduced flow of garbage to landfills.[84]

A refillable glass bottle used over and over requires about 10 percent as much energy per use as an aluminum can that is recycled. Cleaning, sterilizing, and re-labeling a used bottle requires little energy compared with recycling cans made from aluminum, which has a melting point of 660 degrees Celsius (1,220 degrees Fahrenheit). Banning nonrefillables is a quintuple win option—cutting material use, carbon emissions, air pollution, water pollution, and garbage flow to landfills. There are also substantial transport fuel savings, since the refillable containers are simply back-hauled by delivery trucks to the original bottling plants or breweries for refilling.[85]

Another increasingly attractive option for cutting CO_2 emissions is to discourage energy-intensive but, to use a World War

II term, nonessential industries. The gold and bottled water industries are prime examples. The annual production of 2,500 tons of gold requires the processing of 500 million tons of ore, more than one third the amount of virgin ore used to produce steel each year. One ton of steel requires the processing of two tons of ore. For one ton of gold, in stark contrast, the figure is 200,000 tons of ore. Processing 500 million tons of ore consumes a huge amount of energy—and emits as much CO_2 as 5.5 million cars.[86]

From a climate point of view, it is very difficult to justify bottling water, often tap water to begin with, hauling it long distance and selling it for outlandish prices. Although clever marketing has convinced many consumers that bottled water is safer and healthier than what they can get from their faucets, a detailed study by the World Wide Fund for Nature could not find any support for this claim. It notes that in the United States and Europe there are more standards regulating the quality of tap water than of bottled water. For people in developing countries where water is unsafe, it is far cheaper to boil or filter water than to buy it in bottles.[87]

Charles S. Fishman writes in *Fast Company* magazine that "when a whole industry grows up around supplying us with something we don't need . . . it's worth asking how that happened, and what the impact is." In effect, the industry's advertising is designed to undermine public confidence in the safety and quality of municipal water supplies. In the words of Gina Solomon, a Natural Resources Defense Council senior scientist, "Bottled water is largely a market based on anxiety."[88]

Manufacturing the nearly 28 billion plastic bottles used to package water in the United States alone requires 17 million barrels of oil. Including the energy for hauling 1 billion bottles of water every two weeks from bottling plants to supermarkets or convenience stores for sale, sometimes covering hundreds of kilometers, and the energy needed for refrigeration, the U.S. bottled water industry consumes roughly 50 million barrels of oil per year.[89]

The good news is that people are beginning to see how climate-disruptive this industry is. Mayors of U.S. cities are realizing that they are spending millions of taxpayer dollars to buy bottled water for their employees—water that costs 1,000 times

as much as the tap water that is already available in city buildings. San Francisco mayor Gavin Newsom has banned the use of city funds to purchase bottled water and the use of bottled water in city buildings, on city property, and at any events sponsored by the city. Other cities following a similar strategy include Los Angeles, Salt Lake City, and St. Louis. New York City has launched a $5 million ad campaign to promote its tap water and thus to rid the city of bottled water and the fleets of delivery trucks that tie up traffic.[90]

In summary, there is a vast worldwide potential for cutting carbon emissions by reducing materials use. This begins with the major metals—steel, aluminum, and copper—where recycling requires only a fraction of the energy needed to produce these metals from virgin ore. It continues with the design of cars, household appliances, and other products so they are easily disassembled into their component parts for reuse or recycling.

Household garbage, as noted, can be sorted and extensively recycled or composted. With deconstruction, nearly all building materials can be reused or recycled. Switching to refillable beverage containers can lead to a 90-percent reduction in material use and carbon emissions in the beverage industry. The remanufacturing of products, as Caterpillar is doing with diesel engines, helps reduce CO_2 emissions. Phasing out energy-intensive, nonessential industries such as the gold and bottled water industries will also move the world closer to the time when atmospheric concentrations of CO_2 are once again stable.

The Energy Savings Potential

The goal for this chapter was to identify measures that will offset the 30 percent growth in energy demand projected by IEA between 2006 and 2020. We are confident that the measures proposed will more than offset the projected growth in energy use. Shifting to more energy-efficient lighting alone lowers world electricity use by 12 percent.[91]

With appliances, the key to raising energy efficiency is to establish international efficiency standards for appliances that reflect the most efficient models on the market today, regularly raising this level as technologies advance. Given the potential for raising appliance efficiency, the energy saved by 2020 should at least match the savings in the lighting sector.

With transportation, the short-term keys to reducing gasoline use involve shifting to highly fuel-efficient cars, restructuring urban transport systems, and building intercity rapid rail systems modeled after those in use in Japan and Europe. This shift in focus from car-dominated transport systems to more diversified systems is evident in the actions of hundreds of mayors who struggle with traffic congestion and air pollution every day. They are devising ingenious ways of restricting not only the use of cars but the very need for them. Neither the nature of the city nor the future role of the car will be the same, as nearly all public initiatives are diminishing the car's urban presence.

Within the industrial sector, there is a hefty potential for reducing energy use. In the petrochemical industry, moving to the most efficient production technologies now available and recycling more plastic can cut energy use by 32 percent. With steel, gains in manufacturing efficiency can cut energy use by 23 percent. Even larger gains are within reach for cement, where simply shifting to the most efficient dry kiln technologies can reduce energy use by 42 percent.[92]

With buildings—even older buildings, where retrofitting can reduce energy use by 20–50 percent—there is a profitable potential for saving energy. As we have noted, such a reduction in energy use combined with the use of green electricity to heat, cool, and light the building means that it may be easier to create carbon-neutral buildings than we may have thought.

One easy way to achieve these gains is through the imposition of a carbon tax that would help reflect the full cost of burning fossil fuels. We recommend increasing the carbon tax by $20 per ton each year over the next 12 years, for a total of $240. High though this may seem, it does not come close to covering the indirect costs of burning fossil fuels.

In seeking to raise energy efficiency, as described in this chapter there have been some pleasant surprises at the potential for doing so. We now turn to developing the earth's renewable sources of energy, where there are equally exciting possibilities.