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Building an Energy-Efficient Global Economy

Advancing technologies offer the world a greater potential for cutting energy use today than at any time in history. For example, during much of the last century nearly all the household light bulbs on the market were inefficient incandescents. But today people can also buy compact fluorescent lamps (CFLs) that use only one fourth as much electricity. And the light-emitting diodes (LEDs) now coming to market use even less.[1]

A similar situation exists with cars. During the century since the automobile appeared, an internal combustion engine was the only option. Now we can buy plug-in hybrids and all-electric cars that run largely or entirely on electricity. And since an electric motor is over three times as efficient as an internal combustion engine, there is an unprecedented potential for reducing energy use in the transport sector.[2]

Beyond energy-saving technologies, vast amounts of energy can be saved by restructuring key sectors of the economy. Designing cities for people, not for cars, is a great place to begin. And if we can move beyond the throwaway society, reusing and recycling almost everything, imagine how much material and energy we can save.

One of the quickest ways to cut carbon emissions and save money is simply to change light bulbs. Replacing

inefficient incandescent bulbs with CFLs can reduce the electricity used for lighting by three fourths. And since they last up to 10 times as long, each standard CFL will cut electricity bills by roughly $40 over its lifetime.[3]

The world has reached a tipping point in shifting to compact fluorescents, as many countries phase out incandescents. But even before the transition is complete, the shift to LEDs is under way. Now the world's most advanced lighting technology, the LED uses even less energy than a CFL and up to 85 percent less than an incandescent. And LEDs offer another strong economic advantage—longevity. An LED installed when a child is born is likely to still be working when the youngster graduates from college.[4]

With costs falling fast, LEDs are quickly taking over several niche markets, such as traffic lights. In the United States, almost 70 percent of traffic lights have been converted to LEDs, while the figure is still less than 20 percent in Europe. New York City has changed all its traffic lights to LEDs, cutting the annual bill for power and maintenance by $6 million.[5]

For the far more numerous street lights, the potential savings are even greater. In 2009, Los Angeles Mayor Antonio Villaraigosa said the city would replace its 140,000 street lights with LEDs, saving taxpayers $48 million over seven years. With replacement well along, the electricity bill for street lights was down 55 percent as of mid-2010.[6]

Leading bulb manufacturers such as Phillips and GE are currently selling their lower-wattage LEDs for $20. As prices fall, Zia Eftekhar, head of Phillips lighting in North America, expects LEDs to take more than 50 percent of the North American and European markets by 2015 and 80 percent by 2020. In 2009, China and Taiwan joined forces in manufacturing LEDs to compete more effectively with Japan (currently the world leader), South Korea, Germany, and the United States.[7]

Energy can also be saved by using motion sensors that turn lights off in unoccupied spaces. Automatic dimmers can reduce the intensity of interior lighting when sunlight is bright. In fact, LEDs combined with these "smart" lighting technologies can cut electricity bills by 90 percent compared with incandescents.[8]

All told, shifting to CFLs in homes, to the most advanced linear fluorescents in office buildings, commercial outlets, and factories, and to LEDs for traffic lights would cut the world share of electricity used for lighting from 19 to 7 percent. This would save enough electricity to close 705 of the world's 2,800 coal-fired plants. If the world turns heavily to LEDs for lighting by 2020, as now seems likely, the savings would be even greater.[9]

A similar range of efficiencies is available for many household appliances. Although the U.S. Congress has been passing legislation since 1975 to raise efficiency for 22 broad categories of household and industrial appliances, from dishwashers to electric motors, the U.S. Department of Energy (DOE) had failed to write the standards needed to implement the legislation. To remedy this, just days after taking office President Barack Obama ordered DOE to write the needed regulations and thus tap this reservoir of efficiency. In September 2010, DOE announced that new efficiency standards for more than 20 household and commercial products had been finalized since January 2009, noting that this "will cumulatively save consumers between $250 billion and $300 billion through 2030."[10]

A more recent efficiency challenge is presented by large flat-screen televisions. The screens now on the market use much more electricity than traditional cathode ray tube televisions—indeed, nearly four times as much if they are large-screen plasma models. Setting the U.S. pace in this area, as in so many others, California is requiring that all new televisions draw one third less electricity

than current sets do by 2011 and 49 percent less by 2013. Because the California market is so large, it could very likely force the industry to meet this standard nationwide.[11]

The big appliance efficiency challenge is China, where modern appliance ownership in cities today is similar to that in industrial countries. For every 100 urban households there are 133 color TV sets, 95 washing machines, and 100 room air conditioners. This phenomenal growth, with little attention to efficiency, helped raise China's electricity use a staggering 11-fold from 1980 to 2007.[12]

Along with the United States and China, the European Union has the other major concentration of home appliances. Greenpeace notes that even though Europeans on average use half as much electricity as Americans do, they still have a large reduction potential. A refrigerator in Europe uses scarcely 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, suggesting a huge potential for cutting electricity use further everywhere.[13]

Technological progress keeps raising the potential for efficiency gains. Japan's Top Runner Program is the world's most dynamic system for upgrading appliance efficiency standards. In this system, the most efficient appliances marketed today set the standard for those sold tomorrow. Within a decade, Japan raised efficiency standards for individual appliances by anywhere from 15 to 83 percent. This ongoing process continually exploits advances in efficiency technologies.[14]

Although appliances account for a significant share of electricity use in buildings, heating and cooling require more energy in total. But buildings often get short shrift in efficiency planning, even though the sector is the leading source of carbon emissions, eclipsing transportation.

Because buildings last for 50–100 years or longer, it is often assumed that cutting carbon emissions in this sector is a long-term process. But that is not necessarily the case. An energy retrofit of an older inefficient building can cut energy bills by 20–50 percent or more. The next step, shifting entirely to renewable sources of electricity to heat, cool, and light the building, completes the job. Presto! A zero-carbon building.[15]

In the United States, the stimulus package signed by President Obama in February 2009 provided for weatherizing a million private homes, weatherizing and retrofitting part of the nation's public housing, and making government buildings more energy-efficient. These initiatives are intended to help build a vigorous U.S. energy efficiency industry.[16]

Among the numerous efforts to make older structures more efficient is the Clinton Foundation's Energy Efficiency Building Retrofit Program, a project of the Clinton Climate Initiative. In cooperation with C40, a large-cities climate leadership group, this program brings together financial institutions and some of the world's largest energy service and technology companies to work with cities to retrofit buildings, reducing their energy use by up to 50 percent. The energy service companies—including Johnson Controls and Honeywell—committed to provide building owners with contractual "performance guarantees" assuring the energy savings and maximum costs of the retrofit project. 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.[17]

In April 2009, the owners of New York's Empire State Building announced plans to retrofit the iconic 80-year-old 102-story building, reducing its energy use by nearly 40 percent. The resulting annual energy savings of $4.4

million is expected to recover the retrofitting costs in three years.[18]

The carbon reductions from retrofitting are impressive, but new buildings can be designed to emit far less carbon. As of January 2009, Germany required that all new buildings either get at least 15 percent of water and space heating from renewable energy or dramatically improve the efficiency with which they use energy. The bonus here is that if a builder is putting a solar water and space heater on the roof, it is unlikely that it will be limited to meeting only 15 percent of the building's needs.[19]

One firm believer in the potential for cutting energy use in new buildings is Edward Mazria, a climate-conscious architect from New Mexico who has launched the 2030 Challenge. Its principal goal is to get U.S. architects to design all buildings by 2030 to operate without fossil fuels. Mazria notes that "it's the architects who hold the key to turning down the global thermostat." To reach his goal, Mazria has organized a coalition of several organizations, including the American Institute of Architects, the U.S. Green Building Council (USGBC), and the U.S. Conference of Mayors.[20]

In the private sector, the USGBC—well known for its Leadership in Energy and Environmental Design (LEED) certification and rating program—heads the field. This voluntary program has four certification levels—certified, silver, gold, and platinum. A LEED-certified building must meet minimal standards in environmental quality, materials use, energy efficiency, water efficiency, and site selection, which includes access to public transit. LEED-certified buildings are attractive to buyers because they have lower operating costs, higher lease rates, and happier, healthier occupants than traditional buildings do.[21]

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 water heater, and sleekly designed composting toilets that produce a rich humus used to fertilize the landscape surrounding the building.[22]

A 60-story office building with a gold rating built in Chicago uses river water to cool the building in summer and has covered over half the rooftop with plants to reduce runoff and heat loss. The principal tenant, Kirkland and Ellis LLP, a Chicago-based law firm, insisted that the building be at least silver-certified and that this be incorporated into the lease.[23]

The 55-story Bank of America tower in New York is the first large skyscraper to have earned a platinum rating. It has its own co-generation power plant and collects rainwater, reuses waste water, and used recycled materials in construction. Worldwide, Pike Research projects the floor area of buildings certified by green building standards to expand from 6 billion square feet in 2010 to 53 billion feet by 2020.[24]

Within the transportation sector itself, there are numerous opportunities for energy savings. The first step in increasing efficiency and cutting carbon emissions is to simultaneously restructure and electrify the transport system to facilitate the shift from fossil fuels to renewable electricity. Restructuring involves strengthening urban public transportation and designing communities to reduce the need for cars. For traveling between cities, developing a high-speed intercity rail system, similar to those in Japan, Western Europe, and China, is the key.

Urban transport systems based on a combination of subways, light rail, bus lines, bicycle pathways, and pedestrian walkways offer the best of all possible worlds in providing mobility, low-cost transportation, and a healthy urban environment. And since rail systems are geographically fixed, the nodes on such a system become

the obvious places to concentrate high-rise office and apartment buildings as well as shops.

Some of the most innovative public transportation systems have evolved in developing-country cities such as Bogotá, Colombia. The success of Bogotá's bus rapid transit (BRT) system, which uses special express lanes to move people quickly through the city, is being replicated in scores of other cities, including Mexico City, São Paulo, Hanoi, Seoul, Istanbul, and Quito. In China, BRT systems operate in 11 cities, including Beijing.[25]

In Paris, Mayor Bertrand Delanoë inherited some of Europe's worst traffic congestion and air pollution when he was elected in 2001. The first of three steps he took to reduce traffic was to invest in more-accessible high-quality public transit throughout the greater Paris area. The next step was to create express lanes on main thoroughfares for buses and bicycles, thus reducing the number of lanes for cars. As the speed of buses increased, more people used them.[26]

A third innovative initiative in Paris was the establishment of a city bicycle rental program that has 24,000 bikes available at 1,750 docking stations throughout the city. Rates for rental range from just over $1 per day to $40 per year, but if the bike is used for fewer than 30 minutes, the ride is free. Based on the first two years, the bicycles are proving to be immensely popular—with 63 million trips taken as of late 2009. Hundreds of other cities, including London, Washington, Shanghai, Mexico City, and Santiago are also adopting urban bicycle rental systems. Bicycle sharing is an idea whose time has come.[27]

Any serious global effort to cut automotive fuel use 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 248 million passenger vehicles out of the global 965 million—not only has by far the largest fleet

of cars but is near the top in miles driven per car and near the bottom in vehicle fuel efficiency.[28]

The car promised mobility, and in a largely rural society it delivered. But the growth in urban car numbers at some point provides not mobility, but immobility. The Texas Transportation Institute reports that U.S. congestion costs, including fuel wasted and time lost, climbed from $17 billion in 1982 to $87 billion in 2007.[29]

Many American communities lack sidewalks and bike lanes, making it difficult for pedestrians and cyclists to get around safely, particularly where streets are heavily traveled. Fortunately, the country that has lagged far behind Europe in developing diversified urban transport systems is being swept by a "complete streets" movement, an effort to ensure that streets are friendly to pedestrians and bicycles as well as to cars.[30]

The National Complete Streets Coalition, a powerful assemblage of citizen groups, including the Natural Resources Defense Council, AARP (an organization of nearly 40 million older Americans), and numerous local and national cycling organizations is challenging the "cars only" model. As of October 2010, complete streets policies were in place in 23 states, including more populous states like California and Illinois, and in 98 cities.[31]

America's century-old love affair with the automobile may be coming to an end. The U.S. fleet has apparently peaked. In 2009, the 12.4 million cars scrapped exceeded the 10.6 million new cars sold, shrinking the fleet by nearly 1 percent. While this has been widely associated with the recession, it was in fact caused by several converging forces, including market saturation, ongoing urbanization, economic uncertainty, oil insecurity, rising gasoline prices, frustration with traffic congestion, and mounting concerns about climate change.[32]

Perhaps the leading social trend affecting the future of the automobile is the declining interest in cars among

young people. For past generations, growing up in a country that was still heavily rural, getting a driver's license and a car or a pickup was a rite of passage. In contrast, now that the United States is 82 percent urban, more young Americans are growing up in families without cars. They socialize on the Internet and on smartphones, not in cars. Many do not even bother to get a driver's license. Because of these converging trends, I believe that the U.S. fleet could shrink 10 percent by 2020. Japan's fleet, second in size to the U.S. fleet, is also shrinking.[33]

Beyond shrinking the fleet, the key to reducing U.S. gasoline use in the near term is to raise fuel efficiency standards. The 40-percent increase in the fuel efficiency of new cars by 2016 announced by the Obama administration in May 2009 will reduce both carbon emissions and dependence on oil. A crash program to shift the U.S. fleet to plug-in hybrids and all-electric cars could make an even greater contribution. And shifting public funds from highway construction to public transit and intercity rail would further reduce the number of cars needed, bringing the United States closer to the Plan B goal of cutting carbon emissions 80 percent by 2020.[34]

Plug-in hybrids and all-electric cars are coming to market. The Chevrolet Volt plug-in hybrid is scheduled to be available in late 2010. At the same time, Nissan will be bringing its all-electric car, the Leaf, to market in the United States, Japan, and Europe. And in 2012, Toyota plans to release a plug-in version of its popular Prius hybrid. With the transition to renewable energy gaining momentum, cars could one day run largely on wind-generated electricity that costs the equivalent of less than $1 per gallon of gasoline.[35]

Shifting to plug-in electric hybrids and all-electric cars does not require a costly new infrastructure, since the network of gasoline service stations and the electricity grid are already in place. A 2006 study by the U.S. Pacific Northwest National Laboratory estimated that over 70 percent of the electricity needs of a national fleet of plug-in cars could be satisfied with the existing electricity supply, since the recharging would take place largely at night when there is an excess of generating capacity. What will be needed in addition to home hookups are readily accessible electrical outlets in parking garages, parking lots, and street-side parking meters to facilitate recharging.[36]

Few methods of reducing carbon emissions are as effective as substituting a bicycle for a car on short trips. A bicycle is a marvel of engineering efficiency, one where an investment in 22 pounds of metal and rubber boosts personal mobility by a factor of three. On my bike I estimate that I get easily 7 miles per potato. An automobile, which typically requires at least a ton of material to transport one person, is extraordinarily inefficient by comparison.

The bicycle has many attractions as a form of personal transportation. It is carbon-free, alleviates congestion, lowers air pollution, reduces obesity, and is priced within the reach of billions of people who cannot afford a car. Bicycles increase mobility while reducing congestion and the area of land paved over. As bicycles replace cars, cities can convert parking lots into parks or urban gardens.

As campuses are overwhelmed by cars, and with the construction of parking garages costing $55,000 per parking space, colleges, like cities, are turning to bikes. Chicago's St. Xavier University launched a bike-sharing program in the fall of 2008, with students using their ID cards instead of credit cards. Emory University in Atlanta, Georgia, has introduced a free bike-sharing system. Ripon College in Wisconsin and the University of New England in Maine have gone even further: they give a bike to freshmen who agree to leave their cars at home.[37]

The key to realizing the bicycle's potential is to create a bike-friendly transport system. This means providing

both bicycle trails and designated street lanes for bicycles and then linking them with public transit options. Among the industrial-country leaders in designing bicycle-friendly transport systems are the Netherlands, where 25 percent of all trips are by bike, Denmark with 18 percent, and Germany, 10 percent. For the United States, the equivalent figure is 1 percent.[38]

While the future of transportation in cities lies with a mix of light rail, buses, bicycles, cars, and walking, the future of intercity travel belongs to high-speed trains. Japan's bullet trains, operating at up to 190 miles per hour, carry nearly 400,000 passengers a day. On some heavily used intercity lines, trains depart every three minutes.[39]

Over the last 46 years, Japan's high-speed trains have carried billions of passengers in great comfort without a fatal crash. 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.[40]

Although the first European high-speed line, from Paris to Lyon, did not begin operation until 1981, Europe has since made enormous strides. As of 2010 there were 3,800 miles of high-speed rail operating in Europe. The goal is to triple this track length by 2025 and eventually to integrate the East European countries into a continental network.[41]

High-speed intercity rail links are changing travel patterns by reducing long drives and short flights, each of which is carbon-intensive. When the Brussels-to-Paris link opened, the share of people traveling between the two cities by train rose from 24 to 50 percent. The car share dropped from 61 to 43 percent, and plane travel virtually disappeared.[42]

While France and Germany were the early European leaders in intercity rail, Spain is quickly building a high-speed rail network that is enormously popular. Before the

recent Barcelona-to-Madrid high-speed rail connection, 90 percent of the 6 million trips between the two cities each year were by air. By early 2010, more people were making the trip by train than by plane. By 2020, half of the country's transportation budget will be going to rail. As *The Economist* notes, "Europe is in the grip of a high-speed rail revolution."[43]

Until recently, there was a huge gap in high-speed rail between Japan and Europe, on the one hand, and the rest of the world on the other. That is changing as China moves to the fore with both the world's fastest trains and the most ambitious high-speed rail construction program of any country. For various reasons, including land scarcity and oil dependency, China is shifting the emphasis from building American-style expressways to building an intercity network of high-speed trains linked directly to urban subway systems, some 60 of which are under construction. The goal is to reduce the need for cars and planes for medium and longer distance travel. When a 300-mile-long line opened in 2010 between Zhengzhou and Xi'an, the low-cost, two-hour train ride was so popular that all flights between the two cities were discontinued.[44]

China is spending $120 billion on high-speed rail in 2010, whereas the United States is spending $1 billion. While the United States allocated $8 billion for high-speed rail from its stimulus package, China allocated $100 billion of its stimulus funding to this cause. It thus comes as no surprise that by 2012 China will have more high-speed rail track mileage than the rest of the world combined.[45]

The United States has a "high-speed" Acela Express that links Washington, New York, and Boston, but unfortunately neither its average speed of 70 miles per hour nor its reliability remotely approach those of the trains in Japan, Europe, and now China.[46]

It is time for the United States to shift investment from

roads and highways to railways to build a twenty-first century transport system. In 1956, President Eisenhower launched the interstate highway system, justifying it on national security grounds. Today, both climate change and oil insecurity argue for the construction of a national high-speed rail system.[47]

Carbon dioxide emissions per passenger mile on high-speed trains are roughly one third those of cars and one fourth those of planes. In the Plan B economy, carbon emissions from trains will essentially be zero, since they will be powered by wind, solar, and geothermal electricity. In addition to being comfortable and convenient, these rail links reduce air pollution and congestion.[48]

Restructuring the transportation system also has a huge potential for reducing materials use as light rail and buses replace cars. For example, 60 cars, weighing a total of 110 tons, can be replaced by one 12-ton bus, reducing material use 89 percent.[49]

Savings from replacing a car with a bike are even more impressive. Urban planner Richard Register recounts meeting a bicycle-activist friend wearing a T-shirt that said, "I just lost 3,500 pounds. Ask me how." When queried, he said he had sold his car. Replacing a 3,500-pound car with a 22-pound bicycle obviously reduces fuel use dramatically, but it also reduces materials use by 99 percent, indirectly saving still more energy.[50]

The production, processing, and disposal of materials in our modern throwaway economy wastes not only materials but the energy embodied in the material as well. The throwaway economy that has evolved over the last half-century is an aberration that is now itself headed for the junk heap of history.

In their book *Cradle to Cradle: Remaking the Way We Make Things*, American architect William McDonough and German chemist Michael Braungart conclude that waste and pollution are to be avoided entirely. "Pollution," says McDonough, "is a symbol of design failure."[51]

Cutting the use of virgin raw materials begins with recycling steel, the use of which dwarfs that of all other metals combined. 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. With the number of cars scrapped now exceeding new cars sold, the U.S. automobile sector actually has a steel surplus that can be used elsewhere in the economy. The U.S. recycling rate for household appliances is estimated at 90 percent. For steel cans it is 65 percent. For construction steel, the figures are 98 percent for steel beams and girders but only 65 percent for reinforcement steel.[52]

Beyond reducing materials use, the energy savings from recycling are huge. Making steel from recycled scrap takes only 26 percent as much energy as that from iron ore. For aluminum, the figure is just 4 percent. Recycled plastic uses only 20 percent as much energy. Recycled paper uses 64 percent as much—and with far fewer chemicals during processing. If the world recycling rates of these basic materials were raised to those already attained in the most efficient economies, world carbon emissions would drop precipitously.[53]

In the United States, only 33 percent of garbage is recycled. Some 13 percent is burned and 54 percent goes to landfills, indicating a huge potential for reducing materials use, energy use, and pollution. Among the larger U.S. cities, recycling rates vary from 25 percent in New York to 45 percent in Chicago, 65 percent in Los Angeles, and 77 percent in San Francisco, the highest of all.[54]

One way to encourage recycling is simply to adopt a landfill tax. For example, when the small town of Lyme, New Hampshire, adopted a pay-as-you-throw (PAYT) program that encourages municipalities to charge residents for each bag of garbage, it dramatically reduced the

flow of materials to landfills, raising the share of garbage recycled from 13 to 52 percent in only one year, simultaneously reducing the town's landfill fees, and generating a cash flow from the sale of recycled material. Nationwide, more than 7,000 U.S. communities now have PAYT programs.[55]

In addition to measures that encourage recycling, there are those that encourage or mandate the reuse of products such as refillable beverage containers. Finland, for example, has banned the use of one-way soft drink containers. A refillable glass bottle used over and over requires only 10 percent as much energy per use as recycling an aluminum can. Banning nonrefillables is a quintuple win option—cutting material use, carbon emissions, air pollution, water pollution, and landfill costs simultaneously.[56]

Bottled water is even more wasteful. In a world trying to stabilize climate, it is difficult to justify bottling water (often tap water to begin with), hauling it long distances, and then selling it for 1,000 times the price of water from the kitchen faucet. Although clever marketing has convinced many consumers that bottled water is safer and healthier than tap water, a detailed study by WWF found that in the United States and Europe there are more standards regulating the quality of tap water than there are for bottled water. In developing countries where water is unsafe, it is far cheaper to boil or filter water than to buy it in bottles.[57]

Manufacturing the nearly 28 billion plastic bottles used each year to package water in the United States alone requires the equivalent of 17 million barrels of oil. This—combined with the energy used to refrigerate and haul the bottled water in trucks, sometimes over hundreds of miles—means the U.S. bottled water industry consumes roughly 50 million barrels of oil per year, equal to 13 percent of U.S. oil imports from Saudi Arabia.[58]

The potential for reducing energy use across the board is huge. For the United States, the Rocky Mountain Institute calculates that if the 40 least efficient states were to achieve the electrical efficiency of the 10 most efficient ones, national electricity use would be cut by one third. This alone would allow the equivalent of 62 percent of all U.S. coal-fired power plants to be closed down. But even the most efficient states have a substantial potential for reducing electricity use further and, indeed, are planning to keep cutting carbon emissions and saving money.[59]

The opportunities to save energy are everywhere, permeating every corner of the economy, every facet of our lives, and every country. Exploiting this abundance of wasted energy will allow the world to actually reduce total energy use over the next decade. These potentially massive efficiency gains, combined with the worldwide shift to renewable energy outlined in the next chapter, will move the world ever closer to the Plan B energy economy.

Data, endnotes, and additional resources can be found on Earth Policy's Web site, at www.earth-policy.org.