Chapter 11. Raising Energy Efficiency: 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.

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.”

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.

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.

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 80 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.

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.

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.

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.

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.

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.

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.

San José, California, already diverting 62 percent of its municipal waste from landfills for reuse and recycling, is now
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 sponsored by the city. Other cities following a similar strategy include Los Angeles, Salt Lake City, and St. Louis. New York city funds to purchase bottled water and the use of bottled water in city buildings, on city property, and at any events much as the tap water that is already available in city buildings. San Francisco mayor Gavin Newsom has banned the use of 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. Charles S. Fishman writes in that “when a whole industry grows up around supplying us with an anxiety.”

Solomon, a Natural Resources Defense Council senior scientist, “Bottled water is largely a market based on anxiety.”

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 pressure to design appliances so they can be more easily and cheaply disassembled is strong.

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.

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.

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.

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.

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.

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.

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.

If recycled, glass containers are empty of their original contents, they can be transformed into new bottles. If itinerant truckers are allowed to collect recyclables, their trucks can be emptied at recycling centers along the way. Of course, the only way to achieve this outcome is to enforce local laws requiring recycled materials to be collected and to pass this cost on to consumers (via taxes or deposits) or to pass this cost on to producers (via a tax on new products made from nonrecyclable materials).

A more likely outcome is that government regulations will force the fast food industry to provide recycling facilities at their restaurants and to pay whatever is necessary to remove these facilities. To make this work, the government could make waste disposal a tax deductible expense. The fast food industry would then find it in its interest to return the tax deduction to the consumer in the form of lower prices. Thus, the consumer would pay less and, in addition, would pay for the convenience of being able to recycle materials. The result would be a marked increase in recycling.

Another increasingly attractive option for cutting CO2 emissions is to encourage 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 liters of water, more than the processing of two tons of ore. One ton of gold 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 CO2 as 5.5 million cars.

Another potential approach is to encourage recycling of other volatile materials. 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.

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.

Charles S. Fishman writes in 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.”

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.

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...
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 that 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 CO₂ 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 CO₂ are once again stable.

ENDNOTES:


73. Energy savings from using scrap instead of iron ore from Mandil et al., op. cit. note 67, p. 106.


77. Ibid.


81. Ibid.


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. Reducing materials use means recycling steel, the use of which dwarfs that of all other metals combined. 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. McKinsey Global Energy and Materials. Unlocking Energy Efficiency in the U.S. Economy. Executive summary. Despite numerous studies on energy efficiency two issues remain unclear: the magnitude of the NPV-positive opportunity, and the practical steps necessary to unlock its full potential. What appears needed is an integrated analysis of energy efficiency opportunities that simultaneously identifies the barriers and reviews possible solution strategies.

The highly compelling nature of energy efficiency raises the question of why the economy has not already captured this potential, since it is so large and attractive. In fact, much progress has been made over the past few decades throughout the U.S., with even greater results in select regions and applications.