

# the many shades of GREEN

Now that it's  
a matter of  
economics  
as well as  
of political  
correctness,  
manufacturers  
are embracing  
environmentally  
friendly  
practices.

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## THERE ARE MANY WAYS TO BE GREEN, AND AMERICAN MANUFACTURERS ARE TRYING THEM ALL.

From reducing energy use and recycling water to implementing ISO 14001 sustainability programs and reusing packaging, U.S. factories are embracing a more environmentally sensitive manufacturing ethos as fast as they can.

In part, the reason is economic. Sustainable practices focus on reducing inputs per unit of output. Inputs are resources like energy, water, and materials, and their costs have skyrocketed. Between January 2004 and July 2008, for example, the price of oil quadrupled, industrial electricity tripled, and natural gas doubled. Commodity materials like copper, iron, and aluminum also jumped. Water shortages gripped the Southeast and other parts of the country, driving many municipalities to reconsider pricing and availability.

Even companies that visibly disdain green manufacturing are looking for ways to cut expenses to the bone. While the current economic downturn has deflated the cost of many resources, lower demand has kept producers' attention focused on reducing inputs to cut costs in order to remain profitable. Many analysts believe the ability of companies to cut those costs—and at the same time hit green targets—is a measure of their operational capabilities.

Besides, today's downturn may signal a lull before prices start rising again because there will be intense competition for resources. ASME Washington Fellow John Voeller, who represents the Department of Homeland Security on the National Science and Technology Council, gave this illustration: "There are six cars for every 1,000 people in China and more than 300 cars for every 1,000 people in the United States. When the Chinese increase that to eight cars per 1,000, they will consume as much gasoline as the United States today." He notes that China has spent the last decade locking up mineral resources, from copper to oil, with long-term contracts.

Green technology is also likely to get a push from the new presidential administration. During the campaign, Barack Obama said he favored an economy-wide program to cap carbon dioxide and greenhouse gas emissions. Under the plan, companies that produce less than their cap could sell the credits to factories that fail to meet standards. This would give carbon emissions a dollar value that accountants would have to factor into the cost of any new project.

This is clearly an administration with an environmental agenda, said Howard Learner, a senior energy and environmental advisor to the Obama campaign. "President-elect

Obama views this as a moral, economic, and technical imperative, and thinks he can implement a green energy program in ways that are good for the economy," he said.

Equally important, the sense of urgency for environmental action appears to be growing. A near-universal consensus exists among scientists that human activity is changing the planet. In November 2007, the 600 scientists on the Intergovernmental Panel on Climate Change called the evidence "unequivocal" that global warming was human-driven. The National Academy of Sciences, American Association for the Advancement of Science, American Meteorological Society, and American Geophysical Union have all found compelling evidence that humans are at least partly responsible for climate change.

The effects of climate change could be devastating: rising seas, mass extinctions, changes in farmland fertility, and mass migrations. While skeptics may argue the science, most governments around the world have embraced the majority view.



▲ A worker on Subaru of Indiana's assembly line prepares to recycle plastic backing from door trim. The factory reduced landfill waste to nearly zero and saved \$2.4 million last year.

So have their electorates. This has led to consumer pressure on companies to change. "Survey after survey shows that Millennials—people who grew up in the Nineties and Two-Thousands—will switch products if they are not environmentally sound. They will pay more for green products, and they want to work for companies that are environmentally sensitive," said Louis R. Ferretti, IBM Corp.'s director of environmental compliance and supply chain social responsibility.

"The clock is ticking here. Companies that gamble and choose not to start or to postpone sustainability programs

due to the economy or capital expenditures are going to fall behind," he said.

Besides, as Ferretti and others point out, green can be profitable.

### /// waste not

There are many ways to be green. Ratcheting down energy use, for example, automatically reduces a plant's carbon footprint, because either it burns less natural gas or it buys less electricity from a power plant that burns coal or gas.

Some manufacturers are looking to make cutbacks in the use of water and raw materials. Others buy renewable energy from wind, solar, geothermal, and waste-fed power producers.

They may also design or transport their products differently. Many companies have introduced more energy-

efficient products that offer a quick payback despite their higher costs. Others are re-engineering products for easy disassembly for reuse or recycling. In Europe, it is required by law. Some seek to wring carbon efficiencies out of the supply chain, while others have increased the amount of natural and biodegradable materials in their products.

Where does a company begin? In the sustainable world, the emphasis has long been on the three Rs: reduce, reuse, and recycle. Robert B. Pojasek, a senior associate at an environmental management consulting firm, First Environment, and an adjunct professor at Harvard University, agrees, but says most businesses do better when they focus on waste.

"The way I look at operations, it's all about inputs and outputs," he explained. "Inputs are the resources you use to make your outputs or products. The difference between inputs and outputs is waste, and if you can

### /// nothing for landfill

Early in 2002, Fuji Heavy Industries Ltd. sent word to its U.S. subsidiary, Subaru of Indiana Automotive Inc., that it wanted the company to generate no landfill waste by 2006. Subaru did it by May 2004.

Subaru's healthy continuous improvement culture made such rapid action possible. "We rolled our environmental program into our kaizen program, so that whenever we looked at plant efficiency and quality, we also looked to see if we could reduce waste, recycle materials, and cut back gas, water, and energy use," recalled Subaru's safety and environmental compliance manager, Denise Coogan. "Every section manager on the floor had a piece of this and a target. They were held equally accountable for quality, safety, and environmental targets."

While Coogan called waste reduction "the right thing to do," she also said it was "very cost-effective when done right."

"Every time you throw something away, you've paid to bring it in and you're paying to throw it out. Cut waste and you cut costs," she said.

Subaru's efforts began humbly, with recycling paper, soda pop cans, and plastic in color-coded recycling bins. Her team went dumpster

diving. They would turn over containers on the assembly line to see what was in them, pile up waste, and weigh and categorize it. "Steel was the biggest, then pallets, cardboard, plastic, Styrofoam," Coogan recalled.

In 2000, Subaru generated 459 pounds of waste for every car built. By the end of 2007, it was down to 251 pounds per unit. Of that, 190 pounds were easily recycled steel. That left



Coogan with 61 pounds of pallets, cardboard, and plastic.

Subaru hired a company to come to the plant, and sort and bundle commodities for sale to recyclers. A line worker noted that Subaru was sending metal packaging containers back to Japan and suggested that packaging be included in the shipments. As long as the packaging remains good, it continues to make the transoceanic commute. The company sends its unrecyclable paper and cafeteria waste to a local firm that burns it for power generation, but plans to begin composting some of the organic material in the future.

The plant earned \$2.4 million on waste reduction last year, Coogan said. Actually, it made even more, but it spends some of the profits on activities that lose money. For example, it pays a company to remove hydraulic oil from oil absorbents used in the company's metal stamping shop. The absorbents are then reused in kitty litter.

"Even after picking the low-hanging fruit, we still find something to improve. That's the spirit of kaizen. We just keep making it better and better," Coogan said.

▲ Recycling occurs everywhere on Subaru of Indiana's automotive assembly line. Workers attack waste through the company's continuous improvement programs.





▲ IBM recycles electronic parts from used computer equipment into new products, including silicon wafers for solar cells. It is a \$2 billion business.

reduce waste, you can save money.

“Carbon comes from four inputs that manufacturers can control: energy, water, materials, and labor. Pay attention to those inputs and you will reduce your carbon footprint.”

The key to green success is to take a process focus, Pojasek said: “That’s a skill engineers have. They think in processes. That is a good idea because the whole idea behind resource utilization is to optimize your processes.” He recommends using the same Six Sigma and lean manufacturing tools companies already use to deal with waste and variance on the plant floor.

This makes sense when input costs are rising. Water, for example, is becoming increasingly expensive, and pumping, filtering, heating, and treating it uses vast amounts of energy. In drought-stricken northern Georgia and South Carolina, for example, municipalities have told large water users that their supply is now interruptible, and that they could turn off the tap in a public emergency.

Those companies now have a real incentive to reuse cooling or process water before they discharge it. Ferretti recalls listening to a presentation about a company that used water to chill newly produced wire. “They were a technical organization, but until prices began to rise they never even thought about recirculating water. Doing that saved them \$3 million,” he said.

Companies around the nation have also turned their Six Sigma, lean manufacturing, and other tools on solid waste. If a material does not add value to a product, they eliminate it. Many work with vendors to reduce packaging. The less packaging, the less energy used in a product.

At Federal Signal Corp.’s vacuum truck manufacturing plant in Streator, Ill., for example, the company cut solid waste per vehicle to 1,040 pounds, from 1,450 pounds in three years. (It also installed flushless urinals that save 50,000 gallons of water per year.) Nearby Subaru of Indiana Inc., which builds all U.S.-made Subaru cars and Toyota Camrys, claims it sends less trash to the landfill than the average American family.

Recycling is also popular. According to Pojasek of First Environment, recycling consumer waste makes back only 25 cents for every dollar it costs. Industrial recycling, on the other hand, has better economics because it tends to deal in purer materials. Federal Signal and Subaru, for example, find a receptive market for the steel shavings from their machine shops and presses. Outside of Los Angeles, carpet maker Bentley Prince Street Inc., has no problem selling nylon waste for 50 cents a pound.

Over the past decade, IBM Corp. has created a \$2 billion business recycling electronic equipment at 22 sites around the world. The company started the business as a way to reuse parts from mainframe computers com-

ing off lease. Today, according to company spokesman Fred Clarke, IBM takes in 40,000 pieces of used IBM and other equipment per week. It strips them down to their chips and recovers valuable metals. “We find uses for more than 99 percent of what we take in, and have a return-to-landfill rate of 0.73 percent,” Clarke said. “Our latest thing is to reclaim silicon wafer rejects and sell them to the solar power panel industry.”

### /// creative solutions

In addition to thinking in terms of processes, engineers also excel at innovation. As Ferretti said, “Once you give people constraints, they get very creative.”

Steve Skerlos, an associate professor of mechanical engineering and principal investigator at the Environmental and Sustainable Technology Laboratory at the University of Michigan, believes that economic forces will cause solutions to “self-assemble.” As regulation makes carbon and waste more expensive, innovators will find ways to shave costs. Skerlos’s work in metalworking fluids is an example.

The United States used 2 billion gallons of metalworking fluids to cool and lubricate metals in 2000. They accounted for 12 percent of all machining costs. Skerlos estimates that a typical machining operation uses 1 to 5 gallons of water-based metalworking fluids per hour.

Skerlos describes the fluids as “a lasagna of chemistry.” They begin with oil to lubricate and water to cool. Then come surfactants to mix oil and water, anticorrosives to prevent rust, biocides to stop bacterial attack, stabilizers to inhibit oxidation, and a host of other chemicals. It costs about \$1 per gallon to buy, maintain, recycle, and dispose of the fluids properly.

“We’ve been doing this for 50 years,” Skerlos recounted. In 2003, though, Skerlos had a breakthrough. “I realized that water was the enemy,” he said. “It was the reason the mixture needed all those chemicals. If I could get rid of the water, I could eliminate the chemistry.”

This led him to supercritical carbon dioxide. When separated from the atmosphere and compressed to 1,100 pounds per square inch, it dissolved oil. “The minute you release the pressure, a high-velocity stream of gas delivers a minute amount of oil that provides all the lubricity you need, and the expansion of the gas removes heat right where you generate it. Tools last longer and you can machine faster,” Skerlos said.

Waste disposal disappears as an issue because the process uses only 5 milliliters of oil per hour. At that rate, it would take roughly 30 to 160 days of 24-hour machining to use the same amount of fluid as a conventional

metalworking fluid-cooled machine will use in an hour. "We produce so little waste, it makes no sense to reuse the oil," Skerlos said. "We just dispose of it. And since we're using it only one time, we can use renewable and biodegradable vegetable oil without worrying about thermal breakdown."

It seems counterintuitive to go from cleaning and reusing materials to single use. Yet Skerlos says the waste savings are so great, users come out ahead economically.

Of course, there are other ways to win the technology game when regulations shift. Kenneth Oye, an associate professor of political science at the Massachusetts Institute of Technology, argues that technically adept firms can use regulatory standards, test procedures, and models to achieve a competitive advantage.

He points to two examples. DuPont Co. and Imperial Chemical Industries Ltd. (now part of Akzo Nobel N.V.) initially resisted efforts to regulate the ozone-depleting chlorofluorocarbons they produced. Yet both companies held patents for more benign CFC substitutes. They eventually supported the ban, which drove some competitors out of business and enabled DuPont and ICI to sell proprietary CFC substitutes for greater profits.

In the mid-1980s, Oye noted, changes in food technology and lax regulation led to salmonella outbreaks. At first, large food processors favored only weak voluntary standards. They eventually backed stronger regulation when they realized that they could use their financial and technological strength to put smaller firms at a cost disadvantage.

### /// weakest links

A company's carbon footprint extends outside the plant, and here many companies have faltered. When The Economist Intelligence Unit, the market-research arm of The Economist Group, asked more than 1,200 executives where their sustainability efforts were weakest, they pointed to the supply chain.

"Most companies I talk with are struggling with priorities," said Jordan Sampietro of Sustainable Procurement Strategies, a consulting firm in Albany, Calif., who recently delivered a workshop on sustainable supply chains at a Society of Manufacturing Engineers conference. "The larger companies are getting pressure from activist shareholders and customers. They want to know where they should start and how do they craft a plan."

Sampietro's definition of sustainability is broad and includes such programs as diversity in hiring and sourcing. "One of my main tenets is that sustainability goals should be aligned with business priorities. I try to provide proposals that meet their corporate social responsibility goals, but include cost-saving elements, because that's how companies view the world," he said.

His suggestions range from using copier paper with recycled content and maximizing the value of waste streams to finding more economical ways to bring products back to the factory for rework. They sound familiar to anyone interested in good business practice, and that's the point. "Some companies come to me and they think they have to go to China and audit their supply chain," Sampietro said.

Some companies do exactly that. IBM is one of them. In addition to meeting cost, quality, and delivery targets, vendors from emerging economies must also meet IBM's standards for social and environmental performance. On its own and through outside organizations, IBM has audited 500 vendors over the past four years. The results play a role in deciding which companies receive contracts.

Vendors whose standards are judged to be inadequate have a specific amount of time to improve their performance. IBM's Ferretti understands that it will take time for some companies in developing nations to meet the company's standards. "It's like a marriage, and it's in both our interests to make it work," he said.

IBM's sustainability initiatives are not limited to overseas vendors. The company is working hard to integrate environmental policies into its corporate procurement system. "We expect suppliers to offer environmentally sensitive products and meet requirements not to use hazardous materials. We're going to look at their policies on transportation, energy use, and inventory modes," Ferretti said.

The company has launched an ambitious Carbon Disclosure Project. "IBM is not interested in measuring or approximating a supplier's carbon footprint," Ferretti explained. "Instead, we're collecting information from suppliers across the board about their greenhouse gas emissions so we can see if we can help them put plans in place to reduce it."

Ferretti believes the data will show that vendors share many problems with common solutions. Some fixes will be obvious. For example, IBM reduced its carbon footprint by spending 85 percent of its transportation dollars on carriers enrolled in the U.S. Environmental Protection Agency's SmartWay partnership for fuel-efficient trucks.

"We expect our supply chain to use these carriers, too. I can see us collecting data, analyzing our suppliers' carbon output, looking for common elements, and formulating best practices that improve their performance through information," Ferretti said.

### /// common tradeoffs

Eventually, though, green manufacturing will come down to tradeoffs. Take inventory. Many manufacturers prefer just-in-time shipments so they do not have to tie up capital in inventory. That may mean less-than-truckload

shipments. Since trucks expend 60 to 70 percent of their energy fighting aerodynamic drag, a partly loaded truck uses almost as much fuel as a fully loaded truck. How does a green factory handle the tradeoff?

One approach, Ferretti said, is to accept full truck-load shipments and essentially store the inventory for the vendor. As the vendor releases inventory, it charges the factory. Such an arrangement would require IBM to build storage facilities, but vendors would have to carry the inventory on their books until it was released to the factory. Both would save on fuel costs and split any savings.

Another common tradeoff involves budgets. Green pioneers have complained about accounting for decades. It is usually easier to make a case for a green technology by looking at a product's lifecycle, including proper

disposal. According to Pojasek, powder paints can compete with liquid paints, but only if you factor in the cost of capturing volatile organic emissions, factory space for a distiller, the cost of recycling solvents, insurance, and energy. "These are real costs, but none of these things are ever figured in," he said.

Besides, purchasing, manufacturing, and disposal costs are usually paid by different organizations with different budgets. "We've shown companies that supercritical carbon dioxide could save them money on metalworking fluid waste treatment," Skerlos recounted. "But the waste treatment people refuse to spend a penny on something they think is a manufacturing concern."

Capital projects are even harder to push through, yet they are necessary for further gains once companies have plucked waste reduction's low-hanging fruit. Just

## /// carpet maker vs. waste

Ray Anderson began putting together Interface Inc. in the 1970s. Today, it calls itself the largest supplier of modular carpet tiles, so Anderson obviously knows a lot. Yet when shareholders began asking questions about the environment in the mid-1990s, he didn't know how to answer them. His ultimate response was to announce that his companies would have no net negative impact on the Earth by 2000.

That didn't happen, but Interface's operating divisions have made progress. Take Bentley Prince Street Inc., the company's broadloom manufacturer located in City of Industry, Calif. It initially focused on waste elimination, forgoing energy, water, or material when it did not add value to the company's products.

"Landfilling went down the quickest," Bentley Prince's sustainability manager,

Kim Matsoukas, reported. The company set up programs to recycle scrap nylon carpet, compost cafeteria waste, and recycle cardboard and other packaging. The company bought a machine to bale scrap nylon yarn, because baled material sold for higher prices (up to 50 cents per pound). Such programs eliminated up to 95 percent of solid waste.

The company also reconfigured processes. It produces tiles in rolls with room between the tiles for accurate trimming. Instead of tufting the space with virgin yarn, the company began tufting the space between tiles with damaged yarns that it would have to recycle anyway. This reduced waste and saved money on virgin yarn, which can cost up to \$3.50 per pound.

It applied the same approach to dyeing carpet. Tradi-



tional skein and beck dyeing produce vibrant color mixes, but are energy-intensive. Bentley Prince invested in more energy-efficient new equipment, although it uses it only for carpets that do not need bright or complex colors.

Like other manufacturers around the country, Bentley Prince is facing rising water costs. "To be honest, we've been spoiled with water and this is a way to kick start us to do something about it," Matsoukas said. She added that the company is evaluating water reclamation issues.

Matsoukas is also pushing for more recyclable content in the company's products. The problem is that she has only a handful of suppliers to choose from and her company is not large enough to force concessions from them. "We asked two backing suppliers for more recycled content, and one said it didn't have time to deal with that, but the second was receptive," she said.

Even with the carbon offsets it buys, the company has not reached zero negative impact. But it has found ways to divert 95 percent of its solid waste from the landfill and its energy conservation programs keep it competitive in difficult times.

▲ Carpet maker Bentley Prince Street has redesigned processes to use less virgin material and collects high-value nylon yarns for recycling.