Mimicking Nature by Designing Out Waste

By Cynthia Pollock Shea

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The Worldwatch Institute commissioned me to write the following article on "Mimicking Nature By Designing Out Waste" several years ago. After hearing Bill McDonough's talk at the Net Impact Conference on Saturday night, several people I spoke with requested a copy of the article. So, I am sharing it with all of you. Read, enjoy, and let's work together to put these ideas into practice.

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Change is inevitable. It's the resistance to change that's optional.

In nature, there is no waste. What one organism no longer needs, another organism uses as food. Until recently, factories, cities, and consumption patterns were typically seen as separate from the biosphere. Instead of living within the earth's annual income, industrial societies began to consume its capital -- a giant liquidation sale of unprecedented proportion. After decades of suffering the consequences of the first industrial revolution, leading thinkers, from a variety of fields, are beginning to look to the elegant processes of nature to guide and design the next industrial revolution.

Until recently, ecologists looking at the relationship between industry and nature, focused on the consequences of pollution. As their understanding of the damage caused to human and ecosystem health grew, legislation and regulations were introduced to "command" a floor of acceptable environmental protection and "control" the technologies used to attain that floor.

By 1996, annual global spending on environmental goods and services, primarily pollution control, waste management, and remediation amounted to $452 billion. According to Environmental Business International in San Diego, compliance

with environmental regulations exceeds 10 percent of total costs for some industries. Yet for 30 percent of the world's population, poor sanitation, malnutrition, and air pollution are still the major causes of illness and death.

Leading industrialists, scholars, and policy makers around the world now see both the high cost of controlling pollution and the continued severity of its toll as symptoms of viewing nature and industry as two separate and distinct entities. They are not. Our standard of living is after all made possible largely because of the biophysical system of which we are a part. Food and medicines nourish and repair our bodies, plants and trees filter the air and produce oxygen, and wetlands and watersheds purify and store water, while their inhabitants decompose organic "wastes".

A 1997 attempt to quantify the value of ecological services to the economy resulted in a figure of $33 trillion (within a range of $16 to $65 trillion). Robert Constanza at the Institute for Ecological Economics points out that this is almost double the traditionally measured worldwide human economy of $18 trillion. The latter measures all of the profits associated with producing goods and services, but few of the environmental, social, and health costs.

Accounting for the full social and environmental costs of economic activities, difficult as this may be, is considered essential to bridging the gap that remains between nature on one side and industry on the other. Prescriptive approaches to environmental protection are now widely perceived to have outlived their usefulness. But more innovative and productive resource use, and an emphasis on continuously improved environmental performance, are not yet well rewarded in the marketplace. Only a handful of countries, notably Germany, Austria, Sweden, and the Netherlands have adopted an explicitly precautionary approach of trying to prevent environmental damage before it occurs.

One of the most active international organizations pushing for more productive resource use is the Factor 10 Club, working out of Germany's Wuppertal Institute. Spearheaded by Ernst von Weisacker, president of the Wuppertal Institute, and Amory and Hunter Lovins of the US-based Rocky Mountain Institute, the group issued its influential Carnoules Statement to Government and Business Leaders in 1997. "Within one generation," says the Statement, "nations can achieve a ten-fold increase in the efficiency with which they use energy, natural resources and

other materials." ..."Such a goal is within the reach of technology and, with appropriate policy and institutional changes, could be brought within the reach of economics and politics."

"We call upon governments, industry and international and non-governmental organizations, to adopt a Factor 10 increase in energy and resource productivity as a strategic goal for the new Millenium...We also call upon governments to transform policies that now act as barriers into instruments to realize this goal, facilitating rather than impeding efforts by industry and institutions of science and technology... We also call upon governments to develop and adopt new means of measuring wealth and new indicators for sustainable development. And we call upon industry and non-governmental organizations to support these changes politically."

"Overall, resource efficiency has improved by about 2 percent per year in industrialized countries since 1970 (though energy efficiency has barely changed since 1990)," found the World Resources Institute (WRI) in its most recent biennial survey. Yet a Factor 10 improvement in resource productivity is starting to be viewed as achievable by the "less than 20 percent of North American and European companies" that WRI describes as "proactive in their commitment to improving environmental performance in alignment with sustainable development objectives, which hold that today's wealth and lifestyles should not be achieved at the expense of future generations."

Members of the World Business Council for Sustainable Development advise: "There are seven dimensions of eco-efficiency that every business should take into account when developing products, introducing process changes, or taking other actions with environmental implications. They are:

1. Reduce the material intensity of goods and services.
2. Reduce the energy intensity of goods and services.
3. Reduce toxic dispersion.
4. Enhance material recyclability.
5. Maximize sustainable use of renewable resources.
6. Extend product durability.
7. Increase the service intensity of goods and services."

Many companies now realize that anything leaving the premises as a waste stream, instead of a revenue stream, is both an environmental liability and a drain on profits. Similarly, the more materials used, the more environmental damage will be caused

by extracting, processing, and transporting those resources.
One notable effort to trim both waste and materials use has occurred in Germany. There, a packaging ordinance introduced in the early nineties requires consumer product manufacturers and retailers to pay for the collection and recycling of some 75 percent of the packaging stream. The concept of extending a producer's responsibility, or stewardship, for its product has subsequently spread like wildfire. Automobiles, batteries, electronic goods, and household appliances are just some of the products that manufacturers are now required to take back and recycle. And the producing firm or industry -- not the public sector -- pays for the collection and recycling.
The German government did not dictate how this recovery system would work. It merely directed the private sector to take back their products or risk the imposition of hefty deposits on virtually every item sold. In the case of automobiles, an additional incentive was the threat of classifying plastic "shredder fluff" as hazardous waste. Not only have recycling rates increased, manufacturers now design their products for disassembly and try to eliminate the toxic and other problematic components that hinder or raise the cost of recycling.
MOVING OUT OF THE BOX
Some companies, designers, academics, and industrial complexes are already starting to move beyond the concept of eco-efficiency and striving to adopt more "eco-effective" practices. While it is generally agreed that enormous potential remains to use energy and materials more efficiently, they note that efficiency does not eliminate the generation and release of polluting substances. It merely "mitigates", or reduces, the volume of the pollutant released to the biosphere. And some products, they argue, should simply never be made. There is no safe way, for example, to dispose of many toxic and nuclear wastes or heavy metals.
These pioneers are trying to learn from and replicate natural systems, which they view as the most effective guide to designing products, factories, buildings, cities, and industrial parks. The results are sometimes surprising. Increasing the amount of daylight in offices, schools, and factories, for example, has been found to increase productivity and reduce absenteeism. Fewer light fixtures also reduce electricity demand, both for lighting and for air conditioning, because lights generate heat. The use of back alleys, instead of driveways, cuts neighborhood paving needs 50 percent. Oil and pesticide laden stormwater runoff is reduced and groundwater recharge is enhanced.
Architect and designer Bill McDonough describes the design

philosophy of the first Industrial Revolution this way, "If brute force doesn't work, you're not using enough of it." The ever larger cars and engines of the fifties and sixties, and the popular sports utility vehicles of today, embody this approach. So do huge power plants that convert only one-third of a fuel's energy value into marketable electricity. As physicist and energy guru Amory Lovins first started telling us 25 years ago, we've got to quit cutting butter with a chain saw.

Leaders like McDonough and Lovins look at design problems from a radical perspective. Their approach is elegant, rather than forceful. They step "out of the box" to ask what really needs to be accomplished. Lovins' "negawatts", for example, is now an energy saving term familiar to many. McDonough and Braungart's infinitely reusable "products of service", instead of short-lived discards, is a similarly powerful concept that shows signs of becoming widely accepted. ("Products of Service" will be described fully later in the article.) Agricultural chemical companies are starting to discuss "crop insurance protection" instead of pesticide sales. And scientist John Todd has figured out how to clean waste water using green plants and sunlight. Sounds simple, you say. Then why isn't your water treatment plant or local factory using this cost-effective approach?

"The key to the Next Industrial Revolution -- the design revolution -- is to figure out how to best love all the children," says McDonough. "Let's design buildings, products, cities -- literally everything -- so no harm is done."

Before you start imagining an elder hippie, wearing a tie dye T-shirt and driving a Volkswagen van, you should know that McDonough is the Dean of Architecture at the University of Virginia. He is the founding principal of William McDonough + Partners, an architectural, planning and product design firm with clients around the world. He hosted a three part series on public television, called Planet Neighborhood. He is partner, along with German chemist Michael Braungart, in McDonough Braungart Design Chemistry. And he is the only individual in the United States to have received the Presidential Award for Sustainable Development.

McDonough is a living definition of an "out-of-the-box" thinker. His ability to transcend the expected brings him contracts and awards, from all manner of clients. The buildings, products, and plans he delivers must meet the typical performance, cost, and aesthetic criteria. But they always go a step further to incorporate ecological intelligence, social justice, and concern for the future. That McDonough finds receptive audiences in corporate boardrooms, townhalls, and university classrooms is testament to the universality of his message.

In the October 1998 issue of Atlantic Monthly, McDonough and Braungart describe how what they call the Next Industrial Revolution will work. Product lifecycles need to become harmless, cradle-to-cradle loops, they assert, rather than the dangerous cradle-to-grave system now in place. In this "endless cycle of nutrients and metabolisms", "waste that stays waste does not exist." Ultimately, "wastes" will be regarded as raw materials out of place. McDonough and Braungart are convinced that their concept of "eco-effectiveness", not eco-efficiency, is the key to creatively unlocking and celebrating nature's abundance.

DESIGNTEX

When McDonough and Braungart were asked to design a fabric for a unit of the Steelcase Corporation, the largest office furniture maker in the world, the client felt prepared. DesignTex knew of their green reputation and proposed a fabric made from cotton and recycled soda bottles. The problem, they pointed out, is that cotton accounts for 25 percent of the world's insecticide use, requires massive volumes of water to grow, and has never been associated with social fairness. Moreover, fabrics made from plastic bottles may contain UV stabilizers, antimony residues from catalytic reactions, and other materials that may not belong next to human skin. When combined, the cotton could no longer be composted, and the plastic no longer recycled.

McDonough and Braungart set out to design a whole new fabric. Their standards were almost inconceivably high. Since the fabric would be used for office furniture upholstery and suffer constant abrasion, the airborne fibers could not be detrimental to human health. Interviews with wheelchair users revealed moisture to be a problem over extended periods of sitting so the fabric would have to be an effective wick. Fabrics made from environmentally harmful materials were out of the question. And to top it off, the many dyes and fixatives had to satisfy the self-imposed criteria of being free from mutagens, carcinogens, heavy metals, endocrine disrupters, persistent toxins, and bioaccumulative substances.

Sixty chemical companies were asked to participate in the project and all declined. Finally, Ciba Geigy Ltd. (now known as Novartis) in Basel, Switzerland, agreed to get involved. Some 8,000 chemicals commonly used in the textile industry were reviewed by Braungart and his colleagues. They eliminated 7,962. And they went on to create an entire fabric line with only 38 nonharmful chemicals.

After evaluating many alternatives, the fibers chosen were wool from "happy", free range sheep in New Zealand and organically grown ramie from the Philippines. Wool absorbs water and

ramie, a plant similar to nettles, provides a strong structural fiber that wicks water away. Combining the two keeps chair occupants cool in summer and warm in winter. And at the end of its useful life, the fabric can be safely tossed onto a compost heap.

Production of the fabric took place at Albin Kaelin's Rohner Textil mill in Heerbrugg, Switzerland. When McDonough and his team arrived, Kaelin informed them that even though the mill was regarded as a leader in energy and water efficiency and noise reduction, the Swiss government had just declared his fabric trimmings hazardous waste. The fabric was fine and could be sold, but the trimmings were hazardous waste, a perfect example, according to McDonough, of what is wrong with the first Industrial Revolution.

When the inspectors came to test the water coming out of the mill after McDonough's production run, they thought their equipment was broken. The water coming out was cleaner than the water going in. The fabric was further filtering the water. "When the effluent of your factory is cleaner than the influent, you'd rather use the effluent, for process than influent, which means you can cap the pipe. Which means there are no emissions -- by design," says McDonough.

The richly colored, textured, and patterned fabrics of The William McDonough Collection have won many design awards, including the Gold Medal for Best New Fabric at NeoCon in Chicago. The Climatex®Lifecycle™ fabric is selling well in the market place. And, most importantly, the fabric has established a new standard of excellence, inspiring other manufacturers to reassess their own design and production criteria.

MATERIALS CLASSIFICATION

McDonough and Braungart have developed a propriety design tool for use with their clients that examines products right down to the molecule. Called the Sustainable Design Protocol, the analysis immediately rules out persistent and dangerous components and continuously tracks and monitors improvements. "We look at design as a signal of intention. And we look in the future and say that the filters of the future will not be on the end of pipes. They will be in our heads." "We put things through these intellectual filters and they include no persistent toxins, no bioaccumulatives, no endocrine disrupters, no carcinogens, mutagens, teratogens. So we develop an inventory of what's going into the various products right down to the very elements. And then we do an optimization."

Products that pose hazards, or cannot safely or economically be recycled, are classified as "unmarketables". In the long term, they should not be manufactured, says McDonough. A "Product

of Consumption", on the other hand, is made from "Organic Nutrients" and is designed to be returned safely to nature through the organic life cycle. The DesignTex fabric is such a product. Made from wool, ramie, and innocuous dyes and fixatives, the cloth can be safely composted at the end of its useful life.

In between these two extremes are "Products of Service". Made from synthetic materials referred to as "Technical Nutrients", they are designed to circulate within industrial life cycles -- forever. An example would be nylon carpet tiles that are leased to a customer and later returned to the manufacturer for refurbishment or recycling. Interface Flooring, the world's leading carpet-tile maker with $1 billion in annual sales, has introduced this system through its EverGreen Lease program. Clients like the Southern California Gas Company's Energy Resource Center and the City of San Diego are enthusiastic about the reduced capital outlays and superior environmental performance associated with the arrangement. Interface hopes that the leasing agreements will initially cut its materials flow about tenfold, and ultimately by a hundredfold.

So why would a company want to shift from selling a product once and forgetting about it to selling a service that requires continuous product ownership. Two reasons say McDonough and Braungart. "First, when the product needs replacing, the customer needs to communicate directly with you. You are not disengaged from your previous sale. That is a very powerful long-term marketing relationship." Second, if you are committed to continuously reusing an asset, you are no longer just another vendor selling your product at the lowest possible price. You become interested in fundamental redesign changes like eliminating contaminants and facilitating recycling.

McDonough and Braungart have conceived a new carpet design that would effectively close the loop. The idea is to create a carpet whose top could be peeled off. The backing of the old carpet would stay in place. "And then all you do when you need a new carpet is get a new top, made from synthetic polymer or hemp or whatever. Something that's ecologically intelligent -- biodegradable or technical; but always safe."

"You won't have to ship all that bulk all over the place either. So when you change carpets, you don't take out 8,000 pounds of stuff. You take out 2,000 pounds. And you put back 2,000 pounds." "You are being efficient with volume, material, and shipping -- and more effective over the long-term. You have not just reduced waste, you have eliminated the concept of waste." And, "You as the company have your own pad there. Another company, the competition, would have to bring in a whole new

pad. So you have a competitive advantage. And that's the reason you want to continuously offer a service instead of just a one-time product."

"You also have a crude mountain of technical nutrients for your own industry. So carpet becomes carpet forever. All the world has to do is allocate a certain volume of materials to be floor covering. And then we just keep reusing it forever." Current carpet formulations are another story. McDonough refers to wool and nylon blends as "mules with no future". Similarly, he calls carpets made from nylon embedded in PVC and fiberglass, with synthetic backings, "monstrous hybrids". "You can't recycle that. It's mush."

INDUSTRIAL ECOLOGY

In nature, the study of the complex and interdependent relationships among organisms and their environment is called ecology. In 1989, two General Motor's researchers, Robert Frosch and Nicholas Gallopoulos, wrote about the concept of an "industrial ecosystem" in Scientific American. They suggested that companies could cut costs and reduce pollution by turning one industry's wastes (outputs) into another industry's raw materials (inputs). Although others had earlier written about and discussed the concept, the article struck a chord and encouraged some industrial engineers to act upon their latent intuition. Businesses began to explore how they could turn their waste streams -- a liability and expense -- into sales and income. Environmentalists saw the potential for reducing energy, water, and materials use as well as curtailing waste and pollution. And governments at all levels began to look at the prospect of creating jobs, boosting tax revenues, and improving environmental quality.

Today, several dozen eco-industrial parks are being planned around the world, with a much smaller number already in operation. In some cases, traditional manufacturing and refining operations have spontaneously developed mutually beneficial relationships. In others, extensive searches are underway to find companies that could form symbiotic relationships. At a few sites, there is an explicit goal to incorporate sustainable technologies, reduce environmental impact, and serve as a model for other industrial developments. With the sophistication of information technologies, some of the parks in the conceptual stage are "virtual" and include participants with complimentary energy and materials flows that do not share the same geographic location.

The best known example of industrial ecology, and the one with the longest history, is in Kalundborg, Denmark, a port city 100 kilometers west of Copenhagen. Kalundborg's web of materials

and energy exchanges evolved slowly and spontaneously over the past 25 years. "Originally, the motivation behind most of the exchanges was to reduce costs by seeking income-producing uses for "waste" products, according to Indigo Development, a California-based consulting firm that is a leader in the industrial ecology sector. "Gradually, the managers and town residents realized they were generating environmental benefits as well." Cooperation became a flexible means of achieving regulatory goals.

From five core partners, including Demark's largest power station and oil refinery, a series of bilateral agreements has expanded into a web that includes gypsum suppliers from Spain and Germany. One of the participants, Novo Nordisk, is an international biotechnology company, with annual sales exceeding $2 billion. The Kalundborg plant produces industrial enzymes, pharmaceuticals, and 40 percent of the world's insulin supply. Waste heat and steam from the 1,500 megawatt, coal-fired power plant warm the production facility and provide process heat for manufacturing. Sludge from the factory, and a 57-pond, local fish farm, fertilize nearby farm fields. Surplus yeast from insulin production goes to farmers as pig food. Surplus refinery gas, desulfurized fly ash, gypsum, and liquid sulfur are also traded among the participating companies. As a result, surplus gas is no longer flared, the utility has substituted some coal with desulfurized gas, and the city's district heating system has replaced 3,500 oil furnaces -- formerly a significant source of air pollution. Each year, the linkage arrangements save 30,000 tonnes of coal and 19,000 tonnes of oil. Carbon dioxide emissions are reduced by 130,000 tonnes annually. "This web of recycling and reuse has generated new revenues and cost savings for the companies involved," writes Indigo, "and reduced pollution to air, water, and land in the region. In ecological terms, Kalundborg exhibits the characteristics of a simple food web: organisms consume each other's waste materials and energy, thereby becoming interdependent with each other." "Through 1993, the $60 million investment in infrastructure (to transport energy and materials) produced $120 million in revenues and cost-savings." The payback is presumably much greater if extended to the present. Two other large-scale industrial exchanges have been operating since the mid-eighties. In the Austrian province of Styria, strict regulations and high waste disposal costs have motivated some 50 companies to sell or share their by-products. Participating industries include agriculture, food processing, plastics, fabrics, paper, energy, metal processing, wood working, building materials, and a variety of waste processors and dealers.

At the Bruce Energy Center near Tiverton, Ontario, a nuclear power plant is the hub of a six company network Waste heat and steam from the Ontario Hydro reactor fuel a broad range of industrial and agricultural processes including dehydration, concentration, distillation, hydrolysis, and space heating. Tomatoes are grown in hydroponic greenhouses, fruits and vegetables are made into concentrates, sauces and purees, and local crops are dehydrated to produce nutrient-rich animal feeds. Industrial and fuel alcohol is produced by Canada's largest manufacturer, and polypropylene film is made for domestic and international markets. A variety of byproduct linkages has resulted in substantial savings for the firms involved, an increase in local jobs, and environmental benefits, according to a study by Toronto-based Peck & Associates.

U.S. DEMONSTRATION PROJECTS

In the United States, a competitive demonstration project, sponsored by the President's Council on Sustainable Development, helped spur interest in eco-industrial parks. Four locations -- in Baltimore, Maryland; Brownsville, Texas; Cape Charles, Virginia; and Chattanooga, Tennessee -- were selected to receive technical and regulatory asistance. Another dozen projects are proceeding independently. Some are at existing, "brownfield" industrial sites. A few are completely new "greenfield" developments. And a couple are "virtual" business networks.

From having the most polluted air in the country in the 1970s, Chattanooga, Tennessee, is now a living laboratory devoted to sustainable development. Walkways line the riverfront, a reclaimed downtown is attracting restaurants, homes, and businesses, and new industries are turning out products like electric-powered buses.

One component of this transformation is a 7,000 acre eco-industrial park located at a former U.S. Army Ammunition Plant. In 1992, Congress allocated $100 million to turn the site into a model for converting national military assets to civilian use. A "cluster" approach is being used to identify potential business linkages and attract and select tenants. Heavy and light manufacturers, companies that focus on environmental services, and industries that remanufacture and reuse existing products are high on the recruitment list. The goal, regarded by some as overoptimistic, is to generate 10,000 new jobs at the site by 2020.

Closer to downtown, the one square mile SMART Park on the Southside is currently a more active reclamation effort. The goal is to integrate the energy, water, and waste flows of the new university stadium, an existing metal foundry, and a chicken

processing facility. A feasibility study now under way is to be followed by active recruitment of compatible new businesses.
In Brownsville, Texas, and across the border in Matamoros, Mexico, the intent is not to develop a discrete site, but rather a regional "industrial symbiosis". Bechtel Corporation, an international engineering firm, has generated an industrial process data base coupled with information about the region's small businesses, large industries, and agricultural entities. Proprietary software developed by the company has already identified some 40 potential matches. Additional tools will quantify and value the materials that could be exchanged.
At the Port of Cape Charles on Virginia's eastern shore, the Sustainable Technologies Industrial Park is one piece of a comprehensive revitalization strategy designed by the community. Located within a National Historic District, the site is intended for mixed residential, commercial, and industrial uses compatible with protecting the area's natural and cultural resources. The goal is to enable people to live down the block from a factory, and walk to work. Solar Building Systems, a photovoltaic panel manufacturer, is the first industrial tenant.
Industries used to "get stuff, make stuff, dump stuff," says Ed Cohen-Rosenthal, director of the Work and Environment Initiative at Cornell University. In today's competitive market place, that strategy no longer works. As Councilman Dave Crockett of Chattanooga says, businesses need to "choose between Jurassic Parks and Eco-Parks." The concept is not just for companies that make environmental technologies. Eco-industrial parks are an option for all companies that can achieve synergies by working together. Cohen-Rosenthal and the Environmental Protection Agency are developing codes and convenants to make it easier for businesses to apply industrial ecology principles to planned and existing projects.
Despite the appeal, the logistics of establishing an eco-industrial park can be complex. A baseline study done by the grassroots Green Institute in Minneapolis, found small-scale manufacturers lacked the time and technical know-how to create workable linkages. Michael Krause, director of the Green Institute points to the Burnside eco-industrial park in Dartmouth, Nova Scotia, as a good model to follow. There, Ray Cote from Dalhousie University has championed and led an effort to site a resource center in the middle of a growing industrial park. By providing university research, technical assistance, and a proactive agenda, Cote and his team have offered tangible and immediate help to the 1300 small and medium sized companies in the park.
GETTING TO ZERO
If one organization's "waste" becomes another organization's

"food", then zero emissions become possible. Researchers at the Zero Emissions Research Initiative (ZERI), headquartered at the United Nations University in Tokyo, are working to turn this premise into reality. Launched in 1994 by Belgian businessman Gunter Pauli, ZERI has projects underway on five continents. ZERI advocates an industrial revolution in which industry mimics nature's sustainable cycles. In theory, all inputs would be used in final products or converted into value-added inputs for other industries or processes.

"For industry, Zero Emissions means greater competitiveness and represents a continuation of its inevitable drive towards efficiency," writes Pauli. "First came productivity of labor and capital, and now comes the complete use of raw materials - producing more from less." "For governments, the full use of raw materials creates new industries and generates jobs even as it raises productivity. Moreover it provides the means to feed, clothe and house their populations without destroying the ability of future generations to do the same." "From an environmental perspective, the elimination of waste represents the ultimate solution to pollution problems that threaten ecosystems at both local and global levels. In addition, the full use of raw materials, accompanied by a shift towards renewable sources, means that utilization of the earth's resources can be brought back to sustainable levels."

ZERI's work has moved quickly beyond the theoretical. An intentional focus on biomass- or mineral-based industries in developing countries led to breweries as the first major research and demonstration effort. A survey of agro-industries around the world, found that breweries produce the largest quantities of liquid, solid, and gaseous wastes, and their number is increasing rapidly. George Chan, with over 30 years of experience in the closed-loop recycling of liquid and solid wastes from integrated livestock-agriculture-aquaculture farms in China, runs the biomass program -- all the way from design and training to implementation and operation.

Traditionally, only 15 percent of the grain used at a brewery goes into the beer. The remainder became waste or was sold as a difficult-to-digest livestock feed. Under the guidance of S.T. Chang from Hong Kong, the ZERI process grows high-value mushrooms in the grain residue. The microbes involved in mushroom production turn the substrate into quality livestock feed. Alternatively, the substrate can be used as a soil conditioner for earthworm production. Earthworms are a high-protein feed for chicken and shrimp.

Biogas energy is produced from the livestock waste and used to power the farm. The liquid waste from the brewery is channeled

to large ponds that grow plankton to feed various fish species. Up to 15 tons of fish can be harvested annually from each hectare of pond. Trellises made of bamboo or mangrove sticks edge the pond and support crop production. "No watering, manuring or weeding needs to be done, and enough nutrients should be removed daily to prevent eutrophication." Transformed from an expensive disposal problem, grain residues and liquid brewery wastes become valuable inputs into readily marketable agricultural products.

Following a successful pilot project in Fiji, the first commercial application was launched in Tsumeb, Namibia. Mushrooms are harvested on a daily basis, even when the outside temperature falls to 40 degrees. There are no climate controls. The Shinano Brewery, one of the first microbreweries in Japan, plans to convert its operation in the Japanese Alps into a zero emissions facility. Guiness wants to apply ZERI principles and concepts to its network of breweries, starting with Seybrew in the Seychelles. In combination with an adjacent slaughter house and piggery, the brewery will generate methane gas and carbon dioxide. At present, all fuel and some carbon dioxide at Seybrew's soft drink operation are imported.

North of Bogota, Colombia, an old steam train has resumed operation and will bring weekend visitors to the popular El Portico brewery site. The Universidad de la Savannah in Columbia, which is in charge of the ZERI Diploma and is planning the ZERI Master of Science Program, will coordinate the design and implemention process. KAISER, a large Brazilian brewer, plans to adapt its eight facilities around the country. And, after the first ZERI Training Program, hosted by the North Coast Brewery in Fort Bragg, California, last March, one US and two Canadian breweries are preparing to implement the ZERI approach.

In Germany, where some laborers still drink beer during their morning "coffee break", a medium sized brewery recently joined the program. At the World's Fair in Hannover in the year 2000, an on-site zero emission brewery will be available for visitors to tour.

The ZERI concept, however, is about far more than redesigning breweries. At Yakushima, an island of 14,000 people in Southern Japan, the entire town has embraced zero emissions. Already designated a World Heritage Landmark, local residents elected to become an "Environmental and Cultural Village." Eliminating waste and fossil fuel use are part of the plan. A fleet of electric vehicles, powered by wind energy, is one of many projects on the drawing board.

In the corporate sector, DuPont became one of the first ZERI

champions. Waste reduction and resource efficiency have become corporate mantra. EBARA, a large Japanese engineering firm, intends to open an eco-industrial park in Fujisawa in 2002. The plan is for 2,000 people to live and work on six hectares of land without creating any waste. With university affiliations and training programs in Africa, Asia, Europe, and South America, ZERI is actively trying to influence the next generation of business leaders and scientists. New technologies, climate policies, and public-private partnerships are all part of the mix.

APPLYING OUR KNOWLEDGE

"Man can no longer expect the Earth to produce more, the time has come for us to do more with what the Earth produces," say Zero Emissions Research Initiative publications.

An impressive example of putting this principle into practice is offered by **John Todd and his brainchild, "the living machine"**. As much a botanical garden as a sewage treatment plant, Todd's invention treats wastewater from virtually any source -- factory or sewer. The plants, fish, and bacteria chosen for a project depend on the constituents in the wastewater. After flowing through a series of concrete tanks for two days, the water emerges as clean or cleaner than it would from a traditional sewage treatment plant. The town of South Burlington, Vermont, an M&M/Mars candy factory in Waco, Texas, and the Body Shop Canada headquarters in Toronto, Canada have all found the system functional, cost effective -- and pretty. No longer would sewage treatment plants need to remain out of sight and out of smell. An attractively designed living machine is a pleasant place to stroll.

In essence, good design is about applying our knowledge to make more productive use of the earth's metabolic systems. Instead of squandering energy and materials, degrading their value and the integrity of ecosystems, we need to use them more "eco-effectively." As we improve our "intellectual filters" in the design of our neighborhoods, factories, buildings, products, and infrastructure, we can tap into and harness nature's abundance. If we are smart and creative, the concept of waste may one day cease to exist.

Incorporating ecological intelligence, social justice, and concern for the future into business and government decision-making will be no easy task. Despite mounting evidence to the contrary, many governments, corporations, and voters continue to assume that using more energy, materials, and resources will produce more jobs and a healthier economy. Our present system of accounting for costs and measuring value presents a skewed picture of the relationship between nature and the

economy.
Many industry leaders and their advisors, on the other hand, are moving away from a focus on products and materials and toward an approach that emphasizes the delivery of services. Monsanto, for example, has sold off its chemical division to focus on life sciences. DuPont and others are working to depolymerize used plastics, returning them to their valuable chemical building blocks. Energy service companies "sell" buildings with comfortable climates and good lighting. In the years ahead, many more examples of "products of service" are sure to proliferate.
Working in partnership is key to virtually all the changes needed to create a more sustainable economy. Natural scientists can inform engineers about the functioning of biophysical cycles. Corporate executives and technology specialists can create symbiotic partnerships with companies in other industries. Business strategists can convince financing sources that a new approach will be lucrative. And the list goes on.
Perhaps the greatest need at present is to "get out of our boxes". Taking a long term view of the types of services, green spaces, and Main Streets we would like to see in the future often leads to a different work plan than solving today's crisis.

THE HANNOVER PRINCIPLES
written by William McDonough, were commissioned by the city of Hannover and adopted as the official design principles for the World's Fair in Germany in the year 2000.

1. Insist on the rights of humanity and nature to coexist in a healthy, supportive, diverse and sustainable condition.

2. Recognize interdependence. The elements of human design interact with and depend upon the natural world, with broad and diverse implications at every scale. Expand design considerations to recognizing even distant effects.

3. Respect relationships between spirit and matter. Consider all aspects of human settlement, including community, dwelling, industry and trade, in terms of existing and evolving connections between spiritual and material consciousness.

4. Accept responsibility for the consequences of design

decisions upon human well being, the viability of natural systems, and their right to coexist.

5. Create safe objects of long-term value. Do not burden future generations with requirements for maintenance or vigilant administration of potential danger due to the careless creation of products, processes or standards.

6. Eliminate the concept of waste. Evaluate and optimize the full life-cycle of products and processes, to approach the state of natural systems, in which there is no waste.

7. Rely on natural energy flows. Human designs should, like the living world, derive their creative forces from perpetual solar income. Incorporate this energy efficiently and safely for responsible use.

8. Understand the limitations of design. No human creation lasts forever and design does not solve all problems. Those who create and plan should practice humility in the face of nature. Treat nature as a model and mentor, not as an inconvenience to be evaded or controlled.

9. Seek constant improvement by the sharing of knowledge. Encourage direct and open communication between colleagues, patrons, manufacturers and users to link long term sustainable considerations with ethical responsibility, and re-establish the integral relationship between natural processes and human activity.

Compare the Hanover Principles with the Earth Charter at www.earthcharter.org