

Industry's role in air quality improvement: environmental management opportunities for the 21st century

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1. INTRODUCTION

More than 200 years ago Adam Smith, the founder of modern economics, wrote in the *Wealth of Nations* that "...consumption is the sole end and purpose of all production; and the interest of the producer ought to be attention to...that of the consumer." In recent years the rapid growth of the world economy has given Adam Smith's maxim new meaning. The age-old hunger for consumption grows unabated and increasing numbers of consumers around the world are attaching new value to the environmental quality of goods and services and expressing concern over the environmental impacts of industrialization. That concern is growing because more than 70% of the world's urban population live in areas where the air is seriously polluted and as many as 750,000 people - the majority in developing countries - die each year of ailments caused by air pollution.¹

Over the past 25 years corporations throughout the world have made dramatic changes in the way they do business as more people come to understand how the ecological system works and how polluted air and water endanger human health. The key to increasing industry's participation in the drive for higher standards of air quality is the growing realization that effective environmental management, technological development, and technology dissemination are cost-effective and profitable business strategies. Global competition is making firms around the world more customer-conscious and, to the extent that consumers demand products that minimize environmental degradation and enhance the quality of their lives, businesses in every industry must respond in order to survive.²

This paper examines how changes in business practices, driven by a better understanding of how natural environments function, are converging to provide new opportunities for environmental management that goes beyond regulatory compliance to reduce air pollution. Although sound and well-enforced environmental regulations are an essential foundation for improving air quality, command-and-control systems alone are unlikely to achieve the lower levels of pollution that will be necessary to achieve sustainable development in the 21st century. In cooperation with government, businesses in every industry can play crucial roles in achieving higher standards of air quality while at the same time maintaining acceptable levels of economic growth. We explore three ways in which corporations can contribute to environmentally sustainable development: (1) by adopting proactive environmental management systems that focus on air pollution prevention; (2) by developing new technologies for air pollution control and reduction; and (3) by transferring air pollution control and prevention technologies through international trade and investment.

2. TOWARD A HOLISTIC VIEW OF BUSINESS AND ENVIRONMENT

Recent developments in the global economy are pushing firms in every industry to develop new strategies of competition and new processes for managing their environmental impacts. These trends include: (1) a growing awareness of the

relationships between economic and environmental sustainability; (2) a better understanding of the business opportunities—both potential cost reductions and higher profits—in adopting quality environmental management practices; (3) a growing realization in government and the private sector that regulatory controls, while necessary, are not sufficient to achieve pollution prevention; and (4) growing international pressures on corporations to adopt voluntary standards for environmental management that go well beyond regulatory compliance as a precondition for participation in global trade and investment.³

2.1. Changing Business Perceptions of the Environment

We should not for a moment think that environmental performance is, or ever will be, the dominant concern of business. In market economies the primary purpose of business is to create wealth for shareholders who risk capital in anticipation that it will appreciate sufficiently to give them a fair return on investment. Customers, in addition, demand goods or services of value, the sales of which allow companies to earn profits, pay their employees' wages, and reward their shareholders. Profit-making will always be the primary objective of corporations, but an increasing number of companies understand that they also share the common benefits of the natural environment. Beyond creating monetary wealth, businesses have a second "bottom line" that reflects the ethical system in which they operate. Firms must develop core corporate values and adopt quality-based management systems in order to satisfy consumers. This second bottom line accounts for things of social value such as environmental health and safety.

Wealth-creation remains a fixed business objective, but the manner in which wealth is created changes continuously. In the 21st century nearly every aspect of the business environment affecting corporate competitiveness will change dramatically. Three trends currently offer hope that businesses will continue to adopt positive cost-effective environmental performance policies that will significantly reduce global air pollution. They include, first, broad changes in business practices, especially those related to quality-based management, that have built-in environmental protection attributes; second, changing attitudes in the business community toward the environment that are making environmental management an integral part of business strategy; and third, new

philosophies and technical approaches to environmental management that are making pollution prevention programs more effective and efficient.

Business leaders have become accustomed to thinking about a firm's environment; the social, political, and economic conditions that directly impinge upon its operations; and ways of adapting their internal organizations to changing external conditions in order to survive and grow. Only recently, however, have corporations defined their environments to include the *biosphere*, the life supporting system from which industries draw their raw materials and deposit their wastes. In the rapidly shrinking world of commerce, corporations must come to grips with the complex web of relationships between the natural environment in which we live and the economic system in which we work. Companies that perceive of environmental systems and economic systems integrally see a *biospheric market place* where environmental, economic, and human life systems are tightly bound. In such a system both producers and consumers begin to understand the broader context of production and distribution. Consumers begin to demand goods and services produced through processes that do not pollute the air they breathe or degrade the natural resources from which they derive their livelihoods.

To make the biospheric marketplace function smoothly, government has traditionally provided infrastructure and imposed regulations that sustain the natural system, just as it manages diseconomies and preserves a minimum level of order in the economic system. Similarly, management in the private sector seeks to guarantee and shape the future of individual businesses. Increasingly the problem that both governments and businesses face is to balance the financial health (cash flow and profitability) of wealth-creating firms with the efficient and responsible use of natural and environmental resources.

Public policies in most countries assume that corporations make environmental decisions and management decisions differently and that the two are basically irreconcilable at the organizational level. They further assume that corporations cannot compare the costs and benefits, for example, of improving air quality with those of production changes or product design options. Some have concluded that the mere act of making environmental decisions automatically forces a conflict of values. And in the past corporations have too often accepted these assumptions, opposing environmental controls with the argument that it is impossible to conserve ourselves into prosperity. However, decades of conflict

over the environment have produced a new economic model. Enlightened corporations have begun to recognize that environmental resources, including the quality of air, must be treated as a unique form of productive capital with properties that make them different but no less important to the economy than manufactured capital. In the words of Frank Popoff, former CEO of Dow Chemical Company, "there can be no economic development without environmental responsibility." Natural resources such as air, water, and forests are capital resources and their wise use benefits industries, employees, and communities.

Industry's role in conserving and, indeed, enhancing environmental resources is now widely recognized. The McKinsey Corporation's survey of more than 400 top executives of companies around the world found that 92% agreed with Sony Corporation president Akio Morita's assertion that the environmental challenge will be one of the central issues of the 21st century.⁴ A growing number of U.S.-based multinational corporations, 3M, DuPont, Monsanto, Xerox, Johnson & Johnson, Procter & Gamble, SC Johnson, and others are beginning to view the natural environment and their business environment holistically.

A recent survey of 256 large and small manufacturing firms in the United States found that nearly 78% of the respondents ranked pollution prevention as "very important" or "important" to corporate performance.⁵ About 84% of the companies were pursuing reduced emissions strategies and 16% were seeking zero emissions levels. Clearly, regulations were a significant factor in their corporate environmental strategies, but respondents also listed corporate citizenship, improving technologies, service to key customers, and improving productivity as critical reasons for adopting proactive environmental management strategies.

Enlightened companies begin with a policy and a plan that reflect sound environmental goals and secure top management commitment and long-term funding. More than 79% of the executives responding to the McKinsey survey reported that their firms had written company environmental policy statements. Good policies identify environmental protection as a priority and are reinforced with specific goals, target dates, and issue-specific policies and procedures. The policies are backed up by a long-term strategy. They mandate a strong program to monitor performance and take corrective

action when necessary. Many firms have adopted environmental programs that focus employee and public attention on their objectives—"Pollution Prevention Pays" at 3M, "Waste Reduction Always Pays" at Dow, "Priority One" at Monsanto, and "Save Money and Reduce Toxics" (SMART) at Chevron. But beyond slogans and symbols, successful companies declare clear goals and measurable targets. General Electric adopted a program to decrease toxic emissions by 90% between 1988 and 1993. Xerox reduced hazardous waste generation by 50% between 1990 and 1995. Nortel, the Canadian-based telecommunications MNC, for example, established clear and specific targets for the years 1993 to 2000: a 50% reduction in pollutant releases, a 50% reduction in solid wastes, a 30% reduction in paper purchases, and 10% improvement in energy efficiency.⁶ Kodak uses its customer satisfaction objective as its environmental goal: "to create customer confidence with on-time delivery of defect-free, reliable products and services exactly as ordered with no wasted material or labor."⁷

These corporate policy statements are not merely meant for public image-building; they reflect a new understanding of the economics of environmental resources. The unwise use of environmental resources can deprive industries of the materials they need for production and eventually drive them into bankruptcy. To profit and grow companies must be able to regenerate natural resources and maintain an ecosystem capable of sustaining both production and consumption. Proactive environmental management and pollution prevention are being adopted by major corporations because they understand that it is a profitable strategy. AT&T saved \$3 million a year by redesigning its circuit board cleaning process to eliminate ozone-depleting chemicals.⁸ Canadian chemical companies that adopted "Responsible Care" practices have saved millions of dollars in insurance costs as insurers began to consider them highly protected risks.⁹ In 1996, Dow Chemical announced that would spend \$1 billion in training, R&D and new facilities to achieve an ambitious set of environmental objectives, including a 75% reduction in emissions of 29 priority compounds and a 50% reduction in emissions of other chemicals, by the year 2005. Dow fully expects a 30% to 40% return on its investment.¹⁰ Proactive corporate environmental policies reflect a growing realization that the objectives of sustainable environmental development and industrial progress are much the same—they both include maintaining growth and improving quality; satisfying the

basic needs of life such as jobs, food, energy, water, and sanitation; conserving and enhancing the natural resource base from which many industries derive inputs; reorienting technology; and managing risk. As world population grows, resource use must be redefined and redirected, a mandate with both fundamental environmental implications and enormous business opportunities.

2.2. The Limitations of Regulatory Controls

A second force driving industry's search for solutions to air pollution problems is the growing realization in both government and the private sector that regulation alone is unlikely to achieve the air quality objectives that are essential for sustainable development in the 21st century. Until recently most people believed that environmental management was mainly the responsibility of government and environmental regulations proliferated as public demands on government grew to remedy the adverse environmental effects of industrialization. In the United States and many other industrialized countries, however, environmental legislation was adopted piecemeal, creating a complex regulatory process. In 1970 there were about 2,000 federal, state, and local environmental rules and regulations in the United States; today there are more than 100,000. Environmental regulations are listed in over 789 parts of the Code of Federal Regulations. A command-and-control system for environmental management became the foundation for scores of environmental, health and safety programs and thousands of federal, state and local standards, regulations, and guidelines within which businesses must operate. This complex system imposes tremendous compliance burdens on corporations and especially on small- and medium-sized firms.

In the United States, the Federal government has steadily increased its enforcement of environmental regulations making business executives and owners liable for environmental pollution. The U.S. Environmental Protection Agency takes hundreds of enforcement actions against businesses every year leading to prison sentences and heavy fines. But regulatory enforcement is expensive for both government and business. The total costs of complying with environmental laws over the past 25 years have easily exceeded \$1 trillion. About \$120 billion is spent annually for pollution abatement and control. Current estimates of compliance costs under the new Clean Air Act

Amendments alone are on the order of \$50 billion a year. Many companies will spend hundreds of millions of dollars on environmental projects over the next few years simply to stay abreast of current environmental regulations.

Clearly, sound and well-enforced regulations have brought tremendous progress in reducing air and water pollution and toxic hazards in North America, Western Europe, and other regions of the world. As Table 1 indicates, air pollution has been reduced significantly in the United States over the past 25 years. These reductions in air pollution are all the more remarkable because they occurred during a period in which population increased by 28%, vehicle miles traveled rose by 116%, gross domestic product grew by 99%, and most Americans attained a higher quality of life.

Table 1

Common air pollutants U.S. air pollution emissions 1970-1995

Pollutant	Million Short Tons Annually		
	1970	1995	Change
Carbon monoxide	127	90	-28%
Nitrogen dioxide	24	25	+6%
VOC's	31	24	-25%
PM-10	15	3	-79%
Sulfur dioxide	30	21	-41%
Lead	225	10	-98%

Source: U.S. Environmental Protection Agency, National Air Quality and Emissions Trends Report, Washington, DC: U.S. EPA, 1995.

But the steady proliferation of regulations and the continuing expansion of an already complex regulatory system has made enforcement more expensive and marginally less effective. The continuous tightening of environmental laws in piecemeal fashion in the United States has placed more sophisticated and costly burdens on state and local governments. Rarely, however, have national or state lawmakers fully understood or

reassessed the cumulative effects of their environmental regulations.

Unfortunately this reliance on constantly changing regulations may simply produce a temporary false sense of security, since controls require add-on technologies that must be replaced or modified every time regulations change or new ones are added. Under a command-and-control system businesses are constantly struggling to comply. And both scientists and corporate environmental managers are discovering that the complex command-and-control approach to environmental protection, which often addresses only one environmental medium at a time, can merely be an expensive way of moving pollutants around. Water treatment often results in the collection of hazardous wastes or toxic sludge that must be deposited on land or incinerated and returned to air in some form. Air controls often depend on liquids and gases which must be treated and disposed of through water or land.

The growing complexity of environmental regulation and the all too common technical inefficiencies and administrative weaknesses of command-and-control systems have spawned increasing interest in pollution prevention. Governments everywhere have limited financial resources to monitor pollution and enforce regulations even in the best of economic times, but the continued reliance on regulatory controls keeps bidding up the costs. In every country governments must struggle to oversee and enforce environmental laws. Consequently, governments are under growing pressures to motivate the private sector to become proactive through market mechanisms and pollution prevention programs.

2.3. Changing Business Practices

A third force that is creating positive pressures for industry to reduce air pollution are changes in business practices (see Table 2). The traditional business traits of *individuality, independence, hierarchy, local markets, and limited communication* are giving way to corporate strategies that emphasize *community, interdependence*, that they cannot survive unless they adopt the environmental values of the community.¹¹ Although every business has a fiduciary responsibility to shareholders, it must also answer to a broader audience of stakeholders, including owners, employees, customers, regulators, suppliers, competitors, community interest groups, and the media.

Table 2

Changing profile of general business practice

Traditional Business Traits	Emerging Business Traits
Individual----->	Part of a Community
Independence----->	Interdependence
Hierarchy----->	Networks
Local or Regional Markets----->	Global Markets
Crisis and Cost----->	Proactive-Investing in the Future
Maximized Profits----->	Sustained Business
Quantity-Price----->	Quality-Value
Limited Communication----->	Immediate Global Communication
Supply and Inventory----->	"Just in Time" Delivery and Service

As the global economy becomes more integrated, corporations inevitably become part of a network or a "value chain" that constitutes a worldwide system of exchange. In the network, information, raw materials, goods, services, and even pollution and wastes are moved around in the process of generating revenue and creating wealth. For a business to be part of a network, it must abide by broader environmental protection standards—examples in the United States include the chemical industry's adoption of the "Responsible Care" Program, the carpet industry's testing and labeling program, and the electronics industry's move away from chemicals that contribute of stratospheric ozone depletion and global warming.

Because of the enormous improvements in communication and transportation systems, business networks are expanding rapidly. This network expansion connects virtually every business to the "global village" and its market. The rapidly expanding global consensus that environmental protection is crucial for survival is reflected in the environmental requirements of international trade agreements that have steadily grown over the past 50 years. Those corporations that seek access to the global market must be prepared to meet international environmental performance expectations.

A basic principle of the market asserts that when people have access to information they make better choices. The tremendous advances in communication technology make it possible to observe and communicate with every region of the world almost instantly. The information age makes it possible to acquire information on virtually any subject, including environmental pollution, in a matter of minutes. More information means more choices and consumer demands. A business must keep up with changing demands for better environment performance or risk the loss of market share. One of the benefits of rapid communication and transportation, for example, is just-in-time delivery of goods and services, a practice that is good for both business and the environment. JIT systems reduce the environmental costs associated with over-production, inventory management, spoilage, and disposal.

Business' traditional objective has been to *maximize profits*. As global competition becomes more intensive, corporations must develop quality-based management competencies that are now essential for long-term business success. The strengths emphasized in a quality-based management system are conducive to positive and proactive environmental performance and overall business success.

Leadership. Quality management begins at the top of successful organizations in the form of strong leadership. Leaders set the tone, commitment and high standards for environmental responsibility and performance. When there is a strong and consistent vision of environmental performance from the top, quality-based businesses almost always demonstrate exemplary environmental performance.

Intense Customer Focus. In quality-based management there is always an intense focus on customer needs and values. If customers value the quality of the environment, so will the quality-based business.

Proactive Environmental Behavior. Almost always in a well-managed organization there is a clear environmental policy and a process within the company of complying with environmental regulations and using pollution prevention strategies.

Valuing Human Resources. In quality-based organizations there is a tendency of management to use fully the creative abilities of employees, suppliers, and customers to arrive at strategies and solutions to all problems including environmental management issues. The various environmental values held by stakeholders motivate improved

environmental performances of the organizations that allow them to participate in decision-making and problem solving.

Management By Fact. In quality-based organizations decisions are based on good science and factual information. Quality-based organizations know where they stand in relation to the business world and the natural environment. Products and services are fashioned through careful analysis and by building on knowledge and experience within the company.

Creativity and Flexibility. In quality-managed organizations there is much thinking "outside of box". Managers realize that the business faces different threats and opportunities at different times. The quality-based organization excels at maximizing the different inherent capabilities of the organization to be successful.

Quality Over Cost. Although cost-efficiency is always a concern, well-managed organizations emphasize quality-seeking ways of managing environmental pressures, internalizing environmental values, and meeting customer demands simultaneously.

Constancy of Purpose. Businesses that focus on quality constantly improve the business process including their environmental performance. Environmental performance is often used as a service to customers, as a means of protecting existing the existing customer base, and as a way of diversifying and expanding market share

Win-Win. In quality-based organizations all stakeholders are winners. The win-win management philosophy produces a culture based on civility, where environmental values are respected. The win-win strategy often leads to economies and opportunities both for stakeholders and for the corporation.

Quality Tools, Technology, and Systems. The success of a company's environmental management program depends on using and developing economically viable operating systems. Logistics, for example, is critical to business efficiency but is also critical to reducing pollution. Less wasteful new technology and quality systems make businesses more accessible to existing customers, more attractive to potential new customers, and more efficient in pollution prevention.

Quality management principles require firms to shift their goals from maximizing profits by manipulating quantity and price to sustaining profit growth by adopting an intense customer focus, continuous improvement, and error and waste reduction.

2.4. International Standards of Environmental Performance

The fourth factor driving greater industry participation in finding solutions to air pollution problems in the 21st century are international pressures to adopt voluntary standards that emphasize the integration of environmental management and corporate strategy. For example, the American Society for Testing and Materials (ASTM) is making headway in standardizing environmental auditing, assessment, and criteria for investment and insurance. British standard BS7750 was an industrial response to the adoption of the 1990 Environmental Policy Act in Great Britain that has been widely adopted internationally. The European Community has issued a Standard Eco-Management and Audit Scheme (EMAS), which member nations are expected to implement. Through these international standards, firms are finding that it is better to make a product right the first time and save the cost of re-work later; that it is cheaper to prevent a spill in the first place than to clean it up; and that it is more cost-effective to prevent air pollution rather than to control emissions.

The ISO 14000 series is likely to become the dominate international standard for environmental management systems. These standards seek to integrate environmental and corporate management systems. Integrated management systems help firms identify the causes of environmental problems and eliminate them. The 14000 series includes standards for environmental management systems, environmental auditing, environmental labeling, performance evaluation, life cycle inventory and assessment, and environmental aspects in products.¹² As companies become certified under the new standards they are finding many business benefits, including improved environmental performance, reduced liability, lower costs, better access to capital, fewer accidents, more employee involvement, improved public image and enhanced customer trust.

3. INDUSTRIAL RESPONSES TO IMPROVING AIR QUALITY AND ENVIRONMENTAL SUSTAINABILITY

All four of these forces - changing business perceptions of the environment, the limits of regulatory control, changing business practices, and international standards of

environmental performance - are stimulating corporations in a wide range of industries to find more effective ways to reduce or eliminate air pollution. Three responses are likely to intensify in the 21st century: (1) the adoption of proactive environmental management systems focused on pollution prevention; (2) innovations in pollution reduction and control technology, and (3) dissemination of pollution prevention and control technology through international trade and investment.

3.1. Proactive Environmental Management

Truly effective environmental protection requires the prevention of air pollution rather than the control of emissions. Pollution prevention uses materials, processes, or practices that reduce, minimize, or eliminate pollutants or wastes at the source. Pollution prevention technologies in manufacturing include materials substitution, process modification, materials reuse within existing processes, materials recycling to a secondary process, and materials reuse within a different process.¹³

Increasing legal liabilities and rising costs of emission control have become driving forces for corporations to find more effective ways of preventing pollution. Cutting-edge corporations in the United States and around the world are using five major approaches to proactive environmental management that in combination form a comprehensive pollution prevention program: (1) full cost accounting; (2) waste minimization; (3) demand-side management; (4) design for environment; and (5) product stewardship.

The use of full cost accounting (FCA) is beginning to reshape the concept of environmental accounting. Corporations like Dow Chemical, DuPont, and Ciba Geigy use FCA to identify, quantify, and allocate the direct and indirect environmental costs of ongoing operations.¹⁴ FCA identifies and quantifies environmental performance costs for a product, process, or project including direct costs, the hidden costs such as monitoring and reporting, contingent liability costs, and intangible costs such as public relations and good will.

In the 1980's many corporations began focusing on, anticipating, and preventing waste problems before they occurred.¹⁵ By the end of the 1980's waste minimization programs had been adopted by a diverse group of U.S.-based MNC's such as Allied Signal, General Dynamics, Dow Chemical, Chevron, Boeing, AT&T, Amoco, General Electric,

IBM, Polaroid and Xerox.¹⁶ Most successful businesses were voluntarily performing internal environmental compliance audits to identify and correct their environmental liabilities, demonstrate good faith effort, and reduce government pressures. More important, the voluntary audits forced businesses to evaluate operating systems, identify the actual cost of controls, and develop environmental performance strategies to eliminate liabilities altogether. Waste minimization is a powerful business strategy because it encourages the efficient use of raw materials and reduces the costs of waste. But most companies minimize wastes because it provides competitive advantages and satisfies customers' needs. In the process, companies often learn how to control pollution better than the regulators and at lower cost.

Demand-side management is an approach to pollution prevention that originated in the utility industry, but has spread to other industries as well. It focuses on understanding customers' needs and preferences and on their use of products. It seeks to minimize or eliminate wasted product, to sell customers exactly what they demand, and to make the customer more efficient in the use of the product. Demand-side management forces an industry to look at itself in a new light which often leads to the discovery of new business opportunities. In the case of the utilities, demand-side thinking emphasized that companies are not primarily in the business of selling electricity or gas, or even light or heat, but are really in the business of selling environmental conditions such as comfort, brightness, and conveyance.

Design for environment (DFE) is also becoming an integral part of pollution prevention in proactive environmental management. Corporations such as AT&T, Xerox, Hewlett Packard and Baxter International are finding that it is far more efficient to design products for disassembly, modular upgradeability, and recyclability at the outset than to deal with disposal problems at the end of a product's life.¹⁷ Procter & Gamble's objective is to "design manufacturing waste out" of business areas that account for at least 50% of its production volume by the beginning of 1998. DFE reduces reprocessing costs and returns products to market more quickly and economically.

Product stewardship is yet another concept taking hold in industrial countries seeking to curtail air pollution and solid and liquid wastes. Companies such as Dow Chemical, Procter & Gamble, and Scott Paper are responding by using product life cycle analysis

(LCA) to determine ways of reducing or eliminating wastes at all stages -- from raw materials acquisition, production, distribution, and customer use to waste reclamation, recycling, reuse, and disposal.¹⁸ Japanese universities and research institutes are applying LCA to a wide range of products from aluminum cans, automobiles, and office buildings to vending machines, washing machines and steel alloys.¹⁹ Firms serious about product stewardship seek alternative products and applications that are less polluting and alternative materials, energy sources, or processing methods that eliminate waste; compare the cost of managing for conformance versus for assurance; and adapt to customers' needs, preferences and uses of products.²⁰

3.2. Technological Innovation

Inherent in proactive environmental management has been the search for new technologies, processes, systems, equipment, and know-how that reduce or control pollution more effectively. Air pollution in urban areas, for example, reflects more than poorly maintained automobiles; it points to infrastructure and market place breakdown. Entrepreneurial firms see business opportunities in the form of less polluting durable goods especially cars and trucks, mass transit, cleaner fuels, and efficient materials handling. Diesel engine makers such as Varity Perkins in the United Kingdom, for example, are developing new sealing technologies and using computer simulations to market a zero-pollutant engine.²¹

Technological innovation is the key to the environmental progress required for sustainable development. Effective regulatory compliance depends on businesses having access to effective and affordable processes and equipment to meet environmental standards. Pollution prevention is based on process or technological changes that reduce and eliminate waste. By assessing its product and processing technologies, SC Johnson & Son, for example, was able to cut manufacturing waste nearly in half, reduce the use of virgin packaging materials by more than 25%, and reduce volatile organic compound (VOC) use by 16% between 1990 and 1995.²² Its product stewardship projects produced environmental benefits in its plants around the world.

Corporations in a wide range of industries are developing and adapting commercially viable new technologies for pollution control and prevention that are not only used

internally but developed into new products and services. Enlighten firms view pollution reduction and control as business opportunities. New technologies and processes are being developed for input substitution, product reformulation, product unit redesign, product unit modernization, improved operation and maintenance, and internal recycling and reuse.²³

Many firms are developing and adapting process innovations to reduce noxious and toxic emissions. The survey of 256 large and small firms in the United States mentioned earlier found that more than 60% of the firms used improved process technology or new process technology, and about 58% reported using new product technology to prevent pollution.²⁴ The Olin corporation, a specialty chemicals, metals and aerospace products corporation, for example, substantially reduced air emissions of carbon tetrachloride by applying technologies that reclaim the material for reuse in several of its production processes. It also achieved 80% reductions of 1,1,1-trichloromethane by altering its overall production processes to wash parts using water-based cleaners instead of chlorinated solvents.²⁵ Dow Chemical is replacing CFC's and other volatile organic compounds in the manufacture of high volume commercial foam products. Canadian industries have found ways of eliminating halogenated degreasing solvents to reduce the volume of hazardous wastes requiring disposal and eliminating VOC emissions.²⁶

Much of this technological innovation has been driven by regulatory requirements, but in many industries corporations are seeing strong business opportunities in the demand for environmentally sustainable development. The adoption of waste minimization strategies has stimulated computer design processes and new software, expert systems, and comprehensive data bases that integrate waste minimization requirements into process design and plant restructuring. Firms are developing new retrosynthesis- and computational chemistry-based techniques that will make pollution prevention far easier in the chemical industry.²⁷ The technological innovation accompanying the search for environmentally sustainable development is not constrained to North American and Western European firms. Russian scientists have created an air pollution control called Pulsatech that can destroy polluting molecules from industrial smokestacks using specially generated high-frequency, high-voltage pulses within a reaction chamber.²⁸

3.3. Technology Diffusion and Transfer

One of the most effective ways of controlling air pollution and progressing toward environmental sustainability is for companies with effective and efficient pollution prevention and control technologies to commercially diffuse them in international markets. In many of the former socialist and developing countries of the world, significant reductions in air pollution will occur only when indigenous industries have access to highly-effective technologies at a reasonable cost. The Brazilian state petroleum company (Petrobras), for example, by investing \$1 billion in sulfur reduction technologies at five refineries, is now able to distribute low-sulfur (maximum 0.3 wt %) diesel fuel that can improve air quality and vehicle performance in highly polluted Brazilian cities.²⁹ The new low-sulfur diesel will cut sulfur emissions by 900 tons a month in the State of Sao Paulo alone. Diffusing and transferring these technologies from industries that have developed them in North America and Western Europe to developing nations and emerging markets is a win-win solution; it earns revenues for the exporting firms and assists importing firms to reduce noxious or toxic air emissions.

The worldwide market for environmental technology and services is large and growing rapidly. In 1994 the global market for environmental goods and services was estimated at \$408 billion and it was projected to grow to more than \$572 billion by the year 2001.³⁰ The air pollution control segment of the market was more than \$26 billion in 1994 and if it retains its share of the overall market can be expected to reach nearly \$38 billion by the year 2001. In 1997, the world market for particulate systems and parts was forecast to exceed \$6.7 billion, for gas treatment systems and parts to exceed \$8.3 billion, and for other air pollution equipment and services to exceed \$4.7 billion.³¹

Additional opportunities are inherent in other process and prevention technologies, instrumentation, monitoring, and energy technologies not reflected directly in air pollution control market estimates. Although in North America and Western Europe the annual growth in markets for environmental protection technologies and services have stabilized at from 4% to 5% on average, demand in Asia is estimated to be growing at 17% to 20% a year, in Latin America from 12% to 15% a year, and in Africa at about 10% annually. As the economies of Central and Eastern European countries begin to recover and expand, and as their governments seek membership in international trade

organizations, demand for air pollution and other environmental technologies is likely to grow steadily.

4. CONCLUSIONS

As we enter the 21st century, many old business attitudes toward the environment are changing rapidly (see Table 3). The traditional business attitude that industries could "*conquer nature*" and use the environment without limit is rapidly giving way to a strategy that "*conserves nature*." Not too long ago pollution was viewed as a symbol of a strong industrial base and as an unimportant diseconomy. Today pollution is used to measure error and waste. Pollution is increasingly seen as a symbol of poverty, ignorance, mismanagement and industrial inefficiency. Command-and-control regulations framed environmental management as a cost to industry that reduced profit margins. Today many businesses advertise environmental protection as a corporate *value* and operate *beyond compliance* often by *voluntary standards*.

Table 3
Changing business attitudes toward the environment

<u>Traditional Attitude</u>	<u>Emerging Attitude</u>
Command and Control Regulation----->	Voluntary Standards
Regulatory Compliance----->	Beyond Compliance
Conquer Nature----->	Conserve Nature
Pollution: An unimportant diseconomy-->	Pollution: A measure of error and waste
Business uses the environment-----> without limit	Business depends on a healthy environment to sustain business
Environment is an "Issue"----->	Environment is a 'Value'
Environmental protection as a business cost----->	Environmental protection as a business opportunity
Pollution as a symbol of a-----> strong industrial base	Pollution as a symbol of poverty, ignorance, industrial inefficiency, social instability, and mismanagement

Many businesses are embracing environmental management as a rapidly growing business opportunity. By integrating business objectives and environmental values, corporations can enhance their environmentally responsible reputation, create more valuable goods and services, and attain a stronger market position.

There is no longer much disagreement about whether or not the environment should be protected; the dialogue now centers on how to achieve environmentally sustainable development. As we embark on a new century, corporations are building on the creative potential of the market to find new solutions to environmental problems (see Table 4). While there will always be the need for an appropriate level of environmental regulation, proactive corporate environmental management and pollution prevention can make the greatest contributions to sustainable development. Progress will depend on cooperation among governments, corporations, environmental groups, and consumers to convince a larger number of businesses that it is far less costly to prevent pollution than to clean it up.

The spread of pollution prevention and proactive environmental management practices will also depend, however, on the adoption of new and more flexible government regulations. In order to advance the cause of pollution prevention, governments and the public must clearly recognize that there is no such condition as "zero risk." Risk-free management philosophies must be replaced with "acceptable risk" concepts; the principle of "control regardless of cost" must be replaced with "control in relation to benefit." As more corporations use pollution as a measure of waste and business inefficiency, regulations mandating the use of control technology must give way to those allowing companies to seek less polluting process modifications or replacements. Source by source control must be replaced by more efficient and less expensive industrial performance standards.

Table 4
Changing environmental management strategies

Past or Present Strategy	Present or Emerging Strategy
Environmental quality management----->	Pollution prevention
Local ambient environmental----->	Environmental Effects:Indoor,local, concerns and effects regional, and global
Control regardless of cost----->	Control in proportion to benefit
Control technology----->	Process replacement or modification
Air, water, land assessed and----->	Air, water, land assessed and managed as managed as independent media an integrated system
Local and national control ----->	Global pollution control strategies and strategies for pollution and effects international agreements
Standards and emission limitation----->	Tradable emission allowances permits
Source by source control----->	Industry performance standards
Zero risk----->	Acceptable risk

Government has an important role to play in helping businesses find a economic advantage in operating beyond regulatory compliance. It can help firms discover that when manufacturing processes generate less waste, profit margins often increase and pollution control costs decline. Regulatory permitting should be changed so that it works more efficiently, encourages innovation, and creates more opportunities for stakeholder participation. Regulations must be reconstructed to give industry the incentives and flexibility to develop innovative technologies that meet or exceed environmental standards while cutting costs.

The U.S. Environmental Protection Agency's "Common Sense Initiative" is an example of the types of programs government can use to support proactive corporate environmental management.³² Under the initiative, the EPA reviews existing environmental regulations to identify opportunities to get better environmental results at less cost and seeks improved rules through increased government, business, and stakeholder coordination. The program promotes pollution prevention as a standard business practice and the central ethic of environmental management. It establishes systems that make it easier to create, find, use, and disseminate pollution and

environmental management information. It creates incentives to assist businesses that want to obey or exceed legal requirements and, at the same time, it applies harsh penalties to competitors who seek an advantage in breaking the law.

Governments must also adopt market-driven policies for reducing pollution. These include tradable permits and emission trading through which companies can buy and sell, for example, sulfur emission allowances on the open market, a mechanism that is currently being used in the United States to reduce acid rain. More flexibility is needed to allow companies to replace one form of pollution control with another when it achieves overall environmental goals.

In brief, the intensification of all three emerging trends—the adoption of proactive environmental management and pollution prevention practices, the pursuit of technological and process innovation in industry, and the transfer and diffusion of pollution control and prevention technologies through international trade and investment—can give business a central role in improving air quality and attaining environmentally sustainable economic development during the 21st century. But to accomplish this goal, governments and businesses must work together in new partnerships that seek to attain sustainable environmental objectives in ways that benefit both the public and the private sector and that allow businesses to satisfy the needs of consumers.

REFERENCES

1. Jane Vise Hall, "Air Quality in Developing Countries," *Contemporary Economic Policy*, Vol. 13, No. 2 (1995): 77-85.
2. Peter Bartelmus, *Environment, Growth and Development -- The Concepts and Strategies of Sustainability*, New York: Routledge, 1994.
3. Michael A. Berry and Dennis A. Rondinelli, "Proactive Corporate Environmental Management: A New Industrial Revolution?" Working Paper, Chapel Hill, NC: Kenan Institute of Private Enterprise, University of North Carolina at Chapel Hill, 1997.
4. McKinsey & Company, "The Corporate Response to the Environmental Challenge," Summary Report, Amsterdam, The Netherlands: McKinsey &

- Company, 1991.
5. Richard Florida, "Lean and Mean: The Move to Environmentally Conscious Manufacturing," *California Management Review*, Vol. 39, No. 1 (1996): 80-105.
 6. Margaret G. Kerr, "Looking at Environmental Management through the Lens of Quality," press release, Mississauga, Ontario, Canada: Nortel, 1995.
 7. Eastman Kodak Corporation, Health, Safety and Environment 1995 Report, Rochester, NY: Kodak, 1996.
 8. Amal Kumar Naj, "Some Companies cut Pollution by Altering Production Methods," *The Wall Street Journal*, (December 24, 1990): 1, 28.
 9. Dave Lenckus, "Taking Initiative to Prevent Pollution Can Reduce Premiums," *Business Insurance*, (November 11, 1996): 30.
 10. William H. Miller, "Making Pollution Prevention Pay," *Industry Week* (May 20, 1996): 136L.
 11. Michael A. Berry, Dennis A. Rondinelli and Gyula Vastag, "Nitrokemia's Environmental Communications Strategy: Building Public Trust through Effective Communications," *Corporate Environmental Strategy*, Vol. 4, No. 1 (1996): 73-79.
 12. See Dennis A. Rondinelli and Gyula Vastag, "International Environmental Management Standards and Corporate Policies: An Integrative Framework," *California Management Review*, Vol. 39, No. 1 (1996): 106-122.
 13. Thomas W. Zosel, "Pollution Prevention in the Chemical Industry," in David S. Ederly (ed.) *Opportunities for Innovation: Pollution Prevention*, (Washington, DC: U.S. Department of Commerce, National Institute of Standards and Technology, 1994):13-25.
 14. Elizabeth Kirschner, "Full Cost Accounting for the Environment," *Chemical Week*, Vol. 154, No. 9 (1994): 25-26.
 15. Kathi Futornick, "Government and Industry Programs for Reducing Pollution," in Thomas E. Higgins (ed.) *Pollution Prevention Handbook*, (Boca Raton, FL: Lewis Publishers, 1995): 15-42.
 16. Robert P. Bringer and David M. Benforado, "Pollution Prevention and Total Quality Environmental Management: Impact on the Bottom Line and Competitive Position," in Rao V. Kolluru, *Environmental Strategies Handbook*, (New York: McGraw Hill, 1994): 165-197.
 17. Robert B. Shelton and Jonathan Shopley, "Improved Products Through Design for Environment Tools," *Prism*, First Quarter (1996): 41-49.
 18. Patricia S. Dillon and Michael S. Baram, "Forces Shaping the Development and

- Use of Product Stewardship in the Private Sector," in Fischer and Schot, *Environmental Strategies for Industry*, pp. 329-341.
19. David J. Hunkeler and Ellen A. Huang, "LCA in Japan: A Survey of Current Practices and Legislative Trends and Comparison to the United States," *Environmental Quality Management*, Vol. 6, No. 1 (1996): 81-91.
 20. Carl C. Henn and James A. Fava, "Life Cycle Analysis and Resource Management," in Rao V. Kolluru (ed.) *Environmental Strategies Handbook*, (New York: McGraw Hill, 1994): 541-641.
 21. Unsigned article, "Diesel Makers Take Next Step toward Sealed-for-Life Zero Emissions Engine," *Machine Design*, Vol. 69, No. 1 (1997): 32-35.
 22. SC Johnson & Son, Inc., 1990-1995 Sustainable Progress Report, Racine, Wisconsin: SC Johnson and Son, 1996.
 23. Christopher J. Keyworth, "Integrating Pollution Prevention and Environmental Management Programs," *Environmental Manager*, Vol. 1 (August 1995): 18-24.
 24. Richard Florida, "Lean and Green: The Move to Environmentally Conscious Manufacturing," *California Management Review*, Vol. 39, No. 1 (Fall 1996): 80-105.
 25. U.S. Environmental Protection Agency, "Design for the Environment (DfE) Current Projects," Washington, DC: U.S. EPA, 1995.
 26. Brian Kishbaugh and Orlando Martini, "Companies Get Proactive About Pollution Prevention," *PEM: Plant Engineering & Maintenance*, Vol. 18, No. 5 (1995): 16.
 27. G. Sam Samdani, "Cleaner by Design," *Chemical Engineering*, Vol. 102, No. 7 (1995): 32-37.
 28. Unsigned article, "Russian Device Zaps Smokestack Pollution," *Machine Design*, Vol. 68, No. 10 (1996): 28-29.
 29. Unsigned article, "New Low-Sulfur Diesel Debuts in Brazil," *Oil & Gas Journal*, (December 16, 1996): 22-23.
 30. Environmental Business International, "The Global Environmental Market and United States Environmental Industry Competitiveness," Washington: U.S. Environmental Protection Agency, 1996.
 31. Robert W. McIlvaine, "The Air Pollution and Municipal Waste Forecast in 1997," *EM* (January 1997): 34-38.
 32. U.S. Environmental Protection agency, "The Common Sense Initiative: A New Generation of Environmental Protection," Policy Paper, Washington, DC: U.S. EPA, 1994.