Context and Conceptual Framework 3

New questions have emerged in the debate about environmental concerns and industrial competitiveness that suggest a need to re-examine traditional views. Will environmental concerns in time fundamentally alter the way in which business is done? Will concepts like sustainable development come to have a major influence on the way in which development decisions are made? To what extent will environmental needs influence the dynamics of the market? What are the risks for companies—and countries-that fail to accurately gauge the dynamics of this market? What impact will more stringent environmental regulations have for manufacturing industry competitiveness, especially for countries with stronger regulations than their competitors? What, if anything, needs to be done to address the linkages between environmental policy and competitiveness? And what implications do such issues have for jobs and employment? Such questions, while not lending themselves to hard and fast answers, will need to be addressed in the competitive strategies of companies and countries; just as surely, the competitive impacts and commercial implications of environmental policy choices will confront policy makers more and more.

This chapter begins with a discussion of global environmental trends and the likely implications of these trends for both the environmental goods and services industry, and for manufacturing firms generally. A conceptual framework depicting the relationship between environmental and economic factors illustrates the growing importance of environmental considerations in business. This is followed by presentation of a classification of the environmental goods and services industry (specific cases are taken up in detail in ch. 5). The next section explores relationships between environmental issues and economic com-

U.N. DEVELOPMENT PROGRAMME/WORLD BANK

Finding ways to boost living standards for the world's poor while avoiding environmental damage is a critical challenge for sustainable development.

petitiveness. OTA has focused on environment and competitiveness in manufacturing, drawing on examples (discussed in subsequent chapters) from such sectors as chemicals, pulp and paper, and metals finishing. The interactions between environmental regulations and competitiveness could be quite different if other sectors—agriculture and forestry, extractive industries (e.g., mining, energy extraction)--were considered.[1] The concluding section reviews the linkage between environmental and industrial policies.

GLOBAL ENVIRONMENTAL TRENDS

Making economic development and environmental protection more compatible will be a critical challenge for a human population likely to more than double in the next 100 years. Findings from the World Commission on Environment and Development (the Bruntdland Commission), the 1992 United Nations Conference on Environment and Development, and a host of reports emanating from such bodies as the World Bank, the Organization for Economic Cooperation and Development, and the Business Council for Sustainable Development, have warned that a continuation of current patterns of economic growth could result in levels of environmental degradation severe enough to jeopardize the ability of future generations to meet basic needs.

Global environmental problems, including loss of biodiversity, climate change, and stratospheric ozone depletion, have become increasingly important. Problems of air and water pollution and toxic waste disposal are common in all industrialized nations. In developing nations, millions lack access to sanitation services and safe drinking water, while dust and soot in air contribute to hundreds of thousands of deaths each year.[2] Moreover, serious damage from pollution and overuse of renewable resources challenge world fisheries, agriculture, and forests, with significant adverse effects for productivity and biological diversity.

At the same time, an improved standard of living is a critical need for a substantial portion of the world's population. As a result, the key issue is not whether there should be additional growth, but rather how to achieve it without thwarting important social, economic, and environmental goals.[3]

The relation between environmental damage and economic growth is complex. Pollution and environmental damage are a result of the size of the population, per capita income levels, and the amount of environmental damage associated with each unit of gross domestic product (which depends on the level of emissions of the production technology itself and the level of pollution treatment and control).

Population growth and per capita income growth will put new strains on the global environment. In 1960, the world's population was about

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[1] OTA is currently conducting a study of agriculture, trade and the environment scheduled for completion in late 1994.

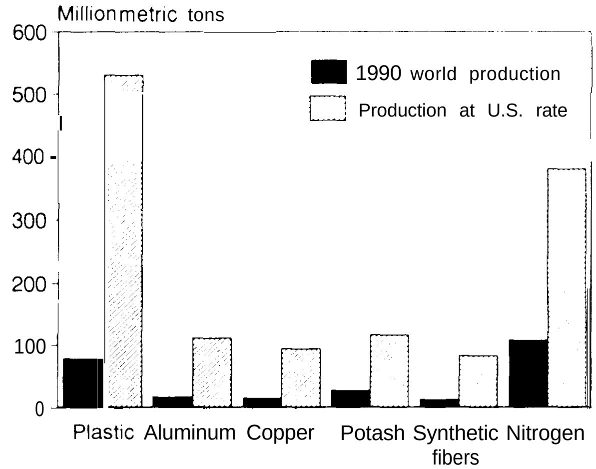
[2] For discussion, see U.S. Congress, Office of Technology Assessment *Development Assistance, Export Promotion, and Environmental Technology, OTA-BP-ITE-1O7* (Washington DC: U.S. Government printing Office. August 1993).

[3] World Resources Institute, in collaboration with the United Nations Environment Programme and the United Nations Development Programme, *World Resources, 1992-1993: A Guide to the Global Environment (New* York, NY: Oxford University Press, 1992).

3 billion; today, it stands at 5.3 billion and, according to the World Bank, could grow to roughly 9 billion-a 70 percent increase by 2030 under a midrange forecast. Moreover, global per capita incomes are estimated to increase by over 80 percent between 1990 and 2030, and developing country per capita incomes may grow by 140 percent.[4] As a result, by 2030, world economic output could, by one projection, grow to as much as $69 trillion, 3.5 times more than presents If pollution rose in step with this projected development, according to the World Bank, the result would be appalling environmental and human costs, Figure 3-1 projects the increase in production of key materials that would be needed if all of the world's current population were to enjoy a per capita consumption level equivalent to that in the United States.

Since continued population growth seems likely and since income growth for a substantial fraction of the world's population is essential, reducing the amount of environmental damage for each added unit of world product (or, as one analyst put it, per unit of human advance[6]) will be crucial. In fact, to simply hold steady at the current level of environmental damage, significant reductions in damage intensity will be needed. Some of this may occur if the expected growth in the developing nations is less materials-intensive and polluting than current economic activity in developed nations. Even given differences in types of growth, however, economic activity overall will have to become less environmentally damaging if we are to hold constant or have only small increases in total environmental damage.

Figure 3-l-World Production of Materials Needed To Match U.S. Per Capita Consumption



SOURCE: U.S. Bureau of Mines

The intensity of damage could be reduced through existing technologies and approaches that use resources more efficiently (e.g., energy conservation, recycling and reuse of materials and products, and more efficient operation of existing industrial equipment).[7] Technological evolution often results in new generations of technology that use materials or energy more efficiently than their predecessors (see table 3-l). One study concluded:

> In a surprising number of cases, the technologies that lead to increased material-efficiency and reduced emissions are also the most economically efficient. The somewhat ironic effect is that a robust and competitive economy encouraging new investment in plant and equipment can lead to a decline, instead of an increase, in the deleterious environmental and health effects of economic activity.[8]

[4] Calculated from data contained in the World Bank, *World Development Report, 1992* (Washington DC: World Bank, 1993).

[5] Ibid., p. 32.

[6] See Robert S. McNamara, 'A Global Population Policy to Advance Human Development in the 21 st Century, ' Rafael M. Salas Memorial Lecture, United Nations, New York, Dec. 10, 1991.

[7] See U.S. Congress, Office of Technology Assessment, *Green Products by Design,* OTA-E-541 (Washington, DC: U.S. Government Printing Office, October 1992).

[8] Henry C. Kelly, Peter D. Blair, and John H. Gibbons, "Energy Use and Productivity: Current Trends and Policy Implications,' *Annual Review of Energy,* Jack M. Hollander, cd., vol. 14, 1989, p. 333.

Table 3-1—Examples of Technological Evolution Leading to More Efficient Use of Energy and Materials

Lumber mills	Computer-assisted selection of saw lines during milling can increase lumber yields by 20 percent, permit sawing to higher grades, and reduce round wood requirements.
Pulp and paper mills	Press drying technology can increase burst and tensile strength needed in some applications, while saving 20 percent on energy. Extended rooking and ozone delignification of pulp can significantly reduce bleaching needed, lowering organo-chlorine emissions, including dioxin.
Paints and coatings	Higher solid content paint can cover more space with less volatile organic compound emissions than conventional paints, while water-based coatings can eliminate VOC emissions.
Polyethylene production	Low pressure polyethylene production saves energy and avoids use of solvents and minimizes costly separation steps relative to high pressure methods.
Steelmaking	Basic oxygen furnaces and increased use of electric furnaces in mini-mills reduce pollutants compared to open hearth furnace steelmaking. Continuous and thin slab casting reduces energy use through increased yields. The development and introduction of cokeless steelmaking offers potentially greater reductions in pollution.
Computerized process controls	Applied to a variety of manufacturing processes, better controls increase efficiencies and overall yields.
Fiber optics	Optical cables use far less material than copper cables per unit of communication. Furthermore, environmental damage from copper mining and smelting can be avoided.

SOURCE: Office of Technology Assessment, 1993.

Of course, this is no hard and fast rule. Many technological innovations have greater impacts on the environment than the systems they replaced.

With stepped up efforts, cleaner manufacturing processes and technologies that produce fewer emissions and are more efficient from a materials and energy standpoint may become available sooner. Also, environmental matters are being addressed earlier in the design of products.[9] (See box 3-A). Reducing the use and emissions of toxic chemicals will have to be a special focus of such technology developments, since toxic chemical emissions tend to increase with greater national per capita income.[10]

Finally, environmental health depends not only on new and more efficient production processes, but also on the degree to which residual pollution is controlled. Countries that are members of the Organization for Economic Cooperation and Development (OECD) have spent, on average, between 0.8 and 1.5 percent of Gross National Product (GNP) on environmental improvement over the last 20 years. Developing nations have invested much less in pollution control and abatement. If environmental problems are to be reduced, these nations will have to increase such expenditures. As developing country per capita incomes grow, they will be better able to afford such investments.

[9] *Green Products by Design,* op. cit., footnote 6, discusses the potential to use the design process to address environmental concerns.

[10] David Wheeler, findings from the World Industrial Pollution Project, Environment Department, World Bank, Washington, DC, 1992.

Box 3-A—Environmental Design and Manufacturing Competitiveness

An estimated 70 percent or more of the cost of a product's development, manufacturing, and use are determined during the initial design stage.[1] The environmental attributes of a product also are largely set in the design stage through choice of materials, and consideration given to such factors as product reuse, recycling, and disposal, energy requirements, and pollution emitted. Product design also influences production processes and associated wastes and emissions. In turn, process modifications often entail changes both in products used by the process and the end product itself. For instance, the process of reducing volatile organic compounds (VOCs) in parts painting may require low emissions painting booths, paint applicators, and new paint formulations. OTA has found that "green design is likely to have its largest impact in the context of changing the overall systems in which products are manufactured, used, and disposed, rather than in changing the composition of products per se."[2]

In many manufacturing industries, success in integrating environmental performance into product and process design is becoming more important to competitive outcomes. Many products already are regulated or labeled by environmental characteristics that may prompt process changes or alter product markets. For instance, in the United States and an increasing number of other countries, air pollution standards for automobiles have led to changes in vehicle design and introduction of catalytic converters. Petroleum refiners in turn have had to modify their processes to produce unleaded gasoline and low sulfur motor fuels. In many countries, various pesticides and toxic chemicals are restricted and in some cases banned. Chloroflorocarbons (CFCs) are being phased out globally. In Germany, packaging design is influenced by legal requirements for manufacturers and distributors to collect packaging for recycling. Germany may later extend recycling requirements to durable goods as well. Eco-labels in

[1] As cited in U.S. Congress, Office of Technology Assessment, *Green Products by Design: Choices for a Cleaner Environment*, OTA-E-541 (Washington, DC: US. Government Printing Office, October 1992), p. 3.

[2] Ibid., p. 9.

(continued on next page)

A FRAMEWORK FOR CLASSIFYING ENVIRONMENTAL ACTIVITIES

The definition of environmental activity has become more and more vague as concern for the environment has developed, Environmental issues cover matters as diverse as energy conservation, control of pollution from factories, development of renewable energy sources, tropical rain forests and endangered species, preservation, reduced use of toxic chemicals, and recycling household solid waste. Environmentally preferable activities differ from less preferable activities in one or more of the following ways:

1) they often use less energy or material;
2) they have less impact on natural systems, the land, or communities; and
3) they result in fewer emissions of harmful pollutants or wastes (including toxic or hazardous waste).

Each stage in a product's life cycle (including materials extraction, processing, manufacturing, product use, and, finally, disposal) may need to be examined to determine its environmental implications. As a result, as global environmental problems have grown, there has been an unprecedented interest in the commercial implications of environmental policies.

The sheer scope of environmental activities makes it necessary to develop a framework to classify activities and undertake analysis. Table 3-2 provides one framework, and also delineates the scope of activities this report will examine.

Box 3-A—Environmental Design and Manufacturing Competitiveness-Continued

Canada, Germany, Japan, and the Nordic countries as well as those being developed by the European Community and two private U.S. organizations may potentially affect market shares earned by manufacturers. At times environmental product standards have become the subject of international trade disputes as in a European Court case involving a 1981 Danish regulation on reuse of beverage containers.[3] With direct regulation of products, even the cleanest and lowest cost production process may be insufficient for gaining markets if the product itself fails to meet standards.

As for industrial processes, environmental regulations can increase demand for conventional pollution control equipment and cleaner production processes and reduce demand for technology that is less preferable environmentally. The phase-out of CFCs and other ozone depleting substances affects the manufacturers of those chemicals and their substitutes and the design of manufacturing processes and capital goods. For instance, markets are developing for new machines to clean metal and electronic parts that use alternatives to CFCs. Designers increasingly need to come up with process innovations to deal with new regulations limiting VOC emissions. In addition to paint and painting equipment, cleaning machines are being developed that recover VOCs or use alternative solvents. Cleaner burners, ultrafiltration devices, and new catalysts are among other examples of industrial products being developed to meet new environmental regulations.

The links between environmental performance, materials use, industrial processes, and product design extend vertically among suppliers and customers as well as horizontally across a sector's firms. In some cases, industry consortia or other cooperative mechanisms might help overcome environmental challenges in manufacturing. Such consortia could benefit regulated industries through the development of cleaner processes that allow lower cost environmental compliance and even cost savings or product improvement. Suppliers to those industries would benefit through the development of new product lines that can be sold domestically and abroad as environmental regulation and enforcement tightened. Furthermore, supplier firms depend on the competitiveness of their customers for their own survival and prosperity.

3 U.S. Congress, Office of Technology Assessment, *Trade and Environment: Conflicts and Opportunities*, OTA-BP-ITE-94 (Washington, DC: U.S. Government Printing Office, May 1992), p. 89-90.

The first dimension for classifying economic activities is the degree to which environmental concerns spur the undertaking of a given economic activity or purchase.11 The importance of environmental considerations among rationales for undertaking an activity ranges from minimal or none (e.g., conventional mining of materials) to almost 100 percent (e.g., installation of advanced wastewater treatment systems or scrubbers), to any possible range in between (e.g., firms may invest in solvent recovery systems not only to reduce volatile organic compound (VOC) emissions but also to save money). Hence, it is often difficult to know the degree to which environmental factors or other concerns, such as cost, energy use, performance, and quality, are refleeted in choices of economic activities. The line between what is and is not an environmental activity is fuzzy and can change over time. However, it is important to note that the environment industry consists of not just those activities that are undertaken almost solely for environ-

11 This should not be confused with the environmental impact of the activity, which may or may not be related to the importance of environmental considerations in undertaking the activity or making the purchase.

Table 3-2—A Framework for Classifying Economic Actions by Primacy of Environmental Motive

	Environment is *prime* motivation for undertaking activity or developing/buying product	Environment is one motivation among several for undertaking activity or developing/buying product	Environment is not a motivation for undertaking activity or developing/buying product
	Cell **A**	**Cell B**	**Cell C**
Resource management and extraction	Biodegradable oil drilling fluids Turtle exclusion devices Wetlands restoration Abandoned mine reclamation Oil spill cleanup	Integrated pest management Drip irrigation Eco-tourism	Unrestricted logging Strip mining Drift net fishing
	Cell D	**Cell E**	**Cell F**
Manufacturing/ commercial activities	Pollution prevention: Desulfurized diesel fuel Chlorine free pulp production Non-CFC solvents End-of-pipe: incinerators Waste water treatment Catalytic reduction of NO_x flue-gas desulfurization	Recycling facility HVLP paint applicators Solvent recovery equipment No-clean solder techniques industrial controls Efficient catalytic reactors Redesigned pulp digesters Solar cells High efficiency gas turbines	Bleached-kraft pulp processes Organic solvent decreasing Mercury cell chloralkali production Conventional circuit board manufacturing Open hearth and basic oxygen steelmaking
	Ceil G	**Cell H**	**Cell I**
Consumer products	Reformulated gasoline Zero or ultra low emission cars Paper with recycled content Low mercury/lead batteries Phosphate-free detergents	Fuel-efficient automobiles Energy-efficient appliances Minimal packaging Residential energy controls	Leaded gasoline Many disposable products Many household cleaners Leaded paints

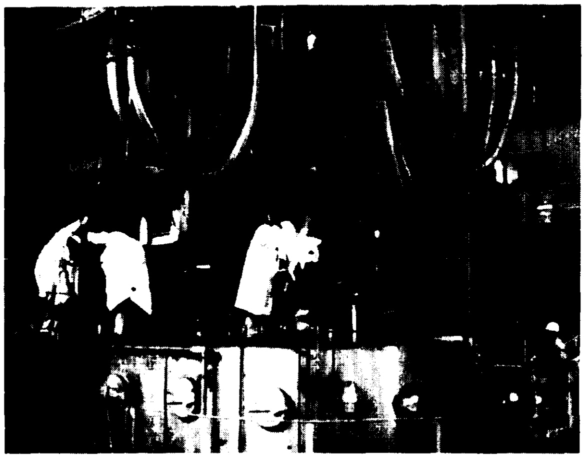
SOURCE: Office of Technology Assessment, 1993.

mental reasons (cells A, D, and G, table 3-2) but increasingly of activities that are strongly influenced by environmental factors (cells B, E, and H, table 3-2).

Activities can also be differentiated by their place in the product cycle.[12] Environmental considerations underlie the development of the features of some products (cell G, table 3-2). Other products, such as high-mileage autos, which are partly driven by environmental concerns and partly by economic concerns, might or might not be considered an environmental product (cell H, table 3-2). Both areas will have potentially significant economic implications either as regulation drives product choices or as consumers include environmental factors in their purchasing decisions. How corporate management responds to such new demands may be a critical factor in determining competitiveness.

A second area concerns resource management and extraction (cells A, B, and C, table 3-2). Land and waterway use, preservation of natural areas such as wetlands, agricultural chemical use and farming practices, sustained yield forest management, depletion of nonrenewable resources, wildlife preservation, and a host of other issues affect

12 See OTA, *Green Products by Design,* **op. cit.,** footnote **6**



U.S. DEPARTMENT OF ENERGY

Research is underway to develop advanced steelmaking processes that could lower environmental imports. This pilot scale research smelter near Pittsburgh, PA to test direct steelmaking is conducted jointly by the American Iron and Steel Institute and the U.S. Department of Energy.

resource management. For people involved in fisheries, farming, mining, quarrying, and oil and gas exploration, such issues are likely to become more central to their economic well-being.

Third is the processing of materials and the production of goods and services (cells G, H, and I). This includes materials used in production, energy generation, and production equipment, as well as end-of-pipe treatment equipment used by industry. Also included are public or private water, sewer, and solid waste utilities. This framework allows for a definition that goes beyond the conventional environmental goods and services (EGS) industry, to include production technologies that inflict less environmental damage than conventional production equipment (cell D, table 3-2). For example, solvent recovery equipment, no-clean soldering equipment, and low-VOC paints would all be part of the EGS industry under this framework, since their development and use is driven largely by environmental considerations (cell E, table 3-2). Similarly, some alternative energy technologies, such as solar cells and wind turbines, would fit here.

As defined here, the environmental industry includes firms that develop and provide products, equipment, or services that have as a primary or significant secondary benefit the improvement of the environment. (Those firms providing consumer products said to be environmentally preferable are not discussed in detail in this report.) Because manufacturers often need to improve the environmental performance of their production process, they are often the principal consumers of these goods and services. Environmental firms often are themselves manufacturing fins. Also, traditional manufacturers may develop and market products that improve the environmental performance of their own and others' manufacturing processes. To the extent that the EGS industry develops processes that lower the cost and raise the effectiveness of environmental goods and services, then U.S. industry as a whole will benefit. Conversely, to the extent that U.S. industry continues to prosper, it can serve as a major market for domestic EGS firms.

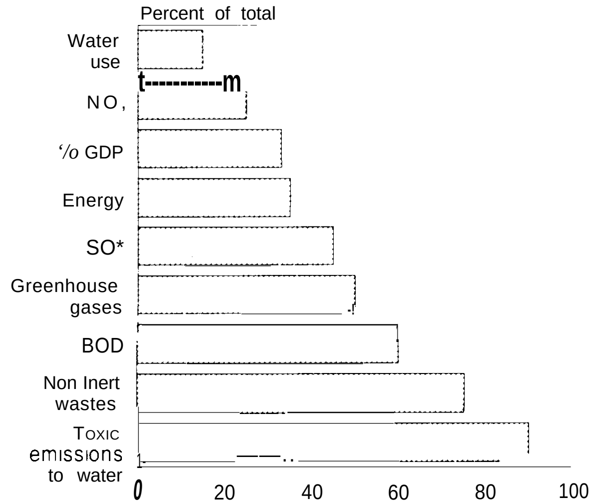
This report focuses in large part on the activities taking place in cells D and E, activities related to the production process and being driven to a large or moderate degree by environmental factors. However, it is important to note that the line between areas is not immovable.

It maybe that the preferable actions are indeed those in the middle cells where both environmental and other factors motivate action. Many pollution prevention activities, which are often preferable to end-of-pipe solutions, fall into this cell. Moreover, because other factors, such as cost, quality, and reliability, are more likely to enter decisionmaking for activities in these middle cells, widespread adoption of these activities is more likely than for those activities executed solely for environmental reasons.

The chapters on competitiveness emphasize manufacturing, as opposed to other sectors, for several reasons. First, concern about U.S. manufacturing competitiveness has assumed center stage in the debate about U.S. economic competitiveness.[13] Second, manufacturing accounts for a disproportionate amount of pollution relative to its share of total economic activity (see figure 3-2). For example, while manufacturing represents approximately one-third of GNP in OECD nations, it accounts for 60 percent of biological oxygen demand in water and 75 percent of noninert waste.[14] Third, along with electric utilities and mining, manufacturing bears a major portion of environmental compliance costs. (see ch. 7).

As economic activity influenced by environmental factors (cells A, D, and G) becomes increasingly important in solving environmental problems, it is important to note that not all environmental problems have the same worldwide consequences. Some such problems (ozone depletion is perhaps the most conspicuous example) are global: activity in one location can affect the Earth's environment as a whole. Other problems, while not necessarily global, have effects that cross national borders (e.g., sulfur dioxide emissions in one country contributing to acid rain in another). Finally, some problems have principally local effects, although, the line between local and nonlocal effects is arbitrary. Locally used toxic substances can be transported far from their points of origin. For example, pesticides, polychlorinated biphenyls (PCBs), lead, and dioxins are found in Arctic regions, far from their points of release.[15]

Figure 3-2—Manufacturing's Share of Pollution in OECD Countries



SOURCE: Organisation for Economic Cooperation and Development, 1991.

THE ENVIRONMENTAL GOODS AND SERVICES INDUSTRY

The issues discussed in this chapter illustrate the competitiveness context that affects both industries that supply environmental goods and services and those that use such products. The perspectives and interests of environmental product suppliers and users can be quite different, although some firms fill both roles.

As discussed in chapter 4, a large industry amounting to $200 billion or more annually worldwide has developed to provide goods and services for the end-of-pipe control, treatment, disposal, and remediation of pollution and environmental damage. If business opportunities for pollution prevention or cleaner production were also included-but the size of such markets is very difficult to estimate-a still larger market would be apparent.

Not all environmental expenditures translate to spending in the environmental goods and services industry. For instance, many industrial firms have substantial internal environmental activities that only partially correspond to purchases of goods and services from outside source. There are, however, companies that have used their accumu-

[13] U.S. Congress, Office of Technology Assessment, *Making Things Better: Competing in Manufacturing*, OTA-ITE-443 (Washington, DC: U.S. Government Printing Office, February 1990).

[14] Organisation for Economic Cooperation and Development, *The State of the Environment* (Paris: OECD, 1991).

[15] Curtis C. Travis and Sheri T. Hester, "Global Chemical Pollution," *Environmental Science & Technology*, vol. 25, No. 5, May 1991, pp. 814-819. Travis and Hester refer to E. Dewailly et al., *Bulletin of Environmental Contamination and Toxicology*, vol. 43, 1989, pp. 641-646.

lated internal expertise to establish environmental business units.

Although some may view the environmental industry as limited to firms that provide end-of-pipe and remediation equipment and services, many of the most significant opportunities for improving the environmental performance of industrial production lie in the realm of pollution prevention, cleaner production, and improved energy efficiency. Such business opportunities are expanding as enterprises seek to improve their environmental performance under pressure from regulators, public opinion, and, in some cases, investors and corporate leaders. This report therefore defines the environmental industry to include pollution prevention goods and services.

By these criteria, products such as advanced gas turbines could be viewed as environmental products. While such turbines offer cost and technical advantages over other power-generating technologies, a significant part of their appeal derives from less complex siting and permitting that accompanies their cleaner performance and lower pollution abatement costs relative to other technologies (e.g., coal-fired steam turbines). Likewise, while industrial controls technologies can improve industrial productivity and product quality, diminished pollution can influence a company's decision to install or upgrade automated monitoring and control equipment.

Competitiveness in the remedial or end-of-pipe pollution abatement industry is affected by the state of cleaner production and pollution prevention technologies. Over time, as pollution prevention becomes more widely practiced, some pollution control technologies could be obviated by pollution prevention technologies. Whether or not this occurs, the interplay of pollution prevention and pollution control is important to the developers and vendors of environmental technologies and to policymakers concerned with competitiveness in the environmental industry. Box 3-B illustrates how pollution prevention and control businesses can interact.

There are other pertinent dimensions beyond the distinction between end-of-pipe and pollution prevention to an assessment of environmental industry competitiveness. One is the distinction between technologies and industries for which there are already large markets and those that are now precompetitive or niche-competitive but offer very large potential markets in the future. Competitiveness policies may differ depending on whether a U.S. industry is fighting to gain or defend a share in an existing market or whether it is competing for prospective markets where major benefits may accrue to early entrants.[16] In some cases, such a market is likely, but the technology is not yet cost-effective (e.g., utility-scale photovoltaic cells). In other cases, the technology is already well understood but a large market has not developed because few countries currently require the technology (e.g., tertiary wastewater treatment).

The pace and characteristics of technological change also affect environmental industry competitiveness. In some cases, technologies are mature and now enjoy a substantial market (e.g., secondary wastewater treatment). In other cases, incremental improvements in the cost and performance of existing technologies might open up a large market (e.g., wind turbines). In still other cases, the industry is likely to be subject to radical innovations because of rapid changes in fundamental understanding and competition among rival technological approaches. This category includes bioremediation, photovoltaic cells, and advanced coatings that can obviate existing dirtier processes.

Examples of how a variety of environmental technologies fall into the categories of end-of-pipe versus pollution prevention and relatively mature versus relatively dynamic technological trajectories appear in table 3-3.

[16] See W. Brian Arthur, "Positive Feedbacks in the Economy," *Scientific American*, vol. 262, No. 2, February 1990, pp. 92-99 for a discussion of how early entrants can gain enduring benefits from introduction of new technologies.

Box 3-B—interaction Between Pollution Prevention and Pollution Control[1]

An example of how a technology not usually considered to be within the environmental industry can emerge as an environmental business opportunity at the expense of traditional disposal and control industries is provided by a recent demonstration project sponsored by the Illinois Hazardous Waste Research and information Center and the U.S. Environmental Protection Agency (EPA) under the Clean Technology Demonstration Program.

Steel delivered to the R.B. White, Inc. plant, a steel-shelving manufacturer in Illinois, must have oil-based rust inhibitors, coolants, and lubricants removed in a decreasing bath prior to painting. Phosphating reagents are present in the bath to promote paint adhesion and corrosion resistance of the steel. The company used to dump its phosphating/degreasing bath periodically as oil built up in the bath and compromised product quality. This process generated about 15,000 gallons a year of hazardous waste that cost the company about $1 per gallon, or $15,000 a year, for hauling and incineration in a cement kiln.

After bench and pilot scale demonstrations, the R.B. White plant installed an ultrafiltration system from Koch Membrane Systems to remove oils from the phosphating/decreasing bath and greatly extend bath life. Koch makes membrane-based filtration systems for pollution control and prevention and in-process materials filtration. Ultrafiltration is normally used in a number of industrial processes, including the concentration of milk and fruit juices. For R.B. White, ultrafiltration lowered the volume of hazardous waste by over 99 percent, to about 30 gallons a year and greatly reduced disposal costs. From the perspective of R.B. White, ultrafiltration was a cost-effective process technology that paid for itself in under 7 months, For Koch Membrane Systems and other manufacturers of ultrafiltration products, the environmental problems of the metal finishing industry offer new market opportunities. But for the environmental companies that haul and treat R.B. White's wastes, ultrafiltration means lost business.[1]

1 This discussion draws extensively from Gary D. Miller et al., "Evaluation of Ultrafiltration to Remove Oil and Recover Aqueous Iron Phosphating/Degreasing Bath," draft, Hazardous Waste Research and Information Center, Champaign, IL, and Tim Lindsey, Hazardous Waste Research and Information Center, personal communication, Jan. 11, 1993.

THE ENVIRONMENT AND COMPETITIVENESS CONTEXT: THE CASE OF MANUFACTURING

There have long been differing views about the environment and manufacturing industry competitiveness. One view is that pollution and waste control regulations (by imposing costs on companies, diverting scarce resources to purposes distant from a company's strategy, etc.) are a dragon competitiveness. While few analyses put such regulations at the top of those factors affecting U.S. industrial competitiveness, compliance can be expensive. For U.S. manufacturing in 1991, pollution control and abatement compliance costs accounted for 1.72 percent of value added. Some industries, such as chemicals, spend a high portion (13 percent or more) of their capital budgets on environmental protection. As detailed in chapter 7, money and resources (including management time) devoted to environmental compliance are money and time not spent on concerns more central to a firm's mission. Moreover, if foreign manufacturers face fewer constraints, they may gain a competitive advantage.

A contrary view is that pollution and waste requirements (at least if properly structured and implemented) could spur competitiveness by prompting technological innovation, encouraging companies to make more efficient use of energy

Table 3-3-A Framework for Categorizing Environmental Technologies*

	Incremental[a]	*Dynamic*[b]
Examples of end-of-pipe/ remedial treatment technologies	Primary/secondary sewage treatment Catalytic converters Flue-gas desulfurization Tertiary sewage treatment	Hazardous waste remediation (e.g., bioremediation) Emissions monitoring Advanced vapor recovery (e.g., membranes) CO_2 recovery
	Incremental[a]	*Dynamic*[b]
Pollution prevention and cleaner technologies	Fuel oil desulfurization Cogeneration[c] Advanced gas turbines[c] Low VOC Coating[c] (e.g., UV curing) No chlorine paper production Wind turbines	Industrial monitoring and Controls[c] CFC substitutes Advanced Coatings[c] (e.g., vapor deposition) Biocatalysis[c] Photovoltaics Fuel cells[c]

a Incremental means fundamental technological changes are not expected, progress wiii come largely through innovation based on existing technology.
b Dynamic means that significant technological evolution is expected as fundamental scientific understanding changes.
C These technologies offer economic or technical advantages in some instances in addition to their environmental attributes.
•The examples offered are illustrations rather than specific sectors examined in this assessment. The distinctions between the different categories, particularly concerning projected technological change, are necessarily judgmental.

SOURCE: Office of Technology Assessment, 1993.

and materials, and stimulating the development of new products (e.g., cleaner, more efficient boilers) that, over the long term, will benefit economies that produce them (see box 3-C). Some who hold this view cite Japan's success in international competition during a period when Japanese industry began to comply with new environmental standards.

In exploring the relationship between environment and competitiveness, this report discusses manufacturing industries in general, with particular attention to chemicals, pulp and paper, and metal finishing. These industries have high environmental impact or compliance costs, but a range of competitive circumstances (see table 3-4). Other industry sectors, such as auto assembly and steelmaking, also receive some attention.

There are several ways in which environmental regulations might contribute to competitiveness. There are also several ways environmental regulation might hinder competitiveness. Major arguments on both sides are outlined below (see also table 1-2 inch. 1). For further discussion of these issues, see chapter 7 and appendix A. The concluding section of this chapter discusses employment issues.

Box 3-C-Does Environmental Regulation Improve Competitiveness?: The Michael Porter Hypothesis

In his book, *The Competitive Advantage of Nations* and in an essay in *Scientific American,* Michael Porter, a professor at the Harvard Business School, discussed the possible positive relationship between some types of regulations and economic competitiveness.[1] As a result, a number of people have cited Porter's hypothesis as evidence that environmental regulations help competitiveness. However, such benefits cannot be assumed to arise without careful case-by-case analysis.

Porter argues that while environmental regulations impose costs and other constraints on industry, they may also stimulate innovations and/or efficiency gains which may offset costs. These can occur through increased economic activity in the environmental goods and services industry or increased innovation in the regulated sector itself, either through new products from product regulations or more efficient processes from process regulations. In contrast to many economists, who concentrate on the short-term static effects of compliance costs, Porter stresses that it is important to also look at the longer term dynamic effects of regulation on innovation. Porter acknowledges, however, that these offsets may not completely compensate for the costs of pollution control borne by industry.

Porter discusses four major ways that innovation can help offset the negative impact of compliance costs on competitiveness.

First, stringent environmental regulations can lead to a competitive advantage in the environmental goods and services industry. Countries with strict regulations are more likely to develop strong firms providing the environmental goods and services used by industry to meet regulations. Porter cites several examples, including Swedish low-noise compressors and the purported German and Japanese leads in air pollution equipment stemming from early and strict SO_2 and NO_x regulations on stationary sources. Chemical companies may gain a competitive advantage from developing low-VOC paints and coatings and from CFC-substitutes, if their customers are faced with environmental requirements leading to the need to use these products. However, their customers, the regulated community, may face higher costs in using these materials or products. (The impact of regulations on the environmental goods and services industry is discussed in chs. 4 and 5.)

Second, Porter points to a number of cases where regulations stimulated the development of innovative or higher quality products. For example, the German Solingen law set rigid standards fort he

[1] Michael E. porter, *The Competitive Advantage of Nations* (New York, NY: The Free Press, 1990); "America's Green Strategy," *Scientific American, vol. 264, No. 4,* April 1991, p. 16S.

(continued on next page)

WAYS IN WHICH ENVIRONMENTAL REGULATION MIGHT HELP COMPETITIVENESS:

Improved Environmental Conditions--If environmental regulations create benefits in excess of costs, then they can improve economic welfare. Lower levels of pollution may lead to lower health care costs, increased agricultural and labor productivity, and lower costs in other parts of the economy resulting from reduced pollution.[17] These benefits may accrue to firms both directly and indirectly (cheaper supplies and inputs). While it is important to include data on these

[17] See Organization for Economic Cooperation and Development, *Environmental Policy Benefits: Monetary Valuation* (Paris: OECD, 1989).

Box 3-C–Does Environmental Regulation Improve Competitiveness?: The Michael Porter Hypothesis–Continued

quality of cutlery.[2] Other examples are Japanese energy conservation laws and taxes that led to development of internationally competitive energy efficient products. However, regulatory impacts on *products* are different than on processes. Consumers can identify and value the regulatory impact on the product and as a result, firms can translate this into competitive advantages It is not clear how much consumers care about the presence or absence of environmental controls in the production of an item (although this kind of valuation appears to be growing). Moreover, the majority of the costs of environmental regulations probably arise from regulations on processes not products.

Third, Porter argues that properly constructed process standards can encourage companies to re-engineer technology to reduce not only pollution but also costs, as production processes become more efficient. However, as discussed in chapter 8, only a small share of investments to comply with environmental regulations are for in-process changes, and of these, it is not clear how many pay for themselves in savings. Environmental regulations often raise capital and operating costs, even with aggressive pollution prevention efforts.

Finally, Porter argues that while some regulations can lead to competitive advantage, those that prescribe particular technologies, as opposed to performance-based standards, do not. To extend this point, it should be noted that regulation that leads to abatement or cleanup, rather than prevention, will increase, not lower, costs for manufacturers. Regulations that make it risky to innovate (e.g., no phase-in periods, strict penalties for companies unsuccessfully trying innovative approaches) will also reduce offsets. As discussed in chapters 8 and 9, many aspects of the regulatory system make it more difficult for industry to develop innovative and low-cost responses to pollution control regulations.

Some forms of regulatory reform will increase the potential of these innovation offsets, but it is by no means clear that these offsets will outweigh the costs and stimulate competitiveness. Nonetheless, Porter enumerates several offsetting benefits for industry from environmental regulation. In the debate on the effect of regulations on industrial competitiveness, it is important, however, to keep in mind that the principal purpose of regulations is to produce a clean environment and protect public health; the resulting societal benefits may justify the added costs to producers and consumers.

2 Ibid., p. 647-649.

3 EPA has commissioned a study to examine the Porter hypotheses and is examining a number of industries affected by regulations. However, most of these are either environmental industries (scrubbers) or products (paints and coatings and pesticides). Making the case that process regulations has helped competitiveness of the regulated industry is more difficult.

benefits in any assessment of the relationship between regulation and economic growth, current measurements are inadequate.

Even if net benefits from regulations exceed costs, the expenditures normally occur in the present while the benefits often occur in the future. If other countries choose to minimize short-term costs by limiting regulation, they may gain a short-term competitive advantage that may continue well into the future.

Improved Manufacturing Efficiency—Another view is that pollution and waste regulation can improve manufacturing efficiency and save money. Pollution prevention may increase competitiveness if it results in firms paying closer attention to

Table 3-4—Economic and Environmental Factors for Selected Industries, 1991

Industry	Important environmental impacts of the production process	Competitive position	Pollution control investments as % of capital investments	Sales 1990 ($ billion)
Motor vehicle production	Volatile organic compounds (VOCs) from painting	Decreased domestic market share, strong Japanese competition	2.9 %	214
Chemicals	Large quantities of VOC air emissions, heavy metals, hazardous wastes	Strong, $18.8 billion trade surplus	13.4 %	***288***
Metal finishing	Acids and heavy metals in wastewater and sludge	Generally not traded but overseas firms are strong	27.5 %	4.5
Pulp and paper	Waterborne pollutants, dioxin	Strong, net exporter of 11.8 million tons of paper, pulp and paperboard	13.8 %	131

SOURCE: Office of Technology Assessment; U.S. Census Bureau, *Pollution Abatement Cost-Expenditures, 1991*, (MA200 (91)-1 (Washington, DC: U.S. Government Printing Office, 1993); U.S. Census Bureau, *Annual Survey of Manufacturers, 1990 M90* (AS)-1 (Washington, DC: U.S. Government Printing Office, 1992).

energy and materials efficiency and continuous process improvement.[18] However, even though an aggressive pollution prevention effort can reduce compliance costs, particularly when compared to the current end-of-pipe approach, industry still faces compliance costs that increase production costs (see ch. 8). Regulation could also drive modernization if it led industry to upgrade production facilities or to invest in new, more productive facilities.

Recently, some corporate leaders have argued that correct pricing of pollution can increase competitiveness.[19] If firms must pay the full costs of polluting (e.g., through a fee or tax), then environmentally conscious firms will gain a competitive advantage if all firms competing in the industry face equivalent costs. In such a situation, firms can reduce costs by becoming cleaner. However, given that firms in other countries do not pay the full costs, such a scheme would raise U.S. production costs relative to foreign costs, unless there were some means, such as a border tax, to impose similar costs on imports and provide rebates for exports.

Increased Innovation-When properly structured, regulation stimulates innovation in the environmental control industry (see ch. 5). In addition, regulations may create pressures on firms to develop new products, thus adding to the dynamism of the economy. For example, regulation is credited with encouraging a number of new automobile technologies.[20] In some cases, overcoming problems related to regulation may have enhanced fins' problem-solving capacities and contributed to commercial innovation.

Early Mover Advantages-If U.S. regulations are copied by other countries, then technology developed to meet U.S. regulations could give

18 See U.S. Congress, Office of Technology Assessment *Serious Reduction of Hazardous Waste," For Pollution Prevention and Industrial Efficiency*, OTA-ITE-317 (Washington DC: U.S. Government printing Office, September 1986); also Michael Porter, "America's Green Strategy, " vol. 264, No. 4, April 1991, p. 168.

19 "Viewpoint," *Chemical & Engineering News,* vol. 71, No. 2, Jan. 11, 1993, p. 8.

20 Robert D, Atkinson and Les Garner, "Regulation as Industrial Policy: A Case Study of the U.S. Auto Industry, '*Economic Development Quarterly, vol.* 1, No. 4, November 1987, pp. 358-373.

U.S. companies an advantage in foreign markets when similar regulations are adopted. Firms in other countries may have to invest sizable amounts to come up to speed and, because they have less experience in dealing with pollution, may do so at relatively higher costs. Therefore, one important characteristic of regulations is whether they lead where other countries are likely to follow. U.S. mobile source air pollution regulations have done so, leading to a competitive U.S. industry in catalytic converters. As U.S. Superfund regulations have not been copied, the cleanup technology developed in response has had only modest use in foreign markets.

Increased Consumer Demand--Regulation could also help competitiveness if it leads businesses to develop products made in less environmentally damaging ways and if consumers value these products more than other products. Leading areas of consumer demand for products manufactured in environmentally friendly ways are in paper, and, to some extent, products manufactured without CFC's. Scott, the world's largest tissue manufacturer, recently dropped from among its pulp suppliers three with the worst environmental performance.[21] Similarly, pressure from European paper consumers are leading pulp suppliers to move to chlorine-free pulp making.[22] Such pressures are relatively weak in North America.[23] Moreover, it is unclear the extent to which consumers will prefer other products made in environmentally preferable ways. If they do not, and regulation imposes costs on the production processes, then firms may be less competitive.

Adaptation to the Future Economy—Finally, some argue that a ''green economy' is a more economically efficient economy.[24] Along these lines, it is argued that many U.S. companies are wedded to an old production system that uses high levels of energy and materials. This reasoning maintains that since future economies will force firms to take these factors into account, U.S. firms will then be at a disadvantage. However, these green savings normally stem from increased efficiency from energy conservation, the development of renewable energy sources, and increased materials recycling. While these changes may increase economic welfare, they do not directly address the issue of the effect of environmental compliance costs on manufacturing processes.

WAYS IN WHICH ENVIRONMENTAL REGULATION MIGHT HURT COMPETITIVENESS:

Societal Costs May Exceed Benefits-Even if pollution and waste-related compliance costs are higher in the United States than in other nations, it is possible that in the long run the nation may not suffer competitive disadvantage since society benefits from these expenditures. Some analysts argue that currently the costs of regulation exceed the benefits and that, therefore, both GDP and social welfare will be lower as a result of environmental regulation.

Analyses focusing on the costs of regulation, particularly the price to industry, often ignore or minimize the benefits of regulation and as a result, findings of net costs are assured.

Regulation May Inhibit Innovation--Some maintain that regulation may inhibit innovation, leading to relatively large costs over the long term.

21 Paul Abrahams, ''Scott's Clean Sheet,' *Financial Times,* Nov. 4, 1992, p. 14.

22 Prices of chlorine-free pulp are slightly higher than pulp made conventionally.

23 A relatively small percentage of U.S. pulp is exported to Europe. Many of the mills that produce pulp for export are moving to minimize or eliminate chlorine bleaching. (Neil McCubbin, "Environment and Competitiveness in the Pulp and Paper Industry,' OTA contractor report, 1993.)

24 Michael Renner, *Jobs in a Sustainable Economy* (Washington, DC: WorldWatch Institute, 1991).

Regulation can hinder innovation by diverting funds from capital investment in new plant and equipment and commercially oriented R&D. Because regulatory requirements are often stricter for new facilities (which often must install best available technology) than for older plants, new investments may be discouraged. Regulation can also delay the introduction of new industrial processes if permit applications take a long time to be processed. Finally, regulation can increase the risk of innovation. If firms feel that regulations are likely to change so as to make pending innovations obsolete or unusable, they may wait until they receive clearer signals.

Regulation May Increase Production Costs—Regulation raises the costs of production for U.S. firms. If U.S. firms face higher environmental compliance costs than companies in other nations, and the benefits they receive do not compensate for the costs, their relative competitiveness will decline, resulting in net export losses; some firms might relocate to countries with weaker regulation. In addition, high compliance costs mean that domestic firms will have less capital and human resources to invest in new products and production processes, thus reducing productivity. Some jobs losses may result, although the size of these impacts is uncertain.

Employment and Environmental Trade

Few aspects of environmental regulations prompt as much debate as their potential for employment effects, Yet, studies of the employment implications of pollution control regulations are poorly developed. Some argue that regulations cost jobs either from plant closures, from the high cost of regulations, or from reduced consumer demand for products produced with high environmental compliance costs. Others argue that environmental regulations create jobs in the environmental goods and service industry, and also environmental jobs in companies complying with regulations.

Estimates of the number of jobs in the U.S. EGS industry vary widely. The Environmental Business Journal estimates that total EGS employment in 1992 was 1,073,000. However, some of these jobs are not related directly to regulations, including many in water supply utilities, alternative energy, and private refuse collection.

It is, however, difficult to declare as benefits jobs to meet domestic EGS demands without also knowing how many jobs are lost in polluting industries due to reduced domestic consumption. These EGS jobs represent resources transferred from one activity to another and, in a sense, are the price we pay to clean the environment.

The better measurement of net employment benefit offered by the EGS industry would be from net jobs created through foreign trade. If the United States exports more in EGS than it imports, the net job creation should be counted against the jobs lost due to higher prices for domestic goods from environmental regulations.

Some also argue that investments in environment and energy-efficiency create more jobs per dollar of investment than highly polluting industries and that, therefore, regulation increases employment.[25] If this is true, productivity and wages in these EGS industries, and in particular in the indirect economic activity created from them, would need to be less than in highly polluting industries, such as chemicals and oil and gas. As a result, there may be a tradeoff in the short term between more jobs at lower wages (and possibly lower skill levels) and fewer jobs at higher wages (and possibly skill levels). In the medium and longer term however, net job creation should equalize.

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25 Howard Geller, John DiCicco, and Skip Laitner, *Energy Efficiency and Job Creation* (Washington, DC: American Council for an Energy-Efficient Economy, October 1992); also Michael Renner, *Jobs in a Sustainable Economy* (Washington, DC: WorldWatch Institute, 1992).

PART II.

Providers of Environmental Technology and Services: The Environmental Industry