Industry, Technology, and the Environment: Competitive Challenges and Business Opportunities

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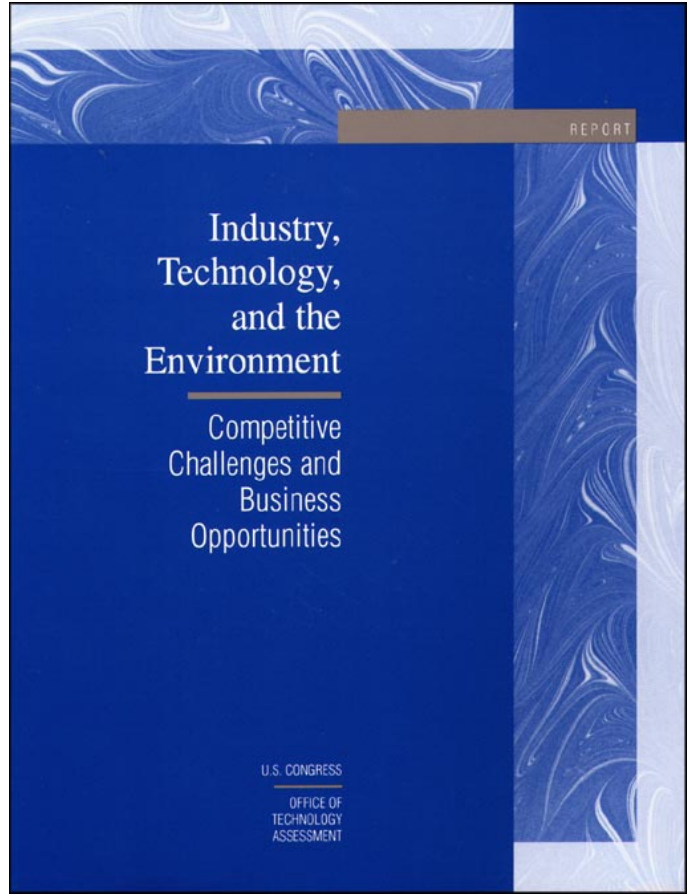

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Foreword

Debate about environmental concerns and industrial competitiveness has been underway at least since the early 1970s, when the United States pioneered strong environmental standards, Today, the debate has new urgency: the world is becoming more aware of the global nature of many environmental problems at a time of intensifying international economic competition.

This report finds both competitive challenges and opportunities from these trends for two sets of American industries affected by environmental regulation: those in the business of making and selling environmental technologies, and the manufacturing firms that are among their major customers.

For U.S. environmental firms, the years ahead could pose unprecedented opportunities to expand into new markets as more countries develop or tighten environmental standards. Yet, as the report documents, they already face strong competition from firms in Europe, Japan, and from some newly industrialized countries.

Perhaps their greatest challenge in the long term will be to integrate environmental concerns into the next generation of manufacturing technologies. Compliance costs in many U.S. manufacturing sectors are already among the highest in the world. Cleaner, more cost effective production technologies could help these firms lower compliance costs while still meeting the U.S. standards that are likely to remain among the toughest in the world.

Policymakers, not only here but in Europe and Japan, are actively debating new approaches to address twin concerns about intensifying global economic competition and global environmental problems. More than is usually the case, government policies play a central role, since regulations both create markets for environmental technologies and the conditions for compliance faced by industry. Other policy areas not traditionally thought of as affecting environmental concerns, including manufacturing research and development, industrial extension, and export promotion, also affect competitive outcomes.

This is the final report in a series of three in OTA's assessment of American industry and the environment, which was requested by the Senate Committee on Finance, the House Committee on Energy and Commerce, and the House Committee on Foreign Affairs. The first publication, *Trade and Environment: Conflicts and Opportunities,* discusses the interactions between these two policy areas. The second, *Development Assistance, Export Promotion, and Environmental Technology,* explores links between foreign aid and export assistance.

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PART I. Summary, Policy, and Conceptual Framework

Summary 1

This study analyzes the international competitiveness of two sets of U.S. industries that are affected by environmental policies:

1. firms that develop and market environmental technologies and services; and,
2. companies (especially manufacturing fins) that must meet U.S. environmental requirements, often while competing with firms from countries that have weaker standards or provide more assistance to their industries,

EXECUTIVE SUMMARY

Both sets of industries operate under new competitive realities—realities shaped not only by intensifying global competition but also by the environmental expectations of their customers and the societies in which they operate.

Environmental problems of new urgency now confront all countries. Some argue that a conceptual shift is beginning to occur in the world marketplace: as recognition grows that economic activity can do serious harm to both the local and global environment, and in the process harm human health and interfere with development objectives, business increasingly will have to internalize a new imperative of avoiding harm to the environment-an approach embodied in the term sustainable development (see ch. 3), Over time, according to this view, environmental imperatives could join the front ranks of business precepts, such as providing quality products at a competitive price, that no business can afford to ignore.

Recognition of global environmental problems, as well as greater attention to local needs in a growing number of countries, are producing new markets for environmental technologies, and could spur technological innovation to meet those needs. In some cases, such as global climate change, technological remedies and strategies have only recently been sought, with responses still in the early stages of development. In other cases, such as wastewater treatment and control of some air pollutants, technologies are well developed but widely used in only a few countries.

Some analysts believe that the expanding global market for environmental technologies will produce major commercial opportunities; how U.S. firms will fare in those new environmental markets has become subject of debate in Congress. Germany, Japan, and other countries with strong environmental industries are also asking how they might capture a greater share of this growing global market.

While environmental regulations produce business opportunities for environmental firms, they also impose costs on the manufacturing firms and other businesses that buy their goods and services. U.S. environmental standards are likely to remain among the world's most stringent. In a more competitive global economy, it will be important to find ways for U.S. industry to achieve environmental goals while avoiding competitive handicap.

The report's two subjects—the industry for which environmental regulations often mean costs and the industry for which environmental regulations mean business-are often thought of separately. But they are linked. The linkages are pertinent to debate about the competitive impact of environmental regulations on U.S. manufacturing firms and about government role in promoting U.S. environmental industries.

Among the linkages:

- Technological advancement (including hardware, technical and scientific knowledge, and management expertise at the business and societal levels) is increasingly necessary to address both competitiveness and environmental needs. A number of initiatives and proposals have been made at Federal and State levels to better integrate environmental objectives within technology policy. Some industries support consortia, involving firms and government or university laboratories, to undertake research and development (R&D) on processes and products that would be environmentally preferable to those now in use.
- The industrial market for environmental equipment and services is likely to be greatly affected by a shift away from conventional pollution control to pollution prevention and cleaner production processes. (These processes produce less waste and pollution, thus reducing the need for waste treatment or disposal. They often use materials and energy more efficiently than conventional processes.)
- This shift, now in its early stages, will have repercussions for both environmental companies and manufacturing fins. Manufacturing firms that use cleaner production processes are likely to reduce compliance costs and, in some cases, production costs. An environmental goods and services (EGS) industry[1] that develops more cost-effective approaches to reducing pollution may fare better in global markets.
- New forms of regulations allowing firms to adopt innovative approaches for addressing pollution can help both developers and users of

[1] The environment industry, as defined in chapter 3, refers to firms that develop and market products, equipment or services that have environmental improvement as a primary or significant secondary benefit. The report focuses on firms that sell technologies and services to control, treat, cleanup, and prevent pollution and waste (including cleaner production and cleaner energy technologies). Environmental management technologies and services used in agriculture, foreshy, fisheries, and mining are not discussed in detail. Firms selling consumer products claimed to be environmentally preferable might be considered part of the environmental industry, but are not covered in this report.

environmental technology. These include performance standards, economic incentives, and adjusting permitting procedures to stimulate the development and adoption of innovative environmental technologies.

- At the same time, government policies can affect these two sets of industries in quite different ways. Policies to speed use of cleaner production processes that offer competitive benefits to firms that must comply with environmental regulations can also reduce the need for remedial or end-of-pipe technologies. Likewise, policies that continue to promote end-of-pipe solutions for environmental problems can impede adoption of cleaner production and pollution prevention approaches.

Environmental and economic policies have often been viewed as in opposition and, for the most part, have been developed separately. Nonetheless, more and more, policymakers see benefits in addressing the two together. The interactions between environmental concerns and industrial competitiveness have ramifications for many policy areas, including pollution control and waste management, technology development and diffusion, export promotion and development assistance, and trade policy and negotiations.

Addressing these interactions could require changes in U.S. Government programs. Among proposals now on the table are those to:

- devise a strategy to promote development and export of U.S. environmental technologies
- create mechanisms to integrate environmental objectives into government support for manufacturing industry R&D and technology diffusion
- develop regulatory approaches that allow industry more options to innovate while maintaining or exceeding current environmental objectives
- work toward bilateral and multilateral agreements on environmental standards that further environmental goals, lessen the likelihood of adverse competitiveness impacts for U.S. firms and workers, and expand opportunities for U.S. environmental firms at home and abroad.

Principal Findings

THE GLOBAL ENVIRONMENTAL MARKET

1. The market for environmental technologies and services is growing in the United States and abroad, in both industrialized and developing countries. Most of the current market is for well-known, widely used approaches and technologies for end-of-pipe pollution control, waste disposal, and remedial clean-up of pollution. According to a widely cited estimate, this global market probably amounted to $200 billion in 1990, and could grow to $300 billion annually by the year 2000. The projected market would be much larger if cleaner production technologies and products were included, but there are no good projections of the potential size of this market.

2. As more countries respond to their environmental problems, the global environmental market is likely to continue to expand—although not as rapidly as predicted in the late 1980s when recession-proof growth in environmental markets was widely assumed. Over the next 10 or 15 years, the advanced industrial economies likely will still account for most of the growth. However, markets are rapidly emerging in the newly industrialized countries and many developing countries, particularly in the Pacific Rim and Latin America. The transformingg economies of Central and Eastern Europe offer large potential markets, although there, as elsewhere, scarcity of financing limits environmental investments. Bilateral and multilateral aid is a significant source of environmental investment in some areas.

3. While the global environmental market is large, most environmental expenditures go to day-to-day operations and construction of facilities that use locally available labor, materials, and parts. International trade thus fills only a small portion of EGS demand. The exact amount of trade is uncertain because the quality of the data

is very poor. However, traded items and services probably do not account for more than 10 or 15 percent of the total market. Even so, this fraction represents a significant amount of trade, which may grow in volume as the world market grows. The most significant prospects for U.S. exports are for relatively sophisticated equipment and professional services. While the attendant growth in U.S. employment probably will be modest, many of these jobs are likely to be high-wage jobs in management, engineering and other technical professions, as well as some blue collar manufacturing jobs.

4. In the long term, cleaner technology and production processes may have the potential to generate more export-related growth and jobs than conventional pollution control equipment. Government technology and export promotion policies aimed at strengthening environmental industries need to take into account the technical possibilities and commercial opportunities in cleaner production.

5. The shift toward cleaner production is likely to occur incrementally over the next 15 or 25 years, as manufacturers build new facilities or upgrade existing plants. There likely will be growing global demand for cleaner and more energy-efficient industrial facilities, including those for power generation, chemical processing, smelting, oil refining, papermaking, food processing, and product assembly. Countries with firms that are competitive suppliers in these areas will benefit from the jobs and commerce generated from trade in capital equipment and related professional services. Moreover, as these countries' domestic producers in other industries invest in cleaner technologies, they may make changes that will enable them to compete more effectively against firms in other countries,

6. Regulations and enforcement (including liability and fees) are likely to continue to drive markets for environmental technologies and services. However, a number of other factors may affect these markets. Energy efficiency investments are often cost-effective even in the absence of regulation as are some pollution prevention projects. Potential users often know little about these alternatives, but as knowledge about their cost-effectiveness grows, they may be used more widely. Some companies also may make environmental investments out of concern for their environmental image among customers, investors, and the public, especially where reporting requirements or consumer labeling exist.

THE COMPETITIVE POSITION OF U.S. ENVIRONMENTAL FIRMS

1. Global competition for environmental markets has become fierce during the last decade. The U.S. environmental industry's overall international performance is mixed. In many foreign markets, U.S. firms remain competitive but not dominant; in other areas, the U.S. position has eroded. Estimates of market shares in major Latin American countries show U.S. sales accounting for about half of environmental imports, but note growing European and Japanese presence. U.S. performance in other regions (including the fast growing Pacific Rim) is less strong. As with conventional environmental equipment, U.S. firms that design, construct, and manufacture cleaner and more energy-efficient capital goods and facilities can expect intense foreign competition.

2. Large and highly competitive environmental industries exist in Germany, some other European countries, and Japan-countries with firms that have a stronger export orientation than many U.S. environmental companies. Several newly industrialized and advanced developing countries have nascent environmental industries that supply basic environmental goods for their own markets and also for export; as developing country environmental investments grow, some of these firms may well become important regional suppliers.

3. While some U.S. environmental firms are major international players, most focus on the huge domestic environmental market, which is by far the world's largest. Here, too, American firms face competition, For European and Japanese environmental fins, the United States is an

attractive export market. It also offers major opportunities for licensing of technologies, joint ventures, and acquisitions of U.S. companies, In the last decade, U.S. firms have become more reliant on foreign technology and foreign capital in a number of environmental sectors. For example, half of the 10 largest U.S. manufacturers of wastewater treatment equipment are foreign owned. Also, U.S. companies have become more dependent on foreign air pollution control and incineration technologies. In some cases these technologies were first developed in the United States and then licensed and improved abroad.

4. To succeed in foreign markets, U.S. firms may need to adapt products developed for U.S. needs to the sometimes quite different conditions in other countries. While U.S. environmental standards and technologies enjoy a good reputation, potential customers in developing country markets sometimes see U.S. products as too expensive or sophisticated. Further, some U.S. suppliers are viewed as insufficiently concerned with service, training of personnel, and provision of parts.

5. Most U.S. environmental firms (especially smaller ones) have little export experience; firms in Japan and many European countries have more. Private export financing in the United States is scarce (especially for smaller firms); it is more plentiful *in* Japan and several European countries, where firms also get more government help with export marketing and financing than in the United States. The U.S. government's help is also poorly coordinated and difficult to access, The U.S. government also provides less confessional financing, and structures its development assistance programs in ways that provide less help to national firms bidding on large capital projects.

6. Technological innovation is likely to be increasingly important for environmental firms competing in global markets. U.S. regulatory and permitting procedures present some impediments to environmental technology innovation. Companies may find it too expensive, uncertain, or time-consuming to secure regulatory permits for R&D and testing of innovative environmental technologies. Regulated industries hesitate to employ innovative technologies not only because of technical uncertainties associated with new approaches but also because of regulatory uncertainties, Permitters often shy away from approving unfamiliar technologies and tend to prefer environmental technologies with established track records, Limited technical expertise, small budgets, and lack of incentives for championing new approaches account for risk-averse behavior by permit writers.

COMPETITIVE IMPACT OF ENVIRONMENTAL REGULATIONS

1. While comparisons are difficult, the compliance costs incurred by U.S. manufacturers for pollution control and abatement are among the highest in the world. Firms in a handful of countries such as Germany face equal or higher costs, but they are the exception. Japanese manufacturers appear to spend lesson pollution control than U.S. industry and that gap has been growing. However, Japanese industries pay more for energy, leading them to implement more energy efficient measures, which provide some environmental benefits. Some countries (including Germany and Japan) provide greater financial incentives (tax incentives, loans, grants) to companies for compliance with their nations' environmental requirements.

2. For most U.S. manufacturing sectors, pollution control and waste management regulations are not among the top ranking factors determining international competitiveness. Even sectors with the highest compliance costs-chemicals, primary metal production, pulp and paper, and petroleum refining-represent a range of competitive positions. However, some U.S. firms face increasing competition for nonenvironmental reasons, and for these firms even small cost differences can erode relative competitive position. Conventional forms of regulation can have effects other than just raising production costs. For example, complex and time-consuming permit-

ting procedures can make it difficult for manufacturers to continuously improve production processes and rapidly introduce new products.

3. A number of experiments are underway across the Nation as regulators and industries seek new regulatory approaches that protect the environment effectively while reducing competitive impacts on fins, These experiments include emphasis on pollution prevention; use of multimedia regulation, permitting, and inspections; development of facility-wide emission caps and performance standards; allowing good environmental performers more choices in selecting how they will comply with regulations; and introduction of economic incentives, including tradable permits and fees. The techniques explored in these experiments can complement and enhance the present regulatory tool kit, but they have yet to be widely adopted,

4. In many cases, economic incentives could lower environmental compliance costs. With tradable permit systems, for example, firms able to reduce pollution cheaply have an incentive to go beyond what otherwise would be required, while firms with higher marginal control costs would not need to do as much as otherwise if they purchase credits from the lower compliance cost firms. Incentives could also stimulate development of lower cost compliance approaches. While incentive systems can lower compliance costs, they cannot be applied in all cases. They are a supplement, not a replacement, for the regulatory system.

5. The traditional means for complying with pollution abatement laws—use of end-of-pipe or remedial technologies to deal with pollution or waste after it has been created—almost always add to manufacturing costs. Pollution prevention alternatives (which include source reduction) and recycling of industrial pollutants and wastes are promising ways for lowering compliance costs. Some source reduction and recycling projects quickly pay for themselves through reduced material and energy use and savings from recovered materials. Source reduction sometimes speeds technical change, leading to increased investment in new plant and equipment. Source reduction and recycling usually pay off when compared to the cost of treating or disposing wastes. But, many projects are not cost-effective in the absence of regulatory requirements.

6. As the simpler steps for pollution prevention become widely adopted, a significant source of environmental improvement will lie in new generations of manufacturing process technologies that are cleaner, and often more productive, than older generations. Cleaner technology has only recently emerged as an objective for industrial R&D. With the exception of some energy related technologies, public and private funding has been limited.

7. Technical assistance can help fins, particularly small and medium-sized firms, implement pollution prevention and recycling measures and more effectively meet environmental regulations. Yet, U.S. programs are very small; many of them, by focusing only on pollution prevention, do not consider productivity and quality issues that could more fully meet manufacturers needs.

Preview of Policy Options

In this study, OTA assumes that U.S. pollution control and abatement standards will continue at their current levels, which makes them among the highest in the world, and that the standards may well become more stringent in the future.[2] OTA does not consider the option of lowering U.S. standards as a competitive response to weaker

[2] Other types of environmental laws and regulations, such as those governing land use, resource management, and protection of species, are not addressed in this assessment.

standards elsewhere.[3] Hence, the major competitive questions in this study are:

1. Given continuation of strong standards, how can U.S. manufacturing maintain or enhance its industrial competitiveness?
2. How can the United States benefit from high standards through an internationally competitive U.S. environment industry?

OTA has examined the pros and cons of a wide range of policy options that bear on these questions, both domestically and abroad (see table 1-4 and additional discussion further on and ch. 2). Domestic measures, for example, might include coordinating Federal support for environmental and manufacturing industry R&D; encouraging States and Federal agencies to integrate delivery of environmental and manufacturing technical assistance to better assist small and medium-sized firms; and giving firms that are strong environmental performers more options to determine how they will meet environmental standards.

The Federal Government also might do a better job of promoting exports of U.S. environmental goods and services. Authorizations in recent laws directed at this goal provide a starting point. Additional measures could be considered. Some steps taken primarily for domestic purposes might enhance exports. For example, the Federal Government could *oversee* more independent evaluations and performance verifications of U.S. environmental technologies, and make this information available to foreign purchasers.

Greater international cooperation on environmental matters could produce new commercial opportunities for U.S. environmental firms and ease negative competitive impacts for manufacturing fins. For example, both competitiveness goals and environmental goals might be served if the U.S. Government were to more vigorously negotiate agreements with other countries to upgrade their environmental standards. It could also help developing countries build their environmental capabilities on a multilateral basis.

The options could be adopted singly or in packages. OTA has formulated two strategies—an incremental approach and a more aggressive effort—that could guide U.S. efforts (see box 1-D further on and ch. 2). Many of the options could be accomplished through more effective integration, coordination, or reorientation of Federal programs. While such steps could be useful, some actions—such as development of next generations of cleaner manufacturing technologies, or increasing access to export financing for U.S. fins-would require new funding beyond the current modest levels.

ORGANIZATION AND SCOPE OF THE REPORT

This report is the third and final publication of an assessment of environmental issues and American industry that was requested by the House Foreign Affairs Committee, the House Energy and Commerce Committee, and the Senate Finance Committee.[4] The final report examines:

- how American business and the U.S. economy might benefit from the growing global interest in controlling emissions, treating wastes, and preventing pollution; and

[3] This assessment does not examine environmental priorities or goals. Nor does it examine risk assessment/management as a way to set environmental spending priorities. The latter approach is advocated by those who argue that the present environmental protection system directs too much spending to areas of relatively little environmental risk and too little to areas posing much higher risks. Another OTA study is examining the research base to improve risk assessment, including environmental pollutants.

[4] The House Foreign Affairs Committee also asked OTA to provide interim products on trade and environment issues, and on environmental industries. OTA produced two background papers in response. See 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) and U.S. Congress, Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology*, OTA-BP-ITE-107 (Washington, DC: U.S. Government Printing Office, August 1993).

- ways to counteract competitive disadvantages for U.S. manufacturers that compete with firms in countries with weaker environmental standards or with firms from countries that provide more government help for compliance with environmental standards.

Part 1 is comprised of this summary chapter, a chapter on policy issues and options, and a chapter about the report's conceptual framework.

Part 2 discusses opportunities for U.S. business in providing environmental technologies and services to a growing global market. The discussion covers, first, the traditional sectors that market equipment and services for control, disposal, and remediation of industrial pollution and household waste, and, second, on a more selective basis, cleaner production technologies and related services. The latter sector can be thought of as an "invisible' environmental industry of pollution prevention and improved energy efficiency. (Green consumer products are not addressed in detail). Government export promotion policies of the United States and some competing countries are also discussed.

Part 3 examines the difficulties manufacturing firms face against competitors in countries with weaker or more flexible regulations or that get more help in complying with environmental regulations or improving technology. It examines ways to reduce potential competitive impacts while maintaining or strengthening standards. These include an increased focus on pollution prevention (including public and private efforts to develop and diffuse cleaner production processes), use of economic incentives, and modifications to make the regulatory system operate more efficiently.

Part 4 examines the organization of environmental technology R&D in the United States and some other nations.

EXTENDED SUMMARY

Results from the report are discussed more fully below. The section immediately below discusses the environmental market and U.S. environmental industry competitiveness. This is followed by discussion of environmental compliance costs, regulations, pollution prevention, and manufacturing industry competitiveness. The final section discusses policy issues and options in 6 areas: technology policy; diffusion of best practices and technologies to industry; regulatory reform and innovation; development assistance, export promotion, and environmental industries; trade and environment interactions; and data needs for policymaking.

Environmental Markets and U.S. Environmental Industry Competitiveness

Estimates of the current and future size of the global market for environmental goods and services vary widely. A study by the Organization for Economic Co-operation and Development (OECD) estimated the 1990 market for environmental services and for traditional pollution control and waste treatment equipment at $200 billion, with the potential to grow to $300 billion in the year 2000.[5] Another estimate placed the 1992 market at $295 billion worldwide, with potential to grow to $426 billion for 1997.[6] Different definitions partly explain the variation. Also, the quality of data varies.

Neither estimate fully accounts for cleaner production technologies (referred to as invisible EGS) which could become a fast-growing segment of the environmental market. Manufacturers

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[5] Organization for Economic Co-Operation and Development (OECD), *The OECD Environment Industry: Situation, Prospects and Government Policies*, OCDE/GD(92)1 (Paris: OECD, 1992). OECD's estimates do not include cleaner production and energy efficiency products or services except for some pollution prevention consulting services.

[6] Grant Ferrier, Environmental Business International, presentation to Environmental Business Council of the United States conference, Washington, DC, June 7-9, 1993. The estimate does not include cleaner technology except for renewable and cogenerated energy.

Box 1-A—Leaders in Cleaner Technologies

in the United States, several northern European countries, and Japan, efforts to develop and establish cleaner technologies are underway. The primary motivation is to further environmental objectives through pollution prevention, reduced use of toxic and hazardous substances, improved energy efficiency, and product reuse or recycling.

In contrast to pollution control, pollution prevention is integral to process and product; therefore, cleaner production technologies change (and can sometimes improve) production systems. In some cases, developers, vendors, and early users of these technologies can gain competitive advantage.

The United States is a leader in the development of many cleaner production technologies. R&D has been spurred by the expense and liability of hazardous substance disposal, phase-out of ozone depleting substances, a requirement that firms report their releases of toxic substances, and increased regulation of volatile organic compounds and toxic air pollutants. As a result, many U.S. firms are actively seeking substitutes and ways to reduce the use of these substances when they cannot be eliminated. Aqueous metal cleaning baths, low emission paint nozzles and coating formulations, advanced curing technologies, better catalysts and chemical reactor designs, and cleaner pulping technologies are among advances that the United States can capitalize on through technology exports and improved domestic production. U.S. firms are a dominant market presence in some clean energy technologies such as gas turbines. There is, however, strong competition from abroad in several renewable energy technologies, some advanced combustion technologies, and emerging technologies like fuel cells. The United States also has pioneered demand-side management approaches for electric power conservation.

Germany appears to be moving toward greater emphasis on pollution prevention. As in the United States, there are strong efforts for replacement and recovery of organic solvents and toxic chemicals. German environmental compliance costs are on the same order as in the United States; industry can find lowest cost solutions through pollution prevention. In addition to pollution prevention, Germany is establishing strong requirements for recycling. Initially focused on packaging, German product take back requirements could soon apply to a wide variety of products including automobiles, computers, and other machinery. Such **requirements can give German industry significant impetus to design products for ease of recycling and to create processes to aid in recovery and reuse. Initial implementation,**

(continued on next page)

and designers of less-polluting and more energy-efficient equipment for power generation, industrial processing, buildings, and transportation are likely to find increased trade opportunities in many regions of the world. In the long run, cleaner production technologies may cut into (although not eliminate) demand for end-of-pipe technologies.

It is very difficult to estimate the current and potential size of the market for cleaner technologies and production processes. Some projections combine conventional technology, cleaner production processes, and energy efficiency into a single forecast for a seemingly enormous environmental market ($600 billion or more) a decade from now. Such projections suggest the growing importance of environmental factors in the demand for a wide range of products and services. While the commercial potential of cleaner technologies is high, development efforts are still in their early stages; aside from the United States, most of the activities are occurring in a few European countries and Japan (see box l-A).

Box 1-A—Leaders in Cleaner Technologies--Continued

however, has proven difficult.[1] If they are adopted in other countries, requirements that make manufacturers responsible for disposal of products could alter the relative competitiveness of American and German firms. German firms are also highly competitive suppliers of renewable energy and other cleaner energy technologies.

Other northern European countries that strongly promote pollution prevention include the Netherlands and the Scandinavian countries. The large Swedish/Swiss environmental and electrical machinery conglomerate, ASEA Brown Boveri, is a major provider of advanced turbines and a leader in some advanced combustion technologies. Scandinavian pulp and paper firms and suppliers are among the world leaders in cleaner pulp and papermaking technologies. In the energy sector, Denmark is the major competitor of U.S. firms in wind energy.

The Dutch use their tax code to promote the development and use of clean manufacturing technologies. Firms that install innovative pollution prevention or control technologies can depreciate their investment in 1 year instead of 10. The tax break only applies to a list of innovative technologies that is annually revised by a group of industry and government experts. Technologies are dropped from the list when they gain a significant marketshare or are required by regulation. Overall, the Dutch spend close to $500 million a year on environmental technology (equivalent on a per capita basis to $9 billion in the United States), and a significant share is for pollution prevention and energy technologies.

Because of high energy prices and aggressive government policies adopted after the energy supply shocks of the 1970s, Japanese industry has made significant strides in adopting energy efficient technologies, which provide direct and indirect environmental benefits. Japan is contending for leadership in some clean energy fields including photovoltaic power and fuel cells. Since early 1992, the Japanese Government has supported its fuel cell industry by subsidizing purchases by hospitals, hotels, and schools. Moreover, Japan is active in recycling technology, a logical interest for a nation that is highly dependent on imported materials and has little space for landfills. Japanese firms also have been very active in developing CFC substitutes. However, in contrast to conventional wisdom, the Japanese do not appear to be in the forefront in other areas of industrial pollution prevention. The distinction between prevention and control of pollution seems to be less advanced in Japan than in the United States and Northern Europe.

1 "Germany's Troubled DSD Offers Lessons on Product Takeback Policy", *Business* and the *Environment*, vol. IV, *No. 7,* July *1993, p. 2.*

According to the OECD estimate, the industrialized countries accounted for more than 80 percent of the 1990 market for environmental services and conventional equipment. The United States accounted for 40 percent of the global market, making it the largest national market. Industrial country markets (the OECD member states) are likely to account for most EGS demand over the next 10 to 20 years.

While small now, some markets outside the OECD may grow more rapidly than the OECD market as a whole. Much of the demand in these nations is for environmental infrastructure, such as water and wastewater treatment, and other basic sanitation services, and control of urban air pollution. The fast-growing East Asian area, already a significant market for some environmental technologies, could emerge as a major new market for a full range of technologies, including cleaner production processes and facilities.

Singapore, one of the four Asian economic tigers, has in place environmental standards that rival those of some OECD countries. South Korea, Taiwan, Thailand, and Malaysia plan major environmental expenditures in coming years. Some less prosperous nations, including China and Indonesia, may grow into significant environmental markets. But U.S. firms seeking to expand into the East Asian markets will face Japan's already strong commercial presence, Some efforts, such as the public/private United States-Asia Environmental Partnership, attempt to give U.S. firms a more visible role in the region.

Latin America is another promising region for American technologies and services. Mexico and Brazil plan multibillion dollar investments to treat drinking and wastewater, and hope to tackle other urban and industrial environmental problems. Other Latin American countries, including Argentina, also plan major environmental investments. The nations of Central and Eastern Europe and the former Soviet Union are trying to repair severe environmental damage. These huge potential markets are likely to be constrained by the rate at which these countries progress economically and move to successful market-based economic systems.

Many factors affect the size and nature of environmental markets, The most important is the strength of a country environmental regulations and its ability to enforce the regulations. Most if not all end-of-pipe and remedial controls are not cost-effective in the absence of regulatory requirements. Other factors are also important. A healthy economy is important for environmental market growth; contrary to some past predictions, the EGS industry is not immune to recession even in countries with strong regulations. The possibility of saving money and realizing gains in quality and productivity can make some investments in source reduction, and waste recycling, and particularly energy efficiency cost-effective even in the absence of regulation. In addition, new technologies to improve productivity often have concomitant environmental benefits.

WORLD BANK/UNDP

Basic services, such as water supply, sewerage, and refuse collection, are major environmental needs in most developing countries.

Also, some consumers are choosing products produced in ways deemed environmentally preferable; this can influence producers even in countries without strong standards. To some degree, environmental investments in countries without strong standards may be driven by the decisions of some multinational companies to apply their home country environmental standards. Public financing agencies and private lenders increasingly consider environmental factors (e.g., possible future liability) in making loans in areas that lack strong standards.

While the worldwide market is large, most spending for environmental infrastructure (water, sewer, and waste utilities), major industrial air and water pollution abatement installations, and remedial treatment is for local construction, fabrication, and operation. In many cases lower value materials like cement and sheet metal will be procured locally rather than imported. Operation of environmental facilities, including trash collection and disposal, and water and sewer service, largely involves local or regional labor forces. Environmental industries are developing in many countries, In local and regional markets these firms may increasingly compete with American and other OECD-based firms. In some cases, local content regulations and tariffs can limit export opportunities although the development of local pollution control expertise may create demands for more sophisticated technologies more likely to be supplied by imports or licensing.

For all these reasons, international trade fills only a fraction of the demand for goods and services associated with environmental projects. Still, that fraction represents a significant amount of trade, for which competition is intense. Trade data and information are inadequate. However, Germany and the United States are believed to be the largest exporters of EGS.

According to one estimate,[7] Germany, the United States, and Japan exported $23 billion in environmental products in 1992—about 7.8 percent of an estimated world environmental products and services market of $295 billion. U.S. product exports were estimated to be nearly $7 billion, or about 20 percent of U.S. environmental goods production. German and Japanese product exports were estimated to be $11 billion and $5 billion, respectively. U.S. service exports were estimated to be $3.5 billion-less than 10 percent of U.S. solid waste management revenues, and 5 percent or less of sales for engineering, hazardous waste, analytical, and other services. (Imports, non-U.S. service exports, and the proportion of production exported by other countries were not estimated).

According to OECD's study, Germany, the United States, and Japan had 1990 trade surpluses—including license royalties-of $10 billion, $4 billion, and $3 billion, respectively. Britain and France had estimated trade surpluses of $500 million each. The Netherlands and Sweden apparently also were net exporters.

An EPA study, based on analysis of several product trade codes deemed environmental, concluded that the United States ($1.7 billion total, $1.1 billion net), Germany ($1.5 billion total, $0.7 billion net), and Japan ($0.7 billion total, $0.3 billion net) were the largest exporters of environmental products.

Environmental services, including engineering and management services, are an expanding component of environmental expenditures. International sales in products center on relatively sophisticated equipment and supplies such as monitoring and control instruments, specialized devices (e.g., aerators, falters) and chemicals, and ancillary equipment (e.g., construction and materials handling machinery). Licensing of technologies is also common.

Environmental components are also embedded in other products or services that are traded. This can complicate analysis. For instance, while U.S. companies are major producers of automotive catalytic converters, the United States imports foreign-assembled catalytic converters that are attached to imported automobiles. And, while there is growing world demand for engineering design services for environmental projects (e.g., waste treatment facilities or scrubbers), such services can be a component of larger contracts for design of whole production facilities (e.g., power plants, refineries, or chemical plants). As cleaner production becomes a more important objective, those engineering firms that are most adept at integrating environmental objectives into the design of full facilities may have a competitive leg up (see box l-B).

U.S. ENVIRONMENTAL INDUSTRY COMPETITIVENESS

It is difficult to assess national competitiveness in most environmental sectors. As discussed previously, data on environmental products trade are limited, while data on trade in services are largely unavailable. Licensing, joint ventures, and multinational acquisitions further complicate analysis. Many large environmental firms now operate on several continents. Flows of profits

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[7] Grant Ferrier, op. cit., footnote 6. The estimate in the next paragraph above is from OECD, op. cit., footnote 5; that in the second paragraph that follows above is from U.S. EPA, "International Trade in Environmental Protection Equipment: An Analysis of Existing Data, " EPA 230-R-93-O06, Washington DC, July 1993.

Box l-B—Engineering Services and Cleaner Production Facilities

Engineering and construction firms could play a role in moving industrial production from a largely end-of-pipe approach toward pollution and waste to a cleaner production orientation. In addition to designing and building wastewater treatment plants, waste disposal facilities, and major air pollution abatement installations, these companies also design power plants, chemical plants, pulp and paper mills, petroleum refineries, steel mills, and other industrial production facilities. In theory, these firms are well-positioned to integrate improved energy efficiency and cleaner production processes into facility design.

Design of whole production facilities could be more commercially rewarding than contracts for discrete environmental add-ens. While potential markets for discrete environmental goods and services are large, the markets for industrial production capital plants and machinery are far larger. Wards of design contracts to U.S. companies can contribute to U.S. exports through fees earned by t hose firms, and indirectly, because U.S. designers are more likely to incorporate U.S. standards and products into their plans. Furthermore, environmental design responsibilities for a facility often may lie with the overall facility designer. The United States is highly competitive in the engineering field and possesses high competency in process engineering. However, major competition is presented by European and Japanese firms that can often bring to the table financial packages sweetened by their governments.

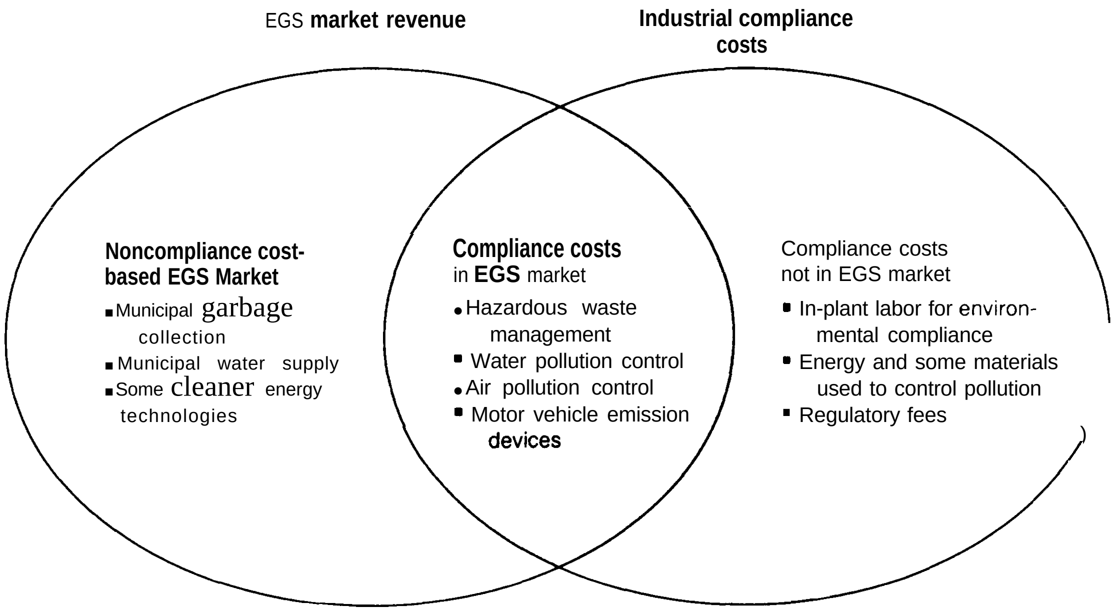
and royalties are difficult to compare with employment and export earnings. For instance, some environmental companies in the United States are subsidiaries of foreign firms but export goods and services from the United States. At the same time, a number of American companies have foreign operations that mainly serve local markets.

Generally, the most competitive environmental industries are found in countries with stringent environmental regulations. However, many other factors are involved, Some, including cost of capital, general export promotion policies, and overall workforce ability, are common to most or all industries. Others are more particular to the EGS sector.

Among the major competitiveness factors are:

1. Strength and form of home country environmental regulations. Leading international environmental firms generally come from countries with the toughest regulations. Also, the form of regulations can influence innovation, which in turn can lead to new product offerings and to export opportunities.
2. Fiscal and other domestic incentives for adoption of innovative environmental technologies or approaches. Countries may use tax incentives, loans, utility regulation, and other techniques to encourage domestic industry to make environmental investments. National environmental firms may be helped as a result.
3. Industrial structure, including company size and financial strength. While small entrepreneurial firms can be innovative, large companies have easier access to capital and possess the resources to pursue export opportunities.
4. Promotion abroad of home country standards, practices, and testing protocols. This can help create markets for technologies known to meet the standards.
5. Export awareness and support. Many U.S. environmental firms are not attuned to export opportunities, while some foreign competitors are more focused on international business.
6. Financing packages, including development assistance. For projects in developing coun-

Figure 1-1--Overlap of Selected Environmental Compliance Costs and EGS Market Revenues



SOURCE: Office of Technology Assessment, 1993.

tries, foreign government aid donors sometimes offer attractive financing packages benefiting their firms that American companies cannot meet.

7. Appropriate technologies, products, and services. Many countries lack resources or do not have the expertise to obtain or maintain advanced technologies. Some products used in high-standard countries maybe too expensive and sophisticated for other markets.
8. Research, development, and demonstration. R&D can yield new and improved technologies, while demonstrations and independent technology evaluation can play an important role in diffusing innovative technologies domestically and internationally.

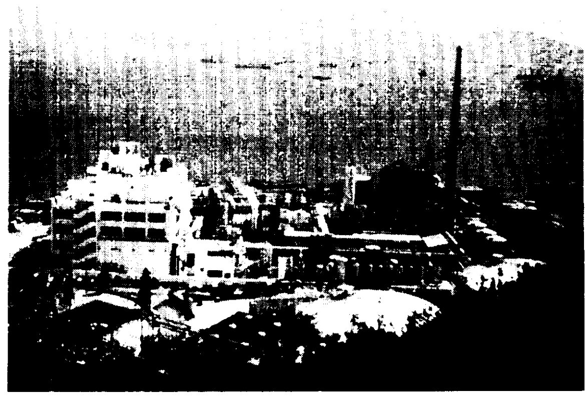
No single factor explains leadership in all EGS sectors. For instance, tough standards in home country markets help explain the strength of German, Japanese, and Scandinavian firms in selling some sulfur dioxide (SO_2) and nitrogen oxide (NO_x) control technologies. But, British and French wastewater treatment companies are strong performers in the international market even though British and French standards are weaker than those in the United States and some other European countries. Strong cash positions following privatization and experience in providing integrated services as large utilities contribute to British and French success.

The U.S. environmental industry is the world's largest, estimated at over 34,000 firms employing over 900,000 people and earning $112 billion in revenues (not including private water utilities or publicly operated water, sewer, and solid waste operations).[8] The revenue estimate is not a measure of final demand or of the total contribution to GDP. Sales from EGS firms to other EGS firms may be double-counted. Sales of some cleaner technologies may not be counted. The revenue estimates also do not include internal costs (e.g., labor) by complying firms. Hence, the revenue estimate differs from estimates of U.S. environmental compliance costs (figure 1-1).

The U.S. industry is comprised of a few large fins, some of which operate on a worldwide basis, and a large number of small- or medium-sized enterprises. Many of their major European and Japanese competitors belong to large, well-capitalized conglomerates that operate in other major markets, including the United States. There are indications that these firms sustain higher levels of private R&D than most of their American rivals. Many major U.S. and foreign firms are active in several businesses, such as engineering and construction, chemicals, power generation, petroleum, transportation, instrumentation, electrical equipment, and materials.

OTA has analyzed international competition in 8 major environmental industry sectors encompassing both goods and services. Most of the cases feature end-of-pipe control, disposal, and remedial technologies and services but some, more selectively, highlight pollution prevention and cleaner production. The cases examined are:

1. design and construction services;
2. stationary source air pollution controls;
3. mobile source air pollution controls;
4. water and wastewater treatment equipment technologies;
5. solid and hazardous waste management;
6. contaminated site remediation;
7. cleaner energy technologies, including gas turbines, advanced coal technologies, renewable energy, and end-use energy efficiency; and
8. cleaner industrial production technologies.



WASTE MANAGEMENT INTERNATIONAL

Some *large environ mental firms operate on a worldwide basis. This hazardous waste treatment facility in Hong Kong is run by a subsidiary of a U.S. firm.*

U.S. companies remain competitive, although not dominant, in most environmental sectors. However, the U.S. position has eroded in some areas, Foreign ownership of U.S. environmental firms has increased over the last decade. U.S. companies seem to depend more on air, water, and incineration technologies developed abroad. Foreign technologies as well as U.S. subsidiaries of foreign-owned firms are prominent in such Federal technology development and demonstration programs as the Clean Coal Technology Demonstration Program. Clearly, competition in international environmental markets has intensified.

American technologies often have a good reputation abroad. However, particularly in developing and newly industrialized countries, they are sometimes perceived as over-engineered and too expensive for local needs. US. vendors are sometimes seen as providing poorer after-sale

[8] Grant Ferrier, op. cit., footnote 6.

service than Japanese, German, and some other foreign vendors.

Because international trade fills only a small fraction of world demand, the growth in export-related jobs in the United States and leading exporters will be smaller than suggested by the size of the global market. However, these export-related jobs are likely to include many high wage engineering and management positions, and relatively skilled blue collar jobs in the manufacture of components and machinery. Some jobs could accrue from exports of ancillary goods such as construction equipment used in building environmental projects.

In the long term, opportunities for the export of cleaner production goods—that is, capital goods for factories, mines, mills, power plants, and other production facilities--could become an important source of export-related jobs. Manufacturers of environmentally superior capital goods, especially those incorporating cost-saving improvements in energy or materials efficiency, will have an advantage as other countries tighten their environmental requirements. The distinction between the visible EGS sector of environmental equipment and the invisible EGS sector of cleaner production goods may blur over time.

While some U.S. environmental companies are keen competitors for international markets, the great majority do not export. Most U.S. environmental firms are small or medium-sized, with modest capitalization. They often lack the interest or the resources to exploit-or even learn about—export opportunities. Even many larger U.S. firms are not well-represented in international markets. The size of the U.S. domestic market has created a large, vibrant, domestic industry that often has little interest in exporting; at the same time, the U.S. market attracts foreign competitors. (Table 1-1 illustrates some of the relative strengths and weaknesses of U.S. environmental industries.)

Increasing export awareness and interest among small and medium-sized U.S. environmental firms will be important for improving U.S. export performance. Improving export awareness among lenders is important as well; banks outside of the major U.S. money centers are often inexperienced in international transactions. As is discussed in chapter 6, U.S. firms receive less export assistance from government than their counterparts in some European countries and Japan.

Both EGS competitiveness and manufacturers' ability to comply with regulations is affected by government support for environmental technology research, development, demonstration, and evaluation. As is discussed in the policy section below and chapter 10, U.S. government agencies spend substantial funds for R&D pertinent to environmental technologies. While there are major exceptions, commercial objectives have not been a key priority for most of these programs. Also, Federal R&D support has not been centrally coordinated (although two interagency bodies have recently been formed). Recent legislation and administration initiatives, if vigorously pursued, could result in more governmentwide coordination and a more commercial orientation; several pending bills address Federal environmental technology R&D.

In Europe and Japan, government support for environmental technology R&D often is funded or coordinated by agencies with industrial policy missions, such as the Japan's Ministry for International Trade and Industry (MITI), Britain's Department of Trade and Industry, Germany's Ministry for Research and Technology (BMFT), and the European Community's Directorate-General XII. The R&D programs focus on technologies with domestic and international commercial promise. The usefulness of R&D to industry is a key concern; for example, Japan's New Energy and Industrial Technology Development Organization (NEDO), a MITI affiliated quasi-public corporation, directly funds industry technology development projects.

Table l-l—The U.S. Environmental Industry: Strengths, Weaknesses, Opportunities, Threats

Strengths:	Weaknesses:
Large domestic market supports U.S. EGS development	Large domestic market inhibits desire to export
Head start; toughest standards in many areas	Other nations often perceive U.S. technology as too expensive/sophisticated
High technical capability of industry	Spotty public/private links in R&D, export promotion
Good reputation of EPA technical information abroad	Limited Federal effort to certify or provide objective evaluations of technologies
Strong Federal and university R&D capacity	Slow transfer of technology to the marketplace
Many small innovative firms	Small firms have difficulty accessing capital, exploiting export opportunities
U.S. political, economic, technical, and cultural leadership	Limited effort to understand foreign cultures, languages, business practices
	Limited role of industry associations in trade and R&D
	Some regulatory measures impede environmental technology innovation
Opportunities:	Threats:
Growing U.S. and foreign demand	Growing foreign environmental industry capacity, including penetration of U.S. market
	Foreign standards highest in some cases
Possibility y of others adopting U.S.-based standards and practices	Possibility of others adopting foreign standards and practices
Development assistance can promote U.S. exports	Other donors' use of tied aid credits keep U.S. firms from winning some business
Internationalization of EGS business: —Acquisitions of foreign firms (U.S. gets profits) —Licensing abroad (royalties) —License from abroad (U.S. jobs)	Internationalization of EGS business: —Acquisition by foreign firms (foreigners get profits) --Licensing abroad (jobs abroad) —License from abroad (royalty paid)
Opening of many countries to greater trade, foreign investment, privatization	Strong foreign public/private cooperation in R&D, export promotion
	Stronger foreign trade association role in trade promotion and R&D

SOURCE: Office of Technology Assessment, 1993.

Table 1-2-Some Economic Costs and Benefits of Environmental Regulation

Potential costs	Potential benefits
• End-of-pipe investments divert funds from more productive investments, thus slowing productivity growth	• Increased benefits from a cleaner environment (e.g., reduced health costs, increased natural resource productivity)
• Some plants facing high environmental compliance costs relocate to pollution havens or close	• Production process changes that increase productivity
• Increased production costs for high compliance cost sectors, therefore reducing exports and increasing imports	• Job creation in environmental goods and services sectors
• Reduced innovation (e.g., uncertainty about regulatory acceptability of new products or processes)	• Possible trade surplus in the environmental goods and services sectors and increased sales from consumer demand for green products
	• Increased innovation (e.g., more efficient products)

SOURCE: Office of Technology Assessment, 1993.

Environmental Regulation and Manufacturing Industry Competitiveness

The impact of the current system of environmental regulations for U.S. manufacturing must be viewed in the context of an increasingly competitive world economy. As other OTA reports have documented, U.S. manufacturing industries have been challenged in the last decade by able foreign competitors from other advanced industrial nations and from some newly industrialized countries.[9]

Environmental regulations, while providing important societal benefits, can have negative impacts for individual fins. In addition to higher costs from treating or controlling wastes, firms may be affected by regulatory delays, and in some cases may avoid using new technologies because of regulatory risks. Of course, some firms may benefit from environmental requirements if they can upgrade production processes and become more efficient. Table 1-2 shows representative costs and benefits.

Environmental regulations are not a principal determinant of industrial competitiveness, Other factors, such as management savvy and time horizon, capital cost and availability, workforce skills, market access and foreign trade practices, and technology innovation and diffusion, play more significant roles. However, because environmental regulations do play *some* role in competitiveness, reducing environmental compliance costs while maintaining current levels of environmental protection can improve U.S. industrial competitiveness. Moreover, certain industrial sectors are affected far more than others.

Efforts have begun to make our environmental protection system more efficient and to reduce the tradeoffs between environment and economics. One way to do this is pollution prevention. Many source reduction and recycling options yield net

[9] Sce for example, U.S. Congress, Office of Technology Assessment, *Competing Economies: America, Europe, and the Pacific Rim,* OTA-ITE-499 (Washington, DC: U.S. Government Printing Office, October 1991); *U.S.-Mexico Trade: Pulling Together or Pulling Apart?,* OTA-ITE-546 (Washington, DC: U.S. Government Printing Office, October 1991); *Making Things Better: Competing in Manufacturing*, OTA-ITE-443 (Washington, DC: U.S. Government Printing Office, February 1990); *International Competitiveness in Electronics,* OTA-ISC-200 (Washington DC: U.S. Government Printing Office, November 1983); and *Technology and Steel Industry* Competitiveness, OTA-M-121 (Washington, DC: U.S. Government Printing Office, June 1980),

positive rates of return equaling nonenvironmental investments; others are less attractive as an investment, or cost money, although usually less than end-of-pipe treatment. While pollution prevention can ease conflicts between environmental protection and industrial competitiveness, it does not eliminate it.

U.S. INDUSTRY'S COMPLIANCE COSTS

According to a Commerce Department survey, U.S. businesses spent $42 billion on pollution abatement and control in 1991. While only about 0.8 percent of total manufacturing sales, compliance costs are more significant when measured against other demands for a fro's resources. For example, U.S. firms spent about $43 billion in 1991 on formal training for their workers, and about $78 billion on research and development.

Manufacturing firms alone spent $21 billion for pollution abatement and control in 1991. (For reasons discussed inch. 7, their expenditures may be underreported by 20 to 30 percent). Process industries experience higher compliance costs than the discrete parts manufacturers and assemblers. Just four process industries-chemicals, petroleum, pulp and paper, and primary metals—account for nearly three-fourths of pollution abatement capital expenditures by manufacturers (but only 22 percent of manufacturers' value added). These industries also account for a disproportionate share of pollution and hazardous waste generation by manufacturers.

Compliance costs are not a major share of total costs for any industry, and are only one of many factors determining competitive advantage. For example, of the high compliance cost sectors mentioned above, chemicals and wood pulp are highly competitive internationally, with significant trade surpluses. The primary metals industry is struggling. These four sectors devoted an average of 15 percent of their capital expenditures to pollution abatement and control, compared to 3.2 percent for all other manufacturing sectors. Their pollution abatement and control expenditures amounted to 4.85 percent of their value added, compared to the average of 1.72 percent for manufacturing as a whole. Some subsectors have much higher compliance costs than the sector average. For example, while the fabricated metals industry as a whole spent 4.6 percent of capital on environmental protection, the metal plating and polishing subsector spent over 27 percent.

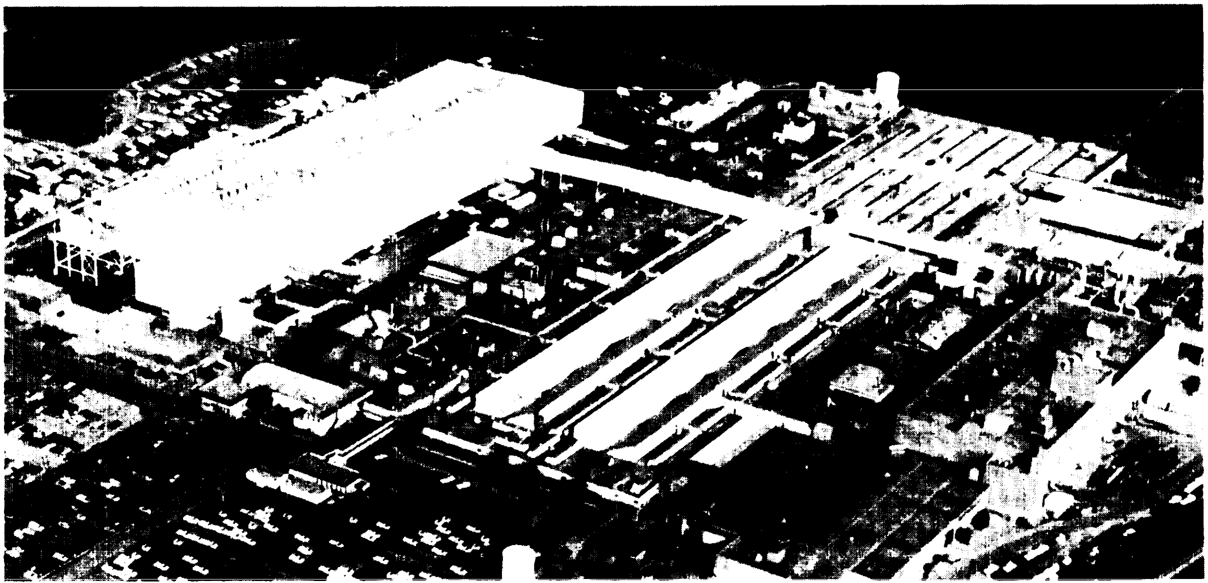
Pollution control and abatement regulations can also make it harder for firms to alter production processes quickly. Flexibility is especially important for batch manufacturers (e.g., specialty chemicals) and discrete part manufacturers (e.g., semiconductors). As more U.S. manufacturers seek to adopt production systems amenable to continuous improvement and rapid new product introductions, some features in the regulatory system may need to be modified accordingly. As discussed below, there are a number of options to lessen adverse competitive impacts on firms that are good environmental performers, and to do so without jeopardizing environmental standards.

As has been discussed, some environmental compliance costs for manufacturing industries represent equipment and services provided by environmental fins. However, there is not a one-to-one relationship between compliance costs and EGS industry revenues. As shown in figure 1-1, some compliance costs are for labor or other internal costs. And some revenues (e.g., for garbage collection or for water purification and supply) are income for environmental firms but are often not considered a regulatory cost.

FOREIGN ENVIRONMENTAL REQUIREMENTS

Environmental cost data for different nations are limited and of varying quality. Even so, judging from the available information, it appears that pollution control and abatement costs in most of the other OECD nations, with the exception of Germany and possibly some of the Nordic countries, are lower than in the United States. Japanese manufacturers' compliance costs appear to be significantly lower than U.S. costs. While Japa-

FORD MOTOR CO.



U.S. automakers spend large sums to build and operate facilities to control painting emissions. Ford estimates that it has spent between $150 to $180 million to build its recent paint shops, of which $20 to $40 million is to control pollution. The paint shop (on the left) of this Ford truck plant in Virginia is larger than the assembly line building on the right.

nese industry made high levels of investments for pollution control in the early 1970s, U.S. industry over the last 15 years has paid more for pollution control and that gap is growing. For example, pollution abatement capital expenditures by U.S. automobile firms (to control pollution from the production process) are approximately five times greater than those of automobile firms in Japan as a percent of total capital investments; they are three times more as a percent of sales. Japanese industry did, however, make major investments in energy efficiency technologies over the same period.

There is also significant variation in the degree to which governments provide both financial and nonfinancial assistance to help polluters meet environmental requirements. A number of countries, including Germany and Japan, offer tax incentives, R&D funds, technical assistance, and loans to firms to help them cover the costs of implementing environmental technologies. This not only helps their manufacturers with compliance but also helps their environmental firms make sales, For example, in 1992, the Japanese Government provided the equivalent of over $2 billion in low-interest loans to firms installing pollution control equipment.

The U.S. Government provides relatively little financial help to its industries to meet environmental standards, U.S. industry must depreciate pollution control equipment over a longer period than firms in some other countries. Some technical assistance is available through State programs, although this also is quite limited.

Compliance costs in newly industrialized countries (NICs) and developing countries are much lower than in most OECD nations, as most of these countries have only recently begun to put in place and enforce environmental standards. Hence, a regulatory gap between the United States and most other countries will continue throughout this decade and beyond. An important issue is whether this gap will make U.S. products more expensive, or encourage U.S. firms to relocate to countries with fewer or less stringent regulations. These questions are now more prominent due to debate about liberalizing trade and investment with developing and newly industrializing nations.[10]

These issues are difficult to analyze, and studies offer mixed results. Most find that environmental regulation has had little overall effect on U.S. trade performance. However, a number of studies detect greater impacts in some sectors where U.S. firms have higher compliance costs than their competitors. As for siting facilities, market access, wages, and labor standards are much more important overall, but environment is a more prominent location criterion for U.S. firms in industries with high compliance costs or regulatory burdens.

To the extent that U.S. manufacturers are disadvantaged, various responses (including both trade and domestic measures) are possible. Trade measures such as countervailing duties could be considered, although there are concerns about their administrative practicality and consistency with trade rules.[11] The United States also could negotiate with other countries for higher standards, as is discussed in the policy section below and in chapter 2, Another possibility, discussed below and in chapters 8 and 9, would be to make it easier for U.S. industry to adopt lower cost compliance strategies through incentives for pollution prevention and changes in the regulatory system to encourage innovation.

POLLUTION PREVENTION, CLEANER PRODUCTION, AND COMPLIANCE COSTS

It is difficult to document the current extent of source reduction or recycling by industry. Some argue that U.S. firms have already done what is easy and inexpensive, and therefore future gains will be small. However, significant source reduction opportunities still appear to exist, particularly those arising from industrial process modifications and the adoption of new technologies.

Widespread diffusion of existing off-the-shelf technologies could go a long way in further reducing pollution. However, many in industry, particularly small businesses, are unaware of pollution prevention options. Some technical assistance is available to industry through State programs and other sources, but programs are small. More importantly, by considering pollution prevention separately from other manufacturing needs, such as productivity and quality improvements, most programs fail to develop the vital synergies and working relationships with manufacturers that are essential to drive both pollution prevention and increased manufacturing competitiveness. Recently, some innovative programs in this country and in Europe have attempted to bridge this gap (see box l-C).

A key to further advances in pollution prevention is development of new cleaner production technology. In some industries, new technologies in development or under consideration offer the potential to reduce pollution, often at lower costs than conventional treatment or disposal methods, and in some cases with lower production costs. The greatest promise is in sectors with high environmental impact and compliance costs, such as the chemical industry, pulp and paper, and metals finishing; however, even when technologies are available, obstacles to their use remain.

As is discussed in chapter 8, a number of emerging technologies in the chemical process industries have the potential to cut pollution, often more cheaply than alternative end-of-pipe methods. New catalysts can increase chemical reactor yields, cutting waste generation significantly. Approaches such as catalytic distillation offer opportunities to cut waste and possibly reduce capital and operating costs. However, the development of new catalysts and reactor designs to cut wastes is still in its infancy, and new reactor

[10] For [u rther discussion, see U.S. Congress, Office of Technology Assessment, *U.S.-Mexico Trade." Pulling Together or Pulling Apart*, op. cit., footnote 9; and U.S. Congress, Office of Technology Assessment, *Trade and Environment: Conflicts and Opportunities*, op. cit., footnote 4.

[11] See, for example, *Trade and Environment*, op. cit., footnote 4, PP 64-68.

Box 1-C--Technical Assistance for Pollution Prevention and Environmental Compliance

Widespread diffusion of best management practices and off-the-shelf pollution prevention technologies would further economic and environmental goals. However, many companies, particularly small and medium-sized firms, need technical assistance to identify and implement pollution prevention measures.

Technical assistance programs for pollution prevention in the United States tend to be small. Moreover, manufacturers may hesitate to use these services, which often are housed in State regulatory agencies. Nor is technical assistance for pollution prevention usually undertaken as part of an effort to address other manufacturing concerns such as productivity, quality, and worker training. Hence, most programs fail to create synergies between pollution prevention and increased manufacturing competitiveness.

However, a number of programs have begun to better address the linkages between environment, energy, worker safety and health, quality, and productivity. These programs appear to be more fully developed in Europe, where efforts to integrate technical assistance, including industrial network programs, grants for technology demonstration, and industrial service centers are more common.

In Italy, the Centro Ceramico, a research/industrial services center funded by 500 ceramics firms in the Bologna area, helps its members solve environmental problems. The Center Conducts research to quantify the environmental impact of ceramic processes and to develop clean ceramic production technologies and technologies for sludge and residue reuse. The center also provides research and technical assistance to help firms reduce energy consumption, develop new materials and products, and put in place more efficient processes.

In Denmark, a national program to seed industrial networks helped create an industrial ecosystem where a power station, oil refinery, plasterboard factory, biotechnology firm, and the City of Kalundborg now exchange and reuse what were formerly wastes.[1]

In Holland, a nationwide network of 18 regional innovation centers, responsible for encouraging transfer of technological knowledge to small and medium-sized Dutch firms, recently received increased funding to work with firms on innovative and lower cost environmental technologies.

There are examples in the United States, as well. One of the older programs is the Center for Industrial Services, established in the early 1960s at the University of Tennessee. Since the mid-1980s, it has operated a pollution prevention program. The Environmental Services Program, a division of the Great Lakes Manufacturing Technology Center (funded by the National Institute of Standards and Technology) works with manufacturers to help them meet environmental regulations and adopt pollution prevention technologies. In both programs, staff are often able to design solutions that result in greater productivity, reduced pollution, and energy savings.

Some programs have begun to work with groups of manufacturers facing common problems. For example, Massachusetts' Center for Applied Technology formed a group of six firms involved in metal stamping, ranging from Gillette to a small company with 20 employees, to help identify, test, and use a set of lubricants that are environmentally preferable, as well as optimize tool performance.

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[1] Hardin B. C. Tibbs, "Industrial Ecology: An Environmental Agenda for Industry," *Whole Earth Review*, winter 1992, pp. 4-19.

designs are generally only feasible when new plants or major retrofits are made.

In the pulp and paper industry, new processes could substitute for chlorine bleaching processes or make them less polluting. Also, several delignification (chemical pulping) processes have been developed that recover one-third to two-thirds of the organic substances that would otherwise be discharged to the mill effluent treatment system, including some that are not biodegradable. Many of these technologies, while requiring capital for installation, can lower operating costs.

In metal finishing, a number of technologies for in-process recycling can either extract certain materials for reuse or extend the life (and reduce pollution) of plating baths. Also, several processes under development have the potential to replace wet-based electroplating, which has caused environmental problems. Currently, high capital costs and low throughput rates impede wider application.

If cleaner technology is to be developed more quickly, industry will need to consciously incorporate environmental concerns into industrial process technology development. While a number of public and private entities now conduct R&D on cleaner industrial production, efforts are small and uncoordinated, and effective transfer of technology to a broad array of industrial users may not happen. Researchers and pollution prevention specialists in the field seldom work together to identity problems and areas of potentially valuable research. Coordination and cooperation with programs in other countries that fund cleaner production technology development, such as those in Northern Europe, are also limited. Some international activities, such as the United Nations Environment Program, are underway but sparsely funded.

Estimates of Federal spending ***are*** imprecise, but it appears that no more than $70 million a year is spent on R&D devoted to waste minimization in industrial processes, although other industrial R&D (e.g., for energy-efficiency) also can advance pollution prevention. Some Federal cleaner production technology R&D programs have involved industry to identify needs, problems and solutions. Some industry-government partnerships and consortia exist as well. However, more can be done to involve industry, and an overall Federal R&D strategy and institutional coordination for cleaner production technology has been lacking.

THE REGULATORY SYSTEM AND ENVIRONMENTAL COMPLIANCE COSTS

At present, differences in compliance costs probably reflect variations in regulatory stringency (including enforcement) among nations. However, among firms from countries with comparable standards, those that are more efficient in complying with regulations will incur lower compliance costs. Moreover, the nature of government regulations and the availability of economic incentives for adopting new technologies affect compliance costs. For these reasons, the form of the U.S. regulatory system and its implications for competitiveness is attracting attention.

It is difficult to generalize about the regulations to control industrial pollution that have been put in place over the last two decades in the United States. However, there is wide agreement about some of its prominent features. For example, end-of-pipe approaches continue to be emphasized. Separate laws, regulatory offices, and enforcement procedures exist for air, water, hazardous waste, and other media. Rather than setting an overall emission limit for a facility, regulations and permits often require control of specific sources within a plant at specified emission rates. The system is usually characterized as command-and-control. In addition, local, State, and Federal laws and reporting requirements often overlap. The system is highly adversarial, with frequent challenges to administrative actions taken by all sides long after laws are first passed. Finally, there is relatively little emphasis on technology development or technical assist-

Table 1-3—Approaches to Environmental Regulation

Elements	Prevailing System	Innovations
Rulemaking process	Adversarial	Negotiated or mediated where possible
Policy tools	Regulations	Regulations may be supplemented by incentives, and voluntary programs (e.g., 33/50 program)
Pollution targets	End-of-pipe treatment and disposal	Priority given to source reduction
Breadth of regulations	Single-media	Multimedia if possible
Specificity y of control	Individual sources controlled (one facility may need many permits)	Facilitywide prevention and control
Level of emission	Uniform release rates by facility	Flexible, determined by taxes or marketable permits
Enforcement mode	Sporadic but inflexible	Systematic, but flexible
Agency organization	Media-organization (e.g., air off ice, water office)	Industry sector focus (e.g., petroleum refining, metals finishing)
Training	Narrow, focused on single media	Broad-based, but with technical focus
Technical development and assistance to industry	Minor focus	Important focus
Intergovernmental mode	EPA-led (headquarters oriented)	EPA-State partnership (e.g., negotiated strategies)

SOURCE: Office of Technology Assessment, 1993.

ance to help industry meet requirements. (Representative features of the prevailing system are listed in the second column of table 1-3).

While major strides have been made under this system in controlling industrial pollution, it is hard to argue that the level of environmental protection enjoyed today could not have been achieved in a more cost-effective fashion. The system was first put in place at a time when few sources were well controlled. But now, as more stringent controls are required, cost-effectiveness and competitive impact are growing concerns. There is considerable interest in finding ways to achieve comparable or higher levels of environmental protection at lower costs and with less potential for adverse competitive impacts on U.S. industry.

Federal and State regulators and industry in many areas around the country are experimenting with new approaches that, if replicated elsewhere in an appropriate manner, could ease adverse impacts on competitiveness while reducing pollution and waste. State and local regulatory officials, who administer most of the Nation's environmental permits and regulations, have initiated many of the more innovative approaches to environmental management. (The third column in table 1-3 lists some characteristic features of these innovations, which are discussed in more detail in ch. 9).

These innovations typically involve one or more of the following:

1. efforts to negotiate areas of agreement among government, industry, environmental groups, and other nongovernmental organizations in devising rules and implementation plans;
2. setting strict emission goals, but letting industry choose among several means to meet these goals;
3. addressing all emissions from a facility, rather than addressing sources or kinds of pollutants individually;
4. paying attention to total emissions in a geographic area, rather than just individual plants or sources, thus making it possible for firms to reduce emissions on the basis of the lowest marginal costs;
5. placing more priority on prevention of pollution rather than end-of-pipe treatment and disposal;
6. organizing regulatory offices and procedures to allow an industry-sector orientation; and
7. promoting technological innovation and diffusion as an additional method of meeting environmental goals.

As long as a backdrop of strong regulation and enforcement is fully maintained, a number of steps could be taken to reduce the competitive impacts on industry while still achieving environmental goals. Some options are discussed in the policy section later in the summary.

Although not addressed in the options, use of economic incentives in environmental regulations also could lower compliance costs. (See ch. 9). The marginal costs of pollution control usually differ among firms, and among processes within the same firm or facility. These variations in compliance cost stem from differences in size, age, technology, cost of substituting inputs, location, management practices, and other factors. Allowing or encouraging more use of market incentives or facility-based performance standards could allow firms to select less costly compliance strategies or strategies more consistent with other objectives, such as modernizing a production line.

Two principal market incentive approaches are marketable permits and taxes and fees. Marketable permits allow firms to meet regulations by either releasing no more than permitted levels of pollution, or by buying the rights to pollute from a firm that has reduced pollution below permitted levels. Alternatively, releases might be taxed so that firms with high marginal costs of control would choose to pay the tax while firms with low costs would reduce releases. In theory, both approaches could be structured so that overall emission levels would be no higher than with regulation alone, but compliance costs would be lower. Firms would also have an incentive to develop technical approaches to reduce pollution because they could get economic benefits from performing better than standards require.

Although economic incentives can reduce compliance costs, they may not always be appropriate. Usually, there will continue to be a need for tough standards and enforcement to protect health and the environment. Moreover, taxes and fees and auctioning of permits could raise total compliance costs for industry, even if abatement expenditures were reduced. However, fees and auction income can be rebated back to companies so that they are revenue-neutral. Another OTA assessment on new approaches to environmental regulations is examining incentives.

Federal Policy Options

It is increasingly difficult to separate environmental policy questions from issues of trade, technology, and competitiveness. Similarly, it is becoming harder to consider economic and technology policies without also considering their environmental ramifications.

Many government policies (in this country and abroad) will affect both the international competitiveness of the U.S. environmental industry and the ability of U.S. manufacturers to meet environmental regulations with minimal competitive disadvantage. These include domestic policies to promote the development and diffusion of new or cleaner technology (e.g., tax incentives and other support for R&D, industrial extension, tax incentives to encourage capital investments). The competitiveness of U.S. environmental firms will also be affected by trade, export promotion and foreign assistance policies-here and elsewhere.

If Congress wishes the Federal Government to play a more active role in addressing these concerns, there are number of steps it could consider, each with its pros and cons. Six issue areas are discussed below, and in more detail in chapter 2. The issue areas are:

A. Federal Technology R&D Policy;
B. Diffusion of Best Practices and Technologies to Industry;
C. Regulatory Reform and Innovation;
D. Development Assistance, Export Promotion, and Environmental Industries;
E. Trade and Environment Issues;
F. Data and Information Needs for Policymakers.

Table 1-4 presents over 30 options in these issue areas that Congress may wish to consider. The options could be adopted either singly or in different packages. Box 1-D identifies two strategies-an incremental approach and a more aggressive approach. The two strategies and each option are discussed in detail in chapter 2.

ISSUE AREA A: FEDERAL TECHNOLOGY R&D POLICY (OPTIONS 1-5 IN TABLE 1-4)

Debate in Congress about the Federal role in commercial technology development has been underway for some time. Environmental technology has become a focus of this debate, with several bills proposed in the 103d Congress.[12] In addition, the Clinton administration has been developing an environmental technology initiative.

Issues include how to identify environmentally critical technologies, how to set related Federal priorities, interagency coordination, and whether to undertake more partnerships with industry to develop cleaner technologies.

New priorities and projects will compete for limited R&D dollars. Precise figures are not available, but the Federal Government probably spent $1.8 billion or more in fiscal year 1993 on R&D pertinent to the environmental technologies covered in this report. (Larger estimates exist, but these have a more inclusive definition of environmental.) The largest portion, about $1 billion, is for energy-related technologies including clean coal, renewable energy, and cleaner and more efficient energy conversion and use technologies. Another large portion (exceeding $500 million) is for R&D on remediation technologies to cleanup contaminated Federal sites. Federal R&D support for advancing end-of-pipe technologies is in the neighborhood of $100 million per year. Pollution prevention R&D probably accounted for only about $70 million of the total (although some industrial energy-efficiency R&D also advance pollution prevention objectives).

Much of industry's pollution prevention effort has focused on relatively simple housekeeping and process modifications, which offered large payoffs for little effort. More significant advances will require greater emphasis on fundamental improvements in manufacturing process technol-

12 Bills include S. 978, the proposed National Environmental Technology Act of 1993, as reported by the Senate Environment and Public Works Committee on July 30, 1993;S.811, the proposed Environmental Competitiveness Act of 1993; H.R. 2224, a proposal to set up a national environmental technology office; and H.R. 3603, the proposed Environmental Technologies Aet of 1993.

Table 14-Summary List of Options

Issue Area A. Federal Technology R&D Policy:

1 Review Federal progress to:
- set priorities and coordinate R&D for environmentally critical technologies
- integrate cleaner production in R&D program missions

2 Review Environmental Protection Agency (EPA) clean technology priorities

3 a) Fund pertinent Department of Energy (DOE) RD&D programs
b) Make cleaner production a central mission of DOE's Office of industrial Technology

4 Increase support for National science Foundation dean technology work

5 Fund startup or expansion of industry sector R&D technology consortia

Issue ***Area B. Diffusion of Best Practices and Technologies to Industry***

6 Evaluate incentives to diffuse cleaner technology to industry

7 Make cleaner production and pollution prevention a mission and service of manufacturing extension services

8 Direct EPA to oversee more technology evacuations, and disseminate results here and abroad

9 Support efforts to integrate environmental components in engineering and business school curricula

Issue Area C. Regulatory Reform and innovation:

10 Set up an EPA pilot project to experiment with innovative permits for firms that are first rate environmental performers

11 Give incentive grants for regulatory reform innovation projects to States and firms

12 Upgrade training of permit and regulation writers

13 Set up industry sector consortia/cluster groups

14 Modify R&D permitting to better accommodate R&D, such as fixed site permits for R&D centers

15 Set up an environmental cooperation institute and sector cooperation councils

issue Area D. Export Promotion, Development Assistance, and Environmental Firms:

16 Work to setup a program to help developing countries identify needed environmental technologies

17 Make cleaner production/pollution prevention a priority in multilateral aid

18 Fund EPACT programs for AID-DOE transfer of innovative energy and environmental technologies to developing countries

19 increase Trade and Development Agency funding for feasibility studies

20 Encourage U.S. firms to emphasize training of developing country personnel in equipment and services contracts

21 Conduct early oversight on the Trade Promotion Coordinating Committee's environmental working group strategy and proposed budget

22 Encourage commercial interactions through:
- increasing overseas commercial officers or contractors;
- increasing outreach to industry associations;
- operating through environmental business centers here and American business centers overseas.

23 Disseminate information about U.S. technologies abroad

24 Provide resources for one stop shopping and regional centers to help smaller firms access and make use of available export assistance

25 Consider ways to expand export financing while keeping environmental safeguards

issue Area E. international Trade and Environmental Policy:

26 Conduct oversight on U.S. policy development for GAIT and OECD trade/environment discussions

27 Expand efforts to develop multilateral or bilateral agreement on environmental standards to address competitive impacts

28 Combine technical assistance with efforts to upgrade developing country environmental standards in advance of trade discussions

29 Work for more effective monitoring and enforcement of multilateral environmental agreements

30 Work to establish a global business charter on environmental standards

31 Encourage other countries to require firms to report toxic release inventories

issue Area F. Data Needs for Policy Making:

32 Direct pertinent agencies to:
- collect and analyze more commercially relevant data on trade and environmental goods and services
- facilitate flow of commercial information to companies
- verify and assess ways to improve pollution abatement cost data
- identify and quantify benefits of regulations through study

33 Gail for periodic assessment of competitive effects of differing levels of environmental regulations among countries, and for development of strategies to address any adverse effects

SOURCE: Office of Technology Assessment, 1993.

Box 1-D--Strategies for Federal Policy

The options discussed in this report are intended to further two competitiveness objectives: (1) realizing opportunities for benefit to U.S. business and society from providing environmental technologies to a growing global market; (2) reducing the adverse competitive impacts faced by U.S. firms in complying with environmental regulations.

These options could be adopted singly or in various packages. Taken singly, they would be modest steps in addressing either issue. Taken together, they would comprise a fundamental shift in how the United States addresses the interactions between its environmental policies and commercial policies.

Several recent laws authorize new programs and initiatives relevant to these objectives. Examples include the Energy Policy Act of 1992 (Public law 102-86), the Export Enhancement Act of 1992 (Public law 102-429), and the Aid, Trade and Competitiveness Act of 1992 (Title lll of Public Law 102-549). The Clinton administration has announced several plans or initiatives important to commercial and environmental technology policy, export promotion, and pollution prevention. Depending on future levels of funding and other indicators of commitment to implementation, these laws and initiatives could be a basis for partly addressing the two competitiveness objectives above.

The incremental approach assumes that some steps will be taken. There are two fundamental changes in the more aggressive approach: (1) more efforts to develop and diffuse environmentally preferable technology to U.S. industry and to promote environmental technology exports; and, (2) much more effort to integrate environmental and competitiveness policies, both domestically and internationally. Under this strategy, environmental objectives would be integrated within U.S. Government support for commercial technology research, development, and diffusion, with more emphasis on diffusion of cleaner and more energy-efficient technology to U.S. industry. Changes in Federal regulatory policies would allow a facility more flexibility, including using pollution prevention, with safeguards to keep environmental standards high and to prevent and detect abuses.

ogies to make manufacturing both greener and more productive.

U.S. firms are making some progress in developing new generations of cleaner production technology. Environmental concerns are slowly being integrated into manufacturing process technology development. However, these efforts are ad hoc, and probably small, although data is poor (see box l-E). The risks to individual firms in proceeding alone with needed R&D on either cleaner production or new pollution control technology could be too great, given the uncertainty about the acceptance of new technologies in the regulatory system, and difficulties in capturing benefits that accrue widely across an industry and across society as a whole.

Developing cleaner technologies and more effective and cost-effective control, recycling, and disposal technologies could require more funding and new ways to conduct government-industry partnerships. If Congress wished the Federal Government to do more to encourage development of such technologies by industry, it could consider a number of steps (see options 1-6 in table 1-4).

Better coordination is one need. Federal support for research on pollution and waste prevention, control, and recycling relevant to manufacturing industry has not been coordinated, limiting its effectiveness and making it difficult to transfer the results to industrial users.

The administration has announced steps for more interagency coordination, and has called on Federal R&D agencies to adjust their missions and priorities to take into account both environmental and industrial competitiveness objectives.

Box 1-E–Private Sector Environmental R&D

According to one estimate, U.S. industry spends a significant share of funds on environmental R&D, as high as 13 percent of its total R&D[1] although methodological problems suggest that this estimate is too high. OTA's calculations suggest that the actual amount is significantly less, between 1.3 and 2.6 percent of total R&D, or between $1 and $2 billion dollars a year.

About half of this spending appears to be by the regulated industry to help it meet environmental requirements, particularly by industries with high compliance costs. For example, in 1990, the petroleum industry spent an estimated $175 m ill ion on environmental R&D, including an estimated $50 m *ill ion* on reformulated gasoline, with nonproduct pollution control R&D amounts to about 6 percent of total R&D. Pollution control R&D by regulated industry is likely to increase in the 1990s, as firms seek to comply with more stringent environmental regulations.

Information about R&D by environmental firms is limited. Relative to manufacturing as *a* whole, which spends approximately 3.3 percent of sales on R&D[2], the environmental equipment sector appears to spend less as a share of sales, perhaps between 2.5 and 3 percent. Small, R&D-intensive startup firms might spend more as a share of sales, although overall expenditures are likely to be small. Environmental service firms, including waste management firms, appear to spend much less.

This suggests that the EGS sector might be spending on the order of $750 million to $1 billion per year on R&D. While this figure is just a guess, it does suggest that the U.S. EGS sector is not highly R&D intensive and moreover, that at least about half the private environmental technology R&D in the United States is not done by EGS firms, but rather by regulated industry.

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1 Brian Rushton, "How Protecting the Environment Impacts R&D in the United States," *Research Technology Management*, May/June 1993, p. 13.

2 Unpublished data, National Science Foundation.

For example, agencies now supporting cornmercial technology R&D could add environmental objectives into their mission statements and planning. Congress could review progress at an early date (Option 1).

Other steps could involve increased funding of government environmental technology programs. The Clinton administration has proposed more EPA funding for environmental engineering and technology development; if it provides these funds, Congress could make sure that cleaner technology and pollution prevention is a priority in EPA R&D (Option 2). The administration also has proposed more funding for the Department of Energy's Office of Industrial Technology, which now cost-shares some R&D projects with industry. Congress could give this office a more direct cleaner production technology mission (Option 3). It also could review RD&D priorities under the Energy Policy Act of 1992 (EPACT, Public Law 102-486) to assure that funding is adequate for continued progress in environmentally pertinent energy technologies (e.g., renewable energy, fuel cells, and improved combustion). Some other agencies (e.g., the National Science Foundation) also support industrially relevant clean technology research activities; these could be expanded (Option 4).

The most far-reaching option considered here would be to seek greater involvement by industry sector organizations. Such organizations could play an important role in the development and diffusion of cleaner production, improved pollution control, and recycling technologies by identifying technology needs, organizing R&D efforts, and diffusing results. The Federal Government could support the start-up or expansion of such organizations, and also share R&D **costs with them** (Option 5). To be eligible, an organization would need **to serve an** industry sector with high environmental impact or high compliance **costs** and include **as** participants many firms in the industry. While industry governance and funding would be crucial, the organization could work cooperatively with Federal laboratories. The organizations could undertake many different **activities:**

- **serving as a** forum for industry **to** collectively identify R&D needs related **to** environment;
- arranging partnerships among researchers, equipment makers, and industrial users **to** develop new manufacturing technology **that is** more energy efficient and cleaner;
- supporting demonstration of cleaner technologies, and improved control, recycling, and disposal technologies;
- identifying and diffusing innovations and best practices in pollution prevention **as well as** control and recycling **to** industry; and
- identifying regulatory barriers **to** more efficient environmental solutions, and training inspectors and permit **writers on** pollution prevention and control in **that** particular industry. (See further discussion in Option 17 in Issue **Area C** below).

While these options would encourage greater industrial **activity on** cleaner production technology, they could have drawbacks. If efforts **at** environmental integration led to set-asides in manufacturing R&D, for example, there could be game playing in identifying environmental projects or, if the set-aside was too large, interference with other crucial objectives. Similarly, at a time of very limited Federal funds, development of more cost-effective remedial technologies for Federal site cleanup may have a special claim on Federal money for environmental R&D. Even so, the long-term benefits to U.S. industry and society from cleaner industrial technologies could be very large, and it is not certain that industry will **act on its own to** develop these technologies unless it is clear **that** government is committed **to their** use in environmental compliance.

ISSUE AREA B: DIFFUSION OF BEST PRACTICES AND TECHNOLOGIES TO INDUSTRY (OPTIONS 6-9 IN TABLE 1-4)

Often, new technologies are not necessary to achieve cleaner, more efficient production; existing technologies and approaches would suffice, but are not well-known to firms. The gap between best industry practice and prevailing practices can be great, especially for small and medium-sized companies with limited resources, management time, and capacity to seek out, evaluate, and adopt unfamiliar approaches.

As discussed below, a number of steps could be taken to help diffuse knowledge about best practices to industry, including use of economic incentives, technical assistance, and enhanced efforts to evaluate technologies. In the long term, some of the greatest opportunities lie in strengthening environmental components in engineering and business school education.

Economic incentives might be considered to diffuse improved environmental practices throughout industry. A variety of approaches, ranging from accelerated depreciation and favorable loans to green fees (pollution taxes), could speed adoption of these technologies; an evaluation of the best choices, and their costs and benefits, could be conducted before deciding to proceed (Option 6).

As part of this evaluation, or separately, Congress also might direct the administration to provide initial evaluation of it use of Federal procurement to achieve environmental goals-as has been the thrust of several recent Executive Orders issued by President Clinton.

Because the government is so large, its procurement policies and practices greatly influence private sector management practices and product offerings. Federal agencies themselves are often major contributors to environmental problems.

The Federal Government already provides some technical assistance to small and medium-sized enterprises. Most states and a few localities also have modest pollution prevention technical assistance programs. However, these services are almost always provided separately from other services to manufacturers. As a result, manufacturers find it difficult to locate assistance, and the programs have limited capacity to carry out pollution prevention under an overall objective of increasing the fro's manufacturing competitiveness. Moreover, some firms may hesitate to seek assistance from regulatory agencies for fear of enforcement action. Thus, Option 7 proposes that pollution prevention be made part of the mission of federally supported manufacturing extension services, and that additional funds be provided to support this expanded mission. (These centers have been singled out for possible expansion in various bills before the 103d Congress and by President Clinton.) Alternatively, EPA might be directed to provide more pollution prevention grants to state or local industrial extension services. EPA could do this now, through its pollution prevention grant program. However, most of its grants have gone to branches of State regulatory agencies or other environmental service organizations.

One disadvantage of the integrated approach is that it may not target firms that contribute little to State economic development objectives, even if they cause environmental damage.[13] If the top priority is to reduce waste, putting pollution prevention programs in manufacturing modernization programs may dilute this focus. This could be addressed in part by requiring waste reduction goals to be an emphasis in the environmental program of the manufacturing extension service. Another possible disadvantage is that separating technical assistance from the regulatory function might further perpetuate regulators' focus on end-of-pipe solutions. Integrating regulatory and technical assistance functions can offer an opportunity to educate regulators on the merits and complexities of pollution prevention.

There is surprisingly little independent information about the performance of environmental technologies, or appropriateness of specific technologies for specific needs. Technology developers now meet market resistance from users of environmental technologies who fear that they will not meet standards or that new technology will be more costly than anticipated. This market hesitancy toward new environmental technology also makes venture capitalists and other investors wary. Independent evaluations or performance verifications could help; Congress might direct EPA to expand its support for evaluation activities, which now center primarily on remedial technologies, to include more control and prevention technologies of pertinence to industry[14] (Option 8). Firms seeking to enroll their technologies for evaluation would pay most of the costs; EPA's cost would primarily be evaluation and dissemination of results.

Such evaluations would also give U.S. firms with good products added credibility with foreign customers. While U.S. Federal authorities do not (and probably ought not) certify or endorse particular technologies or suppliers, independent evaluations of U.S. technologies could help boost U.S. environmental exports--as is further discussed in Option 25 in Issue Area D. A disadvantage of the Government-sponsored evaluation is possible unintentional favoring of some firms over others, if demand for evaluation services outstripped EPA's capacity to respond.

13 For example, many State pollution prevention programs have worked to encourage pollution prevention in sectors such as auto repair, dry cleaning, small print shops, and other local serving firms. While these sectors may have an environmental impact, they have little impact on State or national competitiveness. It should be noted, however, that neither these nor industrial extension programs have generally worked with the most polluting sectors such as chemicals.

14 There are small evaluation programs for innovative municipal solid waste and industrial waste reduction technologies.

Ultimately, the ability of firms to address environmental matters with the least degree of adverse competitive impact depends on knowledgeable, well-trained engineers and managers. Working such matters into the mainstream engineering and business school curricula is the job of schools and professional societies, but Congress could increase funds to the National Science Foundation or EPA for projects to facilitate this process (Option 9). This could provide longer term benefits as new engineers and business executives enter the workforce and become tomorrow's business and technical leaders.

ISSUE AREA C: REGULATORY REFORM AND INNOVATION (OPTIONS 10-15 IN TABLE 1-4)

As discussed earlier, and in chapter 9, current approaches to regulation and enforcement sometimes make it difficult for firms to put in place the lowest cost option to control pollution.

Some potentially lower cost approaches have been difficult to integrate into EPA's operations. Part of the reason is EPA's organization into media-specific offices, each principally concerned with controlling pollutants to one particular medium. For example, pollution prevention often has been carried out as a separate function, with projects peripheral to EPA's main regulatory and enforcement role.[15] While the basic concept and rhetoric of pollution prevention are understood, many managers have a single-medium end-of-pipe orientation to pollution abatement that has changed only slowly. Also, regulations are often biased toward end-of-pipe approaches. In principle, many regulations are performance-based and allow alternative compliance options, but the current reward system and lack of adequately trained personnel for innovative permitting impede use of alternatives to established pollution control technologies.

As long as strong regulation and enforcement are fully maintained, a number of options could be considered to allow firms to implement more cost-effective approaches to controlling pollution without jeopardizing environmental goals. Some alternatives are discussed below (Options 10-15).

Increasingly, manufacturers find that they must continually innovate to respond to rapidly changing technologies, customer demands, and the competition-making expeditious and flexible permitting a competitive need.

Several steps could be taken. For example, EPA might launch a pilot program to experiment with more flexible approaches, and authorize States to conduct experiments in cases where EPA has delegated responsibilities to the States. (Option 10). Incentive grants might be given to States to experiment with different approaches, such as full facility permits and tradable permits. (Option 11).

Examples might include:

- pilot projects for firms or facilities with frost rate environmental records and performance to test more flexible approaches. Participating firms might be given more options to determine how to meet an overall emission cap; more flexibility to change processes within certain parameters without permit revisions; and when permits are needed, priority to get expedited reviews.
- experiments with innovation waivers or fail-safe strategies with firms that are first rate environmental performers. For example, participating firms could be granted innovation waivers that allow limited noncompliance while developing new approaches that promise a larger environmental pay-back.

While experience with such means is growing, a number of barriers and concerns would need to be addressed before these techniques could be

15 Recent developments, such as the June 1993 pollution prevention policy statement from the EPA Administrator, may speed up the Press. Memorandum of Carol M. Browner, Administrator, to all EPA employees, June 15, 1993, titled "Pollution Prevention Policy Statement: New Directions for Environmental Protection.'

widely used, Assurance would be needed that health and the environment would be fully protected. Safeguards would be necessary to guard against, and quickly detect, abuses. New techniques allowing continuous monitoring of emissions would be helpful. It also could be difficult to develop eligibility criteria for qualifying facilities with good environmental records and performance, Concerns exist that flexibility could lead to favoritism or foreclose enforcement options. Thus, EPA could be required to evaluate these regulatory experiments, identify areas for improvement, and provide technical assistance to states to implement these new approaches

Pollution prevention and other alternative technologies are often specific to particular industries and processes. Without greater industrial expertise, it may be difficult for regulators to craft regulations that allow industry to meet environmental goals most efficiently. As a result, regulatory agencies, now organized along media lines, may need more orientation toward industry-sector groups with expertise in all areas, including new technology, pertinent to a given industry.

EPA could significantly expand its ongoing efforts to cluster regulations for specific industry sectors—a step that could deepen regulators' understanding of industry problems and technological solutions specific to each industry. In some cases, there could be both environmental and economic benefits if regulations and rules could be developed that collectively apply to emissions in all media (air, water, and land).

To enable firms to more easily use alternative technologies, permit writers and inspectors would need strong technical backgrounds to deal with a more complicated permitting process and to make judgments about whether alternative approaches are appropriate. Thus, provision would need to be made for training (Option 12), adding to administrative costs.

Regulations and permitting procedures can sometimes impede technology innovation and diffusion. Some of these barriers might be overcome if there were closer links between technology developers, users, and regulators. EPA could work with industry technology organizations (e.g., the centers discussed in Option 5) on such issues as the implications of foreseeable regulations for technology priorities, development, and diffusion. This task could be assigned to industry-sector groups at EPA (Option 13).

The form of domestic environmental regulations can affect innovation by the environmental industry. Best available technology (BAT) or similar standards that tend to make complying firms select and install technologies used as benchmarks by regulatory agencies can assure successful EGS developers of a market. While BAT standards are favorable for suppliers of approved technology, they may inhibit development of new and innovative technology by others. Complying firms are likely to stay with tried-and-true technologies that seem to be endorsed by the regulations.

Environmental technology developers also often find it difficult to obtain a R&D permit under the Resource Conservation and Recovery Act or to use ad hoc procedures under the Clean Air Act and Clean Water Act. There is some anecdotal evidence of firms moving technologies abroad for development and testing. Adjusting procedures to accommodate the needs of innovators, providing permits for fixed R&D and testing facilities, and development of quicker and more predictable permitting procedures might help U.S. innovators (Option 14),

The options discussed above would help stimulate innovation. However, they would still be controversial and, while experimentation with such procedures are already underway, there is no certainty that even demonstrably successful approaches would win broad acceptance with industry, environmental organizations, or regulators. Over the years, many regulated industries have tended to focus on reducing levels of regulation, rather than improving the efficiency of the regulatory system. Moreover, many in industry fear that new approaches to regulation, such as pollution prevention, could in time lead to more burdensome requirements. For their part, many environmental groups have been more concerned with defending existing gains than with changing the system to make it deliver equal or greater environmental benefits at lower costs. Within regulatory agencies, many are reluctant to embrace anew system that departs from accustomed ways of doing things. Moreover, managers may resist efforts to break down organizational walls, particularly when resources are scarce.

Without more trust and commitment among these key parties, the cooperative basis for development of a more effective and efficient regulatory model is unlikely, and the options identified above are likely to have limited application. Thus Congress might consider ways to build more cooperative relationships between government, industry, and environmental organizations (Option 15). One possibility would be to fund an institute for environmental cooperation to promote innovative cooperative projects.[16] EPA could set up a small number of councils, comprised of industry, academic specialists, and representatives from environmental organizations, and other nongovernmental organizations, for sectors with high environmental impacts and compliance costs.

Although not addressed in the options, market incentives can focus pollution reduction on the low-cost sources for reducing pollution. Two systems are normally proposed to do this: taxes and fees, and tradable permits. OTA's assessment on new approaches to environmental regulations, scheduled for completion in late 1994, is examining the potential of these approaches to achieve environmental goals.

ISSUE AREA D: DEVELOPMENT ASSISTANCE, EXPORT PROMOTION, AND ENVIRONMENTAL INDUSTRIES (OPTIONS 16-26)

Debate is occurring about U.S. government export promotion programs, development assistance programs, and their interactions-both for U.S. exports as a whole and for environmental exports in particular. Several bills pertaining to environmental export promotion have been proposed in the 103d Congress.[17] In addition, shortly before this report was sent to press, the Clinton administration submitted a proposed action plan on U.S. trade promotion programs in response to a 1992 congressional directive, and issued an environmental export strategy. The administration had also proposed major changes in U.S. foreign assistance programs. See chapter 6 for additional discussion of export issues.

Multilateral Cooperation for Technical Assistance (Options 16 and 17)--As the size of the global environmental market grows, many countries are pursuing or considering policies to help their firms participate in these markets, including developing country markets. There is a potential for conflict between development assistance objectives aimed at meeting the needs of developing countries (e.g., for environmentally sound development) and the commercial objectives of donor countries (e.g., encouraging exports of environmental technologies whether or not the particular technology is the most suited for the developing country). While a certain level of such tensions is inevitable, the potential for conflicts could be lessened if there were better, more objective information available about the products, approaches, and technologies being sold. This is

16 Also, EPA could fund consensus-building efforts through university programs, For instance, the Massachusetts Institute of Technology has been working with industry, government, and nongovernmental organizations to form mutual understanding on issues related to the use of chlorine in industry.

17 These include H.R. 2112, the proposed National Environmental Trade Development Act of 1993, (reported out of the House Merchant Marine and Fisheries Committee on June 30, 1993); H.R. 2096 to promote exports of environmental technology, goods, and services; S. 979, the proposed Greentech Jobs Initiation Act of 1993; and S. 1074, the proposed National Environmental Trade Development Act of 1993.

always a problem, but especially so in developing countries that increasingly need environmental technologies, but have little information about the best choices.

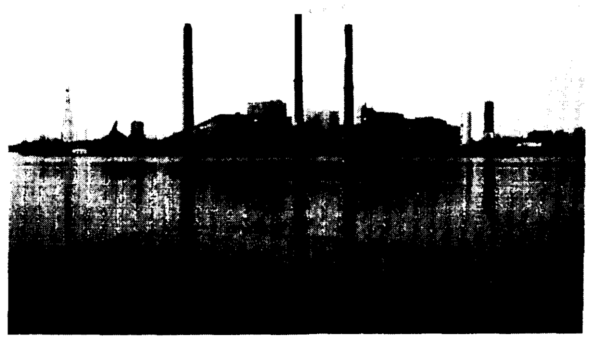
One option for addressing developing country needs while still facilitating U.S. exports would be for the U.S. Government to work with other countries to set up an expanded technical information capability through the United Nations Environment Program or another international agency to provide objective information and technical advice about environmental technologies (Option 16).

As well as helping developing countries, such information could help U.S. firms with appropriate technology compete when it is up against inferior foreign technology marketed more aggressively (such as with foreign tied aid credits).

Developing countries also could benefit from pollution prevention and cleaner technology approaches. Efforts to increase support for such activities through multilateral agencies could help these countries while benefiting U.S. firms that provide such services (Option 17).

Bilateral **Foreign Assistance and Export Promotion (Options 18-20)---The** United States now spends about $650 million per year on environmental and related energy development assistance to developing countries. Relatively little of this aid supports transfer of technology. Provisions in the 1992 Energy Policy Act would authorize increased support for transfer of innovative energy and environmental technologies to developing countries. Funding for such programs (Option 18) could help developing countries and also encourage exports of U.S. environmental goods and services.

An increase in U.S. Trade and Development Agency (TDA) funding of feasibility studies for capital projects in developing countries also might lead to more business for U.S. firms (Option 19). The TDA's mission is to assist U.S. firms in exporting goods and services for major capital projects in developing and middle-income



U.S. DEPARTMENT OF ENERGY

The U.S. Government and industry have cooperated to develop and demonstrate technologies for cleaner burning of coal, including retrofit technologies used in this Illinois power plant.

countries. TDA's annual budget is about $40 million, most of which pays for project feasibility studies by U.S. firms, chosen for the likelihood they will lead to follow-on work by U.S. fins. Many of the projects are for environmental infrastructure or have an environmental component. TDA's feasibility studies have been successful in promoting U.S. exports; funding for them could be increased, in time, to greater parity with a comparable agency in Japan, which funds an estimated $200 million per year of feasibility studies by Japanese fins.

The U.S. Government also could begin to support capital projects in developing countries—something USAID now does rarely. Care would be needed to assure that support went only to environmentally and developmentally sound projects. Some contend that an emphasis on capital projects would run counter to U.S. efforts to discourage other donors from using mixed credits or other tied aid loans.

Many U.S. environmental technologies require highly skilled operators and maintenance workers; this can be an obstacle to their use in developing countries. While training needs to be worked out by the contracting parties, the U.S. Government could help U.S. exporters locate training facilities and personnel in developing countries. Development assistance support for training can sweeten bids of U.S. fins. Training not necessarily linked to a particular project can promote exports by familiarizing potential customers with certain technologies and by helping U.S. firms to make contacts abroad. TDA spends about $7 million per year on training programs designed to promote exports related to capital projects, many of them environmental or with an environmental component. If TDA's budget were expanded, it might support additional training activities. (Option 20).

A capacity to develop and enforce environmental regulations is a prerequisite for environmental market growth in developing countries. U.S. technical assistance and training can help build such capacity while familiarizing recipients with U.S. standards, procedures, and equipment. Some other aid donors have recognized potential commercial benefits of this approach by equipping reference laboratories used by developing country environmental agencies.

Several recent public-private partnerships have been set up to involve U.S. industry in helping developing countries address environmental problems. The United States-Asia Environmental Partnership (US-AEP) works with U.S. agencies and firms to encourage use of U.S. technologies and expertise in addressing Asian environmental problems. The U.S. Environmental Training Institute, established jointly by the U.S. Government and some businesses, brings developing country personnel to the United States to take short courses that include presentation of U.S. firms of their technologies. While it is too soon to evaluate these initiatives, they may, if successful, provide models for further replication.

Other Export Promotion Issues (Options 21-26)—The U.S. Government provides relatively little support to U.S. manufacturing firms for exporting. Recent laws authorize a stronger Federal role. The 1992 Export Enhancement Act (Public law 102-429) called on the interagency Trade Promotion Coordination Committee (TPCC) to develop an overall export promotion strategy and to propose an annual unified export promotion budget. The initial TPCC report, with over 60 proposed steps, was submitted to Congress at the end of September, 1993. TPCC was unable to propose a budget, but did say such a budget would be worked out for the fiscal year 1995 appropriation cycle.[18] The 1992 law also called for a Federal strategy for environmental exports. The administration issued a strategy in November 1993 as this report went to press.[19] Congress could monitor its priorities and implementation plans, including the need for additional actions (Option 21).

One question concerns the nature and degree of private sector involvement. Some contend that there needs to be more private sector involvement in the process, and have proposed creation of a public-private council to prepare an action plan to implement the strategy. The danger is, of course, that such a plan would become a form of special pleading by its private sector members. However, some precedents already exist for industry involvement in priority setting. One example is the Committee on Renewable Energy Commerce and Trade, which could become a model for other subsectors.

A number of other export promotion options could be considered. One possibility would be to increase U.S. foreign commercial service representation, both in general and for the environment per se (Option 22). When agriculture is not considered, the United States spends very little for export promotion-far less than our major competitors. Our foreign commercial service is lightly staffed: Canada has more overseas com-

18 Trade Promotion Coordinating Committee, *Toward a National Export Strategy* (Washington, DC: U.S. Government Printing Office, September 1993), For a critique of the plan, see statement of Allan I. Mendelowitz, U.S. General Accounting Office, before the Economic Policy, Trade and Environment Subcommittee, House Foreign Affairs Committee, Sept. 29, 1993.

19 Ronald H. Brown, Hazel O'Leary, Carol Browner, *Environmental Technologies Exports: Strategic Framework for U.S. Leadership*, November 1993.

mercial officers, despite an economy one-tenth the size of the United States.

The U.S. Government could also assist in disseminating information about U.S. environmental technologies to potential customers in other countries (Option 23). This possibility could be carried out in conjunction with an expanded effort to support independent evaluation of U.S. technologies (discussed in Option 8 of Issue area B).

Certain steps also might make it easier for U.S. firms to get the information they need to expand their export activities (Option 24). Environmental exports might be used as a case for demonstrating one-stop shopping to make Federal programs easier for small firms to access. A more far--reaching approach, proposed in legislation before the 103d Congress, might be to encourage exports through a network of environmental business centers in the United States and American business centers in countries with promising environmental markets .[20] US-AEP has opened a number of environmental business centers in Asia; their efforts could be monitored for efficacy and possible replication.

The U.S. Government assists a much smaller share of its exports with public export financing than several competitor countries; there are also indications that U.S. programs are harder for firms to use. (See ch. 6).

Given this favorable circumstance for foreign fins, a key export promotion issue is the limited public and private funds available here for exporting. Congress might consider export financing needs as it evaluates alternative uses for available Federal resources (Option 25). Funding for financing environmental exports could be increased, of course, but whether this could be done without cutting into other needs remains to be seen.

A disparity exists not only in ordinary export financing, but also with respect to confessional financing. European and Japanese firms often appear to have greater access to confessional project financing from their home countries than do U.S. companies. The United States has a War Chest in the Export-Import Bank (Eximbank) to match confessional financing (below market rates) packages put together by foreign competitors, and Congress recently increased its authorization to $500 million in grant funds (which would support about $1.5 billion in confessional loans). Increased War Chest use could be an effective tool to enable U.S. bids to win on their merit in the face of foreign governments concessional financing. However, this benefit must be balanced against other uses for Eximbank's limited budget, since each dollar of confessional lending reduces by several dollars Eximbank's capacity to make ordinary loans or loan guarantees.

ISSUE AREA E: TRADE AND ENVIRONMENT ISSUES (OPTIONS 26-31)

As mentioned, the United States has stronger environmental requirements than many competitors. Recent efforts to negotiate trade agreements and the emergence of several strong competitors in newly industrialized and advanced developing countries have raised renewed concerns about competitive impacts for the United States. Environmental issues were important in the debate about the North American Free Trade Agreement for Mexico, the United States, and Canada. In addition to provisions in the NAFTA itself, a side agreement addressing environmental matters was negotiated.

Environmental matters will almost certainly arise if other efforts to liberalize trade are undertaken in Latin America or elsewhere. With or without such liberalization, concerns about competitive impacts from differing levels of environmental regulations will arise. One possible response might be for the U.S. Government to

[20] See, for example, Sections 7 and 9 of H.R. 2112, the proposed National Environmental Trade Development Act of 1993, as reported by the House Merchant Marine and Fisheries Committee on June 30.1992.

become more active in negotiating environmental agreements with other countries-partly to address competitive effects (Option 27). Agreements could be combined with U.S. technical assistance to help countries develop and implement appropriate standards (Option 28). As discussed in Options 29-31, the potential for adverse competitive impacts also might be reduced if there were more effective monitoring and enforcement of agreements, if businesses were encouraged to adhere to developed country standards throughout the world, and if other countries took steps such as calling on business to report their releases of toxic substances, as they are required to do in this country.

These approaches would be controversial, both here and in other countries. Moreover, past efforts to adopt such policies have had little success. Yet there could be long-term benefits for the environment and, quite possibly, a more positive climate in this country for trade liberalization with countries that now have weaker environmental standards.

Some might argue that there is no competitive reason for such negotiations, because, they claim, strict environmental regulations can lead to increased competitive advantage. Firms within countries having strong regulatory demands on industrial processes can find that aggressive environmental actions, particularly pollution prevention, make them more competitive relative to other *domestic* competitors. However, as a group, firms within countries with strict regulations will face higher compliance costs relative to *foreign* competitors in countries with more lax standards and enforcement. When waste disposal costs and requirements are high, firms can sometimes save money by controlling pollution and reducing wastes. However, these actions are usually not justified from an economic perspective alone when waste disposal costs and requirements are zero or minimal. Still, as has been mentioned, strong domestic regulations are often a key factor in competitiveness of environmental goods and services industries.

ISSUE AREA F: DATA AND INFORMATION NEEDS FOR POLICY MAKING (OPTIONS 32-33)

Data and information in several areas are flawed or often lacking. While the need for data is seldom so pressing as to preclude rational policymaking, improved information would be helpful (Option 32). For example, it would be very useful to have verification of data obtained for the Census Bureau's Pollution Abatement and Control and Expenditure surveys. Better data on trade and production in environmental goods and services would be helpful. Also, while there are many estimates of the costs of regulations, there is a need for better ways of estimating the benefits of environmental regulations, and for accommodating such benefits in models measuring the impacts of regulation on the economy.

There is an important need for periodic assessment of potential competitive impacts to American industry and the U.S. economy arising from differences in environmental standards among countries. Congress has in the past called on the executive branch to conduct such assessments when enacting some new environmental laws, and to identify strategies for addressing such impacts. As standards and competitive conditions change, periodic undertaking of such assessments and strategies would be helpful (Option 33).

Issues and Options 2

It is increasingly difficult to separate environmental policy issues from those of trade, technology, and competitiveness. It is also becoming harder to consider economic and technology policies without also considering their environmental ramifications.

This is so because:

- Environmental problems became a major policy concern in the United States (and in a few other advanced industrial countries like Japan and Germany) about two decades ago, at a time when many took U.S. industrial supremacy for granted. Since then, a number of events-a slow-down in productivity growth, oil embargoes and energy shocks, and the emergence of Japan as an economic superpower, to name a few—have deepened concerns about U.S. economic competitiveness.
- U.S. industry now competes not only with Japan, Germany, and other Western European countries having comparatively strong environmental regulations, but also with producers in newly industrialized or advanced developing countries. Manufacturers operating in these countries pay lower wages, and usually do not have to meet environmental, health, and safety standards as strict as those in the United States.
- There is a growing sense that economic development in all regions of the world will need to be carried out in ways that produce less harm to the environment (see ch. 3). Some environmental issues (depletion of stratospheric ozone, global warming, loss of biological diversity) are now widely viewed as globally significant problems. Major regional environmental problems (e.g., those in Eastern Europe and the former Soviet Union) have dramatized the serious health and eco-

nomic costs that can result when industry and government pay too little attention to the environment.

Global expenditures to address environmental problems are increasing rapidly, creating new markets for environmental goods, technologies, and services. In the next decade or so, many more countries are likely to begin enforcing environmental standards to a greater extent than before.

These concerns have prompted interest in the commercial implications of environmental policies and the environmental implications of different commercial policies.

Environmental policies and policies to promote competitiveness both aim to influence industrial behavior. Environmental policies often require industries to control their processes and modify products to meet certain standards. Other domestic policies, including technology policies (R&D support, extension services, and tax policies to encourage R&D and capital investment) also influence industrial actions.

The competitiveness of U.S. industry (including the environmental industry) is affected by trade, export promotion, and foreign assistance policies-for example, policies to open foreign markets to U.S. goods and services, to promote U.S. exports, and to link foreign aid to commercial benefits for U.S. firms.

OPTIONS FOR U.S. POLICY

This assessment takes it as a given that U.S. air, water, and waste standards will continue to be among the world's toughest.[1] Within this framework, OTA has examined many options to further two competitiveness objectives:

1. realizing the opportunities for benefit to U.S. business and society from providing environmental technologies to a growing global market; and,
2. reducing adverse competitive impacts faced by U.S. firms in complying with environmental regulations.

Later sections of this chapter discuss six issue areas and related policy options pertinent to these competitiveness concerns. The issue areas are:

a. Technology and R&D policy;
b. Diffusion of best practices and technologies to industry;
c. Regulatory reform and innovation;
d. Export promotion, development assistance, and environmental fins;
e. Interactions between trade policy and environmental policy;
f. Data and information needs for policymakers.

This chapter discusses the pros and cons of over 30 options in these issue areas. The policy tables in the chapter list options for each issue area along with the goals furthered by these options and their likely costs to the Federal Government. All of the options are presented in table 1-4 (in ch. 1).

The options could be adopted either singly or in different packages. Some pertain to one objective only (e.g., development assistance options are limited to environmental technologies and services) while others apply to both (e.g., technology policy, trade, and environment policy).

In many cases, successful implementation of these options will depend on extensive and continuing involvement by industry, environmental organizations, and other affected parties. Outcomes would depend not only on specific packages of options and resources available, but also on strategy, leadership, and continuing commitment to implementation. Two strategies for government action, incremental and aggressive, are discussed below.

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[1] This assessment does not examine the interactions between competitiveness and other types of environmental laws and regulations such as those affecting land use, fisheries, and species protection.

ONE: The incremental approach would entail continued implementation of existing policies, with some new emphases:

- Efforts to develop more cost-effective or improved technology for Federal site clean-up, especially Department of Defense and Department of Energy sites, would continue. Cleaner energy technology R&D would continue to be the largest category of environmentally preferable technology supported by the Federal government. Federal programs for other industrially pertinent technologies for pollution control and prevention or cleaner production would continue at recent modest levels of support. Government-industry cost-sharing of cooperative research and development agreements (CRADAs) on environmental matters might increase, subject to budgetary constraints.
- Programs for independent evaluation or verification of the performance of U.S. technologies would be expanded to give more emphasis to prevention and control technologies in addition to the current emphasis on contaminated site remediation. Such information, which is needed for domestic users, could also help foreign consumers select among competing technologies.
- Clearinghouses, trade publications and associations, and State technical services programs would be used to disseminate information about cleaner technology and more cost-effective compliance approaches to small and medium-sized manufacturing firms.
- On the regulatory front, EPA and State regulatory agencies would experiment with incentives for technological innovation and with alternative permitting and compliance procedures, and encourage wider replication of successful approaches.
- Federal export assistance programs would better coordinate services. The U.S. Trade and Development Agency would fund more feasibility studies in developing countries, creating business for U.S. consultants and some follow-on orders for U.S. exporters. Other export promotion services, including commercial representation abroad, training of foreign nationals in U.S. technologies and approaches, and trade missions, would expand modestly.
- Efforts to develop multilateral guidelines addressing interactions between trade and environmental issues would continue.

TWO: The aggressive approach differs from the incremental approach in strategy, degree of high-level leadership, and level of resources.

- Much effort would be made to integrate environmental and economic issues at a high level within the government. Technology policies, trade policies, and environmental regulations would be developed and implemented with awareness of their interactions and their synergies—positive and negative.
- A major effort would be made to enlist U.S. industry-especially industry sector technology organizations-in cleaner technology development and diffusion. Government would share the cost of R&D, demonstration, and diffusion, and better address regulatory problems for those sectors with high environmental impact or compliance costs.
- Steps would be taken to integrate pollution prevention services with manufacturing modernization services offered at the State level and in new Federal manufacturing extension centers.
- There would be accelerated experimentation with more flexible regulatory approaches that meet environmental requirements. Companies with excellent environmental records might be eligible for expedited whole facility permitting. For example, such companies might be given facility-wide emissions caps and more options to choose among different pollution abatement approaches. Regulations would be made more friendly to environmental technology innovators.
- On the international scene, the United States would signal to developing and newly industrializing countries that their environmental stand-

ards would need upgrading well in advance of possible bilateral discussions on trade liberalization. Through framework agreements or other agreements, the United States might offer more aid for technical assistance and technology transfer to developing countries (with U.S. companies gaining some business from the aid).

- The executive branch would assess differences in regulatory stringency among countries, and related competitive impacts on U.S. firms; alternatives for addressing adverse impacts would be developed for congressional consideration.
- Government efforts to promote U.S. exports, including environmental exports, would intensify.
- Foreign assistance would be tapped to encourage exports of environmentally and developmentally sound technologies and services (e.g., renewable energy technologies, pollution prevention services) to developing countries. On a life cycle basis, such projects could be less expensive for developing countries than conventional technology. In some cases, capital project financing would be made available to encourage transfer of U.S. technology.
- The United States would continue to work to limit commercial advantage from use of mixed credits and other tied aid credits by aid donors; however, when other countries use these credits for unfair commercial advantage, it would respond in kind but use environmental guidelines to prevent transfer of inappropriate technologies.

This strategy might recognize the need to give more priority to broad-based adjustment assistance for U.S. workers. It is seldom feasible to isolate the causes of plant closings and layoffs; the major causes are patterns of trade and investment, changes in consumer preference, and obsolescence of plant and equipment from technological change. Sometimes environmental factors also contribute. While the implications of technological upgrading for U.S. employment as a whole are likely to be positive, the diffusion of cleaner, more energy efficient technologies to industry is bound to produce some displacement.

Not all of the steps listed in either strategy would require new legislation, as several recent laws authorize pertinent programs and initiatives along these lines. Examples include the Energy Policy Act of 1992 (EPACT, Public Law 102-486), the Export Enhancement Act of 1992 (Public Law 102429), and the Aid, Trade, and Competitiveness Act of 1992 (Title III of Public Law 102-549). The Clinton administration has announced several plans and initiatives related to commercial and environmental technology policy, export promotion, and pollution prevention. Depending on future levels of funding and other indicators of commitment to implementation, these laws and initiatives could form part of a basis for the strategies.

Issue Area A. Technology and R&D Policy

Debate is underway in Congress about the Federal role in encouraging the development and commercialization of innovative commercial technologies. Environmental technology has been gaining attention in this debate. The Energy Policy Act of 1992, enacted at the end of the 102d Congress, authorized expanded Federal support for development and application of energy-related environmental and industrial technologies. Several environmental technology bills have been proposed in the 103d Congress,[2] as well as bills pertaining to the Federal role in commercial technology development as a whole.[3] An admin-

[2] See, for example, S. 978, the proposed National Environmental Technology Act of 1993, as reported by the Senate Environment and Public Works Committee on July 30, 1993; S. 811, the proposed Environmental Competitiveness Act of 1993; and H.R. 3603, the proposed Environmental Technologies Act of 1993.

[3] See H.R. 820, the proposed National Competitiveness Act of 1993 passed by the House on May 19, 1993, and S. 4.

Table 2-1—issue Area A. Federal Technology R&D Policy

	Impact on Federal expenditures[a]	Does option require major changes in Federal role?[b]	Policy goals promoted[b]: Enhance overall manufacturing industry competitiveness	Expand markets for U.S. environmental goods and services	Further global or developing country environmental goals
1 Review Federal progress to:					
. set priorities and coordinate R&D for environmentally critical technologies	s	Y	P	P	P
• integrate cleaner production in R&D program missions	s	Y	Y	P	P
2 Review Environmental Protection Agency (EPA) clean technology priorities	s	N	Y	P	P
3 a) Fund pertinent Department of Energy (DOE) RD&D programs;	L	N	Y	P	P
b) Make cleaner production a central mission of DOE's Office of Industrial Technology	M-L	N	Y	P	P
4 Increase support for National Science Foundation clean technology work	M	N	Y	P	P
5 Fund startup or expansion of industry sector R&D technology consortia	L	Y	Y	P	?

a S=small ($ I o million or less); M=moderate ($1 O to $100 million); L-large ($100 million plus); a range indicates that it depends on how the option is implemented.
b Y=yes; P=potentially yes; N=no; ?=effect is unclear

SOURCE: Office of Technology Assessment, 1993.

istration environmental technology initiative is also under development.

For the most part, Federal environmental regulations-their form and strictness-have been the primary government action determining development and use of environmental technology by industry. This will continue to be the case. However, nonregulatory forms of technology policies—support for research, development, and demonstrations, for example--could spur development and use of environmentally preferable products and processes. While not necessarily developed to further specific regulatory aims, such products and processes in some cases could make compliance easier and cheaper for firms.

Discussed below are three issues germane to the question of whether the U.S. Government should expand its support for development of cleaner, more cost-effective technology by industry:

- goals and objectives for Federal environmental technology policy,
- coordination of Federal activities relevant to cleaner technology, and
- partnerships with industry to develop cleaner technologies.

Five options pertinent to these issues are summarized in table 2-1, and presented in greater detail at the end of the discussion for this issue area.

GOALS FOR FEDERAL POLICY

An expanded Federal role in developing cleaner technologies or more cost-effective pollution controls could require more funding and new

ways to conduct government-industry partnerships. The Federal Government already spends nearly $2 billion per year on R&D pertinent to the environmental technologies covered in this report.[4] (See ch. 10.) Over $650 million is spent by the Department of Energy (DOE), the Department of Defense (DOD), and the Environmental Protection Agency (EPA) on remediation technologies for contaminated sites. Large commitments, nearly $1 billion, are also made to cleaner energy research, development, and demonstration (RD&D). This includes renewable energy programs, the Clean Coal Technology Demonstration Program (which demonstrates pollution control and prevention technologies), advanced engine and fuel cell R&D, and electric and other cleaner vehicle technologies, among other areas. Federal R&D support for cleaner industrial process technologies and for improved end-of-pipe controls for manufacturing operations is only a small share of the total-probably on the order of $150 million.

The question of whether, how, and to what degree the Federal Government should support additional initiatives to develop innovative environmental or environmentally preferable technologies depends in part on available resources and Federal priorities.

Several candidate R&D priorities may vie for limited funds, including:

Putting the Federal House in Order—Most remediation R&D centers on clean-up of contaminated defense-related facilities--clearly a Federal or national responsibility. Developing lower cost or more effective clean-up technologies is likely to be a key Federal environmental and fiscal priority for many years to come. Defining technology goals and objectives and securing clean-up R&D resources for this area alone will pose continuing challenges.

Estimates suggest that, using current technologies, it could cost the U.S. taxpayer tens of billions of dollars in the coming years to clean up hazardous and radioactive wastes at DOD and DOE facilities. Improved remediation technologies might reduce clean-up costs and also aid in managing abandoned hazardous waste sites—a Federal responsibility under Superfund.

To some degree, the improved technologies and processes resulting from Federal clean-up R&D could produce export opportunities for U.S. environmental firms. However, most countries now give much more priority to pollution control and prevention than to clean-up of contaminated land. Remediation markets abroad are relatively modest. Also, some of the U.S. R&D no doubt may support further development of processes created by firms in other countries.

Helping Industry Meet Requirements at Less Cost—Another Federal R&D priority might be to encourage development of cleaner production technologies (or, in some cases, more cost-effective end-of-pipe or clean-up equipment). This might further both environmental and industrial competitiveness goals. U.S. industries spend more on environmental compliance than their counterparts in most other countries. Even when compliance costs are comparable, some countries, such as Germany, provide more government technical and financial help to their fins.

It would make sense to concentrate on industry sectors that produce large environmental impacts or that have high compliance costs, For example, as is discussed in Option 5 at the end of this section, the government might share the costs of RD&D efforts with industrial consortia to address industrywide environmental challenges. Regulatory and tax incentives for development and early

[4] Larger estimates exist, but they include other technology support, such as for agriculture, climate monitoring, health effects, management of nuclear wastes, and mass transit that are not addressed in this report, See U.S. Library of Congress, Congressional Research Service, *The Current Status of Federal R&D: Environmental Technologies*, 92-675 SPR (Washington DC: Congressional Research Service, Aug. 25, 1992).

use of innovative environmental approaches can also be useful.

Spurring Development of Environmentally Preferable Products and Processes-The Federal Government can help ensure that cleaner technology or production priorities are considered in the technology development activities that it supports, directly or indirectly. With the wide range of R&D funded by the U.S. Government, the long-term effect in stimulating development of cleaner technologies could be significant. Additionally, Federal, State, university, and professional association support for integration of environmental matters in engineering education can help effect a cultural change by bringing environmental criteria from the periphery to the core of product and process design.

Meshing environmental with commercial R&D goals could be beneficial. It could produce technologies and techniques that allow companies to meet their environmental obligations at less cost. For the environmental industry as well as manufacturers of cleaner capital goods, better and more economical pollution control and cleaner production technologies offer new business opportunities at home and abroad. And, of course, the economy, the environment, and public health will benefit if new technological approaches allow better environmental protection at less cost.

Government procurement practices could be used to spur markets for environmentally favorable products and processes, as well. Some examples include specifying cleaner printing and painting, procurement of recycled materials, promotion of energy efficiency in Federal buildings, and acquisition of cleaner vehicles. Military specifications also could be rewritten to address the environmental impacts arising from manufacture of products for DOD. Several executive orders on these matters have been issued or are under consideration in the Clinton administration. Using government buying power as an instrument of environmental policy is controversial with suppliers of conventional products and other industries who fear they might be adversely affected.

Supporting Sustainable Development and Export Opportunities for U.S. Firms-In the years to come, global demand for cost-effective, environmentally preferable technologies can be expected to grow in a wide range of industry sectors. One objective of Federal technology policy might be to encourage development of such technologies in the interest of global environmental improvement and boosting export earnings and jobs for American fins. Joint R&D and industrial consortia among environmental fins, regulated industries, and government can help develop and demonstrate technologies that provide environmental solutions both at home and abroad. In addition to support for R&D, the U.S. Government can help by disseminating information on U.S. technologies abroad and developing export awareness in the United States. Technical assistance to improve foreign environmental management capacity and negotiation of standards and practices in other countries compatible with those employed in the United States can also promote this country's interests.

COORDINATION AND FUNDING

As additional Federal roles in environmental technology are considered, some see an emerging need to articulate an overall strategy[5] and priori-

[5] Developing an environmental technology strategy is one purpose of some environmental technology proposals under consideration in the 103d Congress. The strategy proposed in S.978 as reported by the Senate Environment and Public Works Committee would, among other matters, identify and rank priorities that would benefit from critical environmental technologies; recommend public-private partnerships; recommend measures to encourage commercialization and use of the technologies, especially by small business; and identify barriers, incentives, and appropriate actions for development, use, and exports of the technologies Critical environmental technologies, as defined in the bill, would embody a significant technical advance, have potential to bring about large, cost-effective reductions in health or environmental risks; apply broadly at the precommercial stage; and be likely to have a favorable ratio of social to private returns if adopted.

ties for a coordinated response by pertinent agencies.

Several agencies play, or could play, prominent roles in environmental and/or commercial technology development—including DOE, DOD, the Department of Commerce, and EPA. Working out appropriate roles among these and other agencies will be an important issue for policy makers in Congress and the Executive Branch. Lack of coordination of these programs could limit their effectiveness, as well as complicate technology transfer to industry.

Administration efforts and plans to address environmental technology include:

- an environmental technology strategy. In April 1993, President Clinton directed the Secretary of Commerce to chair an interagency group for creation of a national strategy for environmental technology development, diffusion, and export promotion. Other key agencies include EPA and DOE. This body was expected to issue a report in the fall of 1993.
- an expanded EPA role in environmental technology development. Over a 9-year planning horizon, the projected increase would be $1.85 billion (much of which might pass through EPA to other agencies). The purpose would be to develop more advanced environmental systems and treatment techniques to produce environmental benefits and exports of environmental technologies.
- more funding for RD&D activities under the 1992 Energy Policy Act. (Among other things, EPACT authorized increased Federal support for environmentally significant energy technologies, including renewable energy, cleaner vehicles and fuels, advanced engines, fuel cells, and heating, cooling, and other building technologies. One title authorizes more R&D support for industrial technology related to energy conservation, including waste reduction. For example, it calls for more work on pulp and paper technologies and improvement of energy efficiency and cost-effectiveness of pollution prevention technologies in energy intensive industries-activities supported by the DOE's Office of Industrial Technology. Funding for this office's work on energy efficiency and waste reduction is authorized to grow from about $97 million in fiscal year 1992 to about $137 million in fiscal year 1994.)
- the administration's overall technology initiative calls on key Federal agencies including the Departments of Commerce, Defense, and Energy, to incorporate environmental goals when supporting manufacturing R&D. The National Institute of Standards and Technology (of the Department of Commerce) would help small and medium-sized firms improve energy efficiency and performance (see Issue Area B below).

Two subgroups of the interagency Federal Coordinating Council on Science, Engineering, and Technology (FCCSET) are working on environmental technology priorities. The Subcommittee on Environmental Technology of the Committee on Earth and Environmental Sciences was established to focus on environmental technology issues. Also, the Committee on Manufacturing, which seeks to define Federal priorities for developing and diffusing manufacturing technology to the private sector, plans to look at the environmental aspects of Federal manufacturing R&D. These activities could be affected by plans to reorganize FCCSET.

With so many Federal activities underway or soon to be proposed, Congress might wish to conduct early oversight—with special attention to overall goals and objectives, and the extent to which clean technology objectives are addressed. (See Option 1 at the end of this section). It might also review funding and priorities for specific Federal programs pertinent to cleaner technology development, such as those by EPA, DOE, and the National Science Foundation (NSF), as discussed in Options 2 through 4 below.

PARTNERSHIPS WITH INDUSTRY TO DEVELOP CLEANER TECHNOLOGY

As standards become tougher, more cost-effective ways to improve environmental performance will be needed. To date, industrial pollution prevention efforts typically involve simple housekeeping and process modifications, which often offer large payoffs for little effort. More fundamental improvements in manufacturing process technologies to make manufacturing both cleaner and more productive could require substantial R&D. In some cases, advances in control and disposal technologies also could require more R&D.

While U.S. firms are making some progress in integrating environmental concerns into manufacturing process and product development, most efforts are small and ad hoc. The risks to individual companies in proceeding alone with the needed R&D often appear too great, given technical uncertainties, questions about the acceptance of new technologies in the regulatory system, and difficulties in capturing benefits that accrue widely across an industry or to society as a whole. Companies have been reluctant to develop and try new generations of add-on pollution controls for similar reasons.

Programs carried out through industry consortia or cooperative research and development agreements with Federal laboratories may offer useful vehicles for assuring industry involvement.[6] An industry sector focus for these activities could help allocate efforts toward those sectors that pose the most significant environmental threat or that face the highest compliance costs. While DOE supports some cooperative R&D in specific sectors (e.g., pulp and paper, steelmaking, and foundries), firms tend to sign on for a specific project rather than develop the continuing relationship that a consortium implies. A more aggressive alternative, centered on high environmental impact, high compliance cost industries, is discussed under Option 5 below.

While consortia may hold promise, there are drawbacks. Funding more industrial RD&D could take scarce dollars away from other worthwhile claims on Federal resources. To the extent that new Federal funds are available, getting the Federal Government's own house in order through clean-up of Federal sites might seem a more pressing claim. The substantial funds for technology development in this effort offer promise for new remediation technologies that could be applicable to commercial remediation.[7]

However, the Federal clean-up efforts are needs-driven and highly specialized. Clean-up R&D is not intended to produce technologies for industry to control emissions or to produce cleaner technologies that prevent pollution. Instead, the technology is mostly intended to deal with already contaminated sites.

Many in both government and industry look askance at partnerships and similar attempts by government to influence private sector R&D. Some believe that such partnerships amount to favoritism. Others contend that most such activities would be ineffective, thus wasting the taxpayers money, or, worse, could deflect R&D away from other objectives that could turn out to be more important.

One skeptical analysis of the premise that strict environmental regulations might enhance industrial competitiveness also questioned the contention that R&D subsidies for environmental tech-

6 In this regard, Title II of the House passed version of H.R. 820, the proposed National Competitiveness Act, would authorize the Commerce Department's National Institute of Standards and Technology to support large-scale research and development consortia. Among criteria for an award: significant contribution to environmental sustainability.

7 Further, Federal funds supporting research on environmental sciences are limited. Such research could lead to better understanding of the risks that environmental degradation poses to human health, natural processes, and ecosystems. Improved understanding of the nature of such risks could contribute to more effective policymaking.

nologies would help promote U.S. industry.[8] Government R&D subsidies might be needed to obtain socially desirable investments in environmental improvements. However, in a world of multinational firms and international markets, capturing the benefits of the R&D for domestic developers might be difficult.

Even so, the long-term benefits to U.S. industry and society from cleaner industrial technologies could be very large, and it is not certain that industry will act on its own to develop these technologies unless it is clear that the government is committed to their use in environmental compliance.

Following from the discussion above, a number of options might be considered by Congress if it wishes to broaden the Federal role to encourage development and deployment of new generations of environmental technology by industry. Some are discussed in the two following sections (technology diffusion, and regulatory reform and innovation). Among those that relate to the Federal Government's direct role in supporting R&D activities are the following:

OPTION 1: Begin oversight at an early date on the administration's progress to:

- coordinate and rank Federal R&D priorities for environmentally critical technologies (including those most pertinent to industry);
- integrate cleaner production objectives into missions of commercial technology R&D programs.

OPTION 2: If Congress expands EPA's role in technology development, it could direct the agency to work with other agencies and industry to emphasize cleaner technology and pollution prevention, and to seek to link regulatory development more closely with technological priorities.

OPTION 3: With regard to Department of Energy programs:

- Review funding priorities and monitor progress on Energy Policy Act R&D for renewable energy, clean coal, and other environmentally pertinent technologies. (Option 18 below discusses EPACT provisions for export promotion and transfer of some of these technologies).
- Explicitly add environmental technology to the mission of DOE's Office of Industrial Technology;
- Fund more research, development, demonstrations, and evaluations on cleaner production technologies and pollution prevention processes.

OPTION 4: Increase National Science Foundation support for cleaner technology research, through industry-university research centers, engineering research centers, and individual investigator grants offered through NSF's environmentally benign manufacturing program.

OPTION 5: Authorize support for initiating (or expanding) R&D cost-sharing with industry sector organizations to:

- serve as **a** forum for industry to collectively identify R&D needs related to environment;
- arrange partnerships among researchers, equipment makers, and industrial users to develop manufacturing technologies that are more energy efficient and cleaner;
- arrange similar partnerships to develop more cost-effective control, recycling, and disposal technologies for pollution and wastes;
- support demonstration of cleaner technologies and new control, recycling, and disposal technologies;
- identify and diffuse innovations and best practices in pollution prevention and control to industry; and share information on cost effectiveness of pollution prevention relative to control technologies; and
- identify regulatory barriers to more efficient environmental solutions, and train inspectors

[8] Karen L. Palmer and R. David Simpson, "Environmental Policy and Industrial Policy,' *Resources: Resources for the Future,* **summer 1993, No. 112, pp. 17-21.**

Table 2-2—issue Area B. Diffusion of Best Practices and Technologies to Industry

		Impact on Federal expenditures[a]	Does option require major changes in Federal role?[b]	Policy goals promoted[b]: Enhance overall manufacturing industry competitiveness	Expand markets for U.S. environmental goods and services	Further global or developing country environmental goals
6	Evaluate incentives to diffuse cleaner technology to industry	L[c]	Y[c]	Y	Y	P
7	Make cleaner production and pollution prevention a mission and service of manufacturing extension services	M	N	Y	?	?
8	Direct EPA to oversee more technology evaluations, and disseminate results here and abroad	M	N	Y	Y	Y
9	Support efforts to integrate environmental components in engineering and business school curricula	s	N	Y	P	P

a S=small ($10 million or less); M=moderate ($10 to $100 million); L-large ($100 million plus); a range indicates that it depends on how the option is implemented,
b Y=yes; P=potentially yes; N=no; ?-effect is unclear
c assumes action is taken after review or evacuation

SOURCE: Office of Technology Assessment, 1993.

and permit writers on pollution prevention and control in particular industries. (See further discussion below in Issue Area C: Regulatory Reform and Innovation.)

To be eligible, an organization would need to serve an industry sector with significant environmental impact or high compliance costs (e.g., chemicals, petroleum refining, primary metals, metals finishing, and pulp and paper). In sectors that now have such organizations, Federal support could focus on pollution prevention and environmental technical assistance. While industry governance and funding would be crucial, the organization could work with Federal laboratories.

Issue Area B. Diffusion of Innovations to U.S. Industry

As discussed in chapter 8, there is a wide gap between best environmental practices in industry and prevailing practice. Many firms, especially small and medium-sized companies, have limited knowledge or access to information about innovations that might help them address environmental problems in a more cost-effective manner. The existing regulatory system often encourages compliance-driven approaches that, in the long run, are often not optimal from either an environmental or a competitiveness standpoint. In the final analysis, better integration of environmental and economic considerations will require changes in the educational system for both engineers and managers. Discussed below are several issues and options to encourage diffusion of innovations to industry: incentives; technical help to smaller companies; evaluation of technology performance; and integration of environmental matters in business and engineering curricula. Table 2-2 lists these options,

INCENTIVES FOR DIFFUSION

Companies are often reluctant to install innovative technologies. The costs and risks of being first lead many companies to stick with tried-and-true environmental control approaches. In addition to alteration of regulations and programs for technology verification and demonstration (described elsewhere in this chapter), Congress could consider a range of incentives for innovative environmental technology development and use. To aid in this process, Congress might direct the administration to provide analysis of the costs and benefits of several specific mechanisms (see Option 6 at the end of this section).

Accelerated depreciation and tax credits, loan programs, and environmental taxes are among approaches used in some other countries. Accelerated depreciation is used in the Netherlands, where firms that install innovative pollution prevention or control technologies can depreciate their investment in 1 year instead of 10. The list of eligible technologies is revised each year in consultation with industry and government experts. Technologies that have gained significant market share or that are required to be installed by regulation are ineligible. This kind of approach could also be applied to programs of tax credits or low interest loans.

Environmental taxes applied to production of pollutants or waste is another alternative or complement to the incentives just described. If the added costs are high enough, polluters may seek to avoid such taxes through pollution prevention, or look for alternative technologies. Environmental taxes could provide an incentive for companies to perform better than standards require. Some studies indicate that taxes on pollution and other "bads" can be economically preferable to taxes on "goods" such as labor, investment, and savings.[9] Revenues from environmental taxes could be used for general revenue, to displace income and other taxes, or to finance the above mentioned environmental innovation incentives.

Government procurement can both encourage or discourage the development of markets for environmentally preferable technologies and products. Environmental objectives underlie recent changes in procurement policies for such items as paper (postconsumer recycled fiber content), light bulbs (energy efficiency), and vehicle fleets (less polluting fuels). Other steps (e.g., an Executive Order by President Clinton to reduce toxic waste emissions from Federal facilities to one half by 1999) could encourage development and markets for alternative products. In some cases, other policy objectives may slow adoption of alternative products. Changes in procurement policies can be highly controversial, and provoke heated opposition by affected industries. As part of the Option 6 evaluation, or separately, Congress might call on the administration to assess the early experiences with these changes in procurement policies.

TECHNICAL ASSISTANCE TO SMALL AND MEDIUM-SIZED COMPANIES

Technical assistance programs can help manufacturers, particularly small and medium-sized enterprises (SMEs), understand and cope with environmental regulations, and select low-cost alternative technologies and approaches, such as pollution prevention. Most States and a few localities have pollution prevention programs, which provide information and technical assistance services.

The Federal Government provides some funding and technical support to these programs. However, resources are small relative to need. Some EPA-supported programs are housed in State environmental agencies. Wary manufacturers may not use these services, for fear of triggering enforcement actions.

Pollution prevention is one of several kinds of State or federally supported technical assistance. Company officials may view other needs (e.g., for

[9] **Robert Repetto, Roger C. Dower, Robin Jenkins, and Jacqueline Geoghegan,** *Green Fees: How a Tax Shift Can Work for the Environment and the Economy* **(Washington DC: World Resources Institute, November** 1992).

manufacturing modernization, worker training, and quality improvement) as more important. Few programs provide fully integrated services; in some states, there may be separate technical assistance programs for energy conservation, worker health and safety, pollution prevention, and technology modernization. Manufacturers may not know which program to contact; the fragmentation of services thus limits opportunities to offer pollution prevention in the context of a manufacturer's needs for productivity and quality improvements. Moreover, most programs focus on fabrication and assembly industries, not on highly polluting process industries, such as chemicals or steel.

There are advantages to offering pollution prevention, energy conservation, and manufacturing technology modernization in an integrated or coordinated fashion. Providing services through one-stop centers (or at least through closely coordinated services) might improve efficiency, technical consistency, and cost-effectiveness. Integrated service organizations can respond to a wide range of industry needs and can rely on existing field staff for leads. These organizations can aid technology transfer, by conveying information to firms about new technologies, and aid technology development by providing information to developers about industry needs. As outlined in Option 7 at the end of the section, there are several alternatives Congress might consider as ways to provide integrated or coordinated services.

Such a broad mission might be given to or coordinated with new manufacturing technology centers administered by the National Institute of Standards and Technology in the Commerce Department.[10] While some of these centers have already been established, President Clinton has proposed expanding this system, as have various bills proposed in the 103d Congress. The mission of these centers could be broadened to include energy conservation and pollution prevention along with training, modernization, and quality. Such a move could help integrate pollution prevention into the service infrastructure regularly used by manufacturing firms. The centers would not need to offer these services directly, for they could coordinate with the providers.

One disadvantage of this more integrated approach is that it might not target the firms that produce the most waste or cause the most environmental damage.[11] If the top priority is to reduce pollution and wastes, putting pollution prevention programs in existing manufacturing modernization programs may dilute this focus. However, this matter could be addressed by making sure that the environmental component of these organizations concentrate on achieving pollution and waste reduction goals.

EVALUATION OF TECHNOLOGIES AND DISSEMINATION OF INFORMATION

Objective information about performance capabilities could make it easier to commercialize innovative American environmental technologies. Some users of environmental technologies are reluctant to try innovative technologies for fear that they will not meet requirements or will be more costly than anticipated. Rather than take the risk, they may stick with established technologies that could be less cost-effective for the enterprise and less effective from an environmental standpoint. Independent technology evaluations might help overcome some of the uncertainties accompanying new environmental technologies; hence, Congress might wish to encourage such evaluation activities (see Option 8 at the end of this section).

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[10] S. 978 as reported by the Senate Environment and Public Works Committee would call on EPA and the commerce Department to enter into agreements so that EPA would provide technical assistance and support to the centers for this purpose.

[11] For example, many State pollution prevention programs have encouraged pollution prevention in sectors such as auto repair, @cl*& small print shops, and other local service firms. The environmental problems of these firms might get less attention in a program with more of an economic development or competitiveness focus.

Evaluation information also could aid U.S. environmental firms in marketing their products and services abroad by providing potential customers with a more solid basis for choosing among technologies. Often, such clients hold EPA in high regard as an unbiased source of environmental information. While EPA does not, and probably should not, endorse particular technologies or vendors, some U.S. companies say that lack of governmental endorsement can be an impediment in marketing abroad, and claim that foreign competitors sometimes obtain such blessings from their home governments.

Legislation proposed in the 103d Congress would authorize more extensive Federal support in evaluation of environmental technologies. Among its other evaluation programs, S. 978 (the proposed National Environmental Technology Act of 1993), would establish an EPA program to evaluate, verify, and disseminate performance and cost information on environmental technologies. One function of this program would be to develop protocols and testing procedures. A clearinghouse would disseminate information about technologies that meet or exceed evaluation guidelines. Another bill, the House passed version of H.R. 820, the proposed National Competitiveness Act, would authorize the Commerce Department's National Institute for Standards and Technology to serve as testbed for advanced technologies, including prototype clean manufacturing systems.

EPA already sponsors some evaluations of innovative technologies developed by U.S. vendors, with the vendor picking up most of the costs. Its Superfund Innovative Technology Evaluation (SITE) Program is the largest and best known example. Technology developers pay to design, install, and operate their technologies while EPA pays for site preparation and evaluation. Smaller EPA efforts are the Municipal Innovative Technology (MITE) Program and the Clean Technology Demonstration Program.

Evaluations would not necessarily need to be federally administered; federally supported centers could perform this function. For example, the National Environmental Technologies Applications Corp. (NETAC), a nonprofit corporation founded by EPA in 1988 and associated with the University of Pittsburgh Trust, has provided independent laboratory evaluations on oil bioremediation agents. EPA apparently prefers an independent entity to oversee testing and review of technical data on environmental technologies.[12]

Evaluation programs have their drawbacks. The SITE program received early criticism for evaluating few truly innovative technologies.[13] In addition, vendor demand for evaluations could exceed available resources; in such cases, evaluated technologies might receive a competitive advantage over comparable or even superior unevaluated technologies. Nonetheless, performance verification could be a useful step that would help domestic and foreign customers chose among alternatives. It could be a low cost way to promote U.S. exports in an environmentally desirable way. (See subsequent discussion of Option 23).

ENGINEERING AND BUSINESS EDUCATION

If U.S. industry is to better meld environmental with competitive demands, it will need engineers who are adept at integrating environmental considerations with other cost, quality, and technical performance criteria, and managers who understand how different environmental solutions impinge on cost, quality, and marketing. Environmental goods and services firms also will need such technical and managerial talent to offer

12 "EPA Calls for Independent Environmental Technology Review Office,' *Inside EPA*, Aug. 6, 1993,

13 Office of Technology Assessment, *Coming Clean: Superfund Problems Can be Solved*, OTA-ITE-433 (Washington, DC: Us. Government Printing Office, 1989), pp. 182-183.

customers a full range of environmentally and economically sound solutions. Yet such environmental matters are addressed on the periphery, if at all, in most engineering and business education programs.

In some engineering schools, environmental engineering programs train students to design and operate end-of-pipe pollution control and disposal systems. These students may have a limited understanding of the industrial production processes in which pollution prevention opportunities arise.

Students in traditional engineering disciplines (chemical, civil, electrical, and mechanical engineering) and related areas (e.g., architecture materials engineering, food science, and industrial engineering) usually do not receive much training on how to consider environmental factors in designing or modifying products, processes, and structures. *4 Environmental criteria, such as emissions standards, recyclability, and toxicity of materials, tend to be thought of as externally imposed constraints that are often treated as an afterthought in the design process, As a result, opportunities to improve the environmental performance of industrial processes and products while keeping costs low and quality high may lie unrecognized. Thus, integration of environmental issues and perspectives in the mainstream engineering curriculum could be useful.[15]

As is discussed in Option 9 below, Federal agencies, such as the National Science Foundation (NSF) and the Office of Environmental Education at EPA, might contribute to efforts to change engineering education. For instance, NSF could assemble and disseminate course materials for use in undergraduate curricula. It could help professors and lecturers learn how to address environmental factors in their courses. NSF could support or complement some existing efforts. For instance, the Center for Waste Reduction Technologies of the American Institute of Chemical Engineers has developed a manual for incorporating pollution prevention design and homework problems in chemical engineering courses. Government, industry, professional associations, and universities can work together to produce and use these educational materials. Such materials could help in training undergraduate engineering students and in retraining practicing engineers, such as those leaving defense-related jobs or participating in continuing education.

Business schools tend to treat environmental issues as a peripheral matter, Their students are seldom taught to account for and properly assign all environmentally related costs. Without adequate environmental accounting and accountability, managers and engineers may not attack their environmental problems in the most cost-effective way. The costs of waste disposal may not be assigned to individual processes and product lines, for example. Regulatory costs, potential liability, or loss of community or customer goodwill also may not be fully taken into account. Finally, ways to mesh environmental performance with better quality and productivity are seldom studied. The analogy between environment and quality is discussed further in chapter 8.

Some business schools are beginning to respend.[16] However, only about 1 in 10 has or is developing environmental courses .[17] The Federal Government, in cooperation with professional associations and universities, could support as-

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14 For discussion of issues related to incorporation of environmental factors in the design of products, see U.S. Congress Office of Technology Assessment, Green *Products by Design: Choices for a Cleaner Environment,* OTA-E-541 (Washington, DC: U.S. Government Printing Office, October 1992).

15 Robert A. Frosch and Nicholas E. Gallopoulos, "S~te@es for Manufacturing, " *Scientific American,* vol. 261, No. 3 (September 1989), pp. 144-152.

16 J.E. Post, "The Greening of Management, " Issues *in Science and Technology, vol. 6, No. 4* (summer), pp. 68-72.

17 Information provided by staff of the Management Institute for Environment and Business, August, 1992.

sembly and dissemination of relevant course materials to business schools (see Option 9 below). For example, the Management Institute for Environment and Business seeks to encourage business schools to integrate environmental concerns into their curricula. It has produced a book of case studies on environment and industrial competitiveness.

OPTION 6: Direct the administration to identify and evaluate that best choices among economic incentives (e.g., accelerated depreciation, loans, or fees) to speed diffusion of cleaner technologies to industry. EPA, the Department of Commerce, the Department of Energy, and the Treasury Department could examine the competitive, environmental, and fiscal impacts of such approaches. Congress also might direct the administration to provide initial evaluation of its use of Federal procurement to achieve environmental goals-an approach promulgated in several recent executive orders.

OPTION 7: Make pollution prevention and energy conservation specific mission objectives and services to be provided or facilitated by manufacturing extension services. (Expansion of these services is proposed in legislation before the 103d Congress.) Fund efforts at the State and local level, through existing industrial modernization organizations, to help promote pollution prevention. Use funding currently channeled through several existing Federal technical assistance programs to support full-service industrial extension, including manufacturing modernization, pollution prevention, energy conservation, worker training, and worker safety and health.

Alternatively, Congress could expand EPA's Pollution Prevention Incentives for the States (PPIS) program or the Waste Minimization Assessment Centers (WMAC), and direct that some grants be provided to State industrial extension services. PPIS provides $3 million a year to State pollution prevention technical assistance programs. The three WMACs receive $200,000 a year and are housed at universities where faculty and staff perform free, in-depth waste minimization assessments for small and medium-sized business.

OPTION 8: Direct EPA (either itself or through a center) to undertake independent evaluations of the technical, environmental, and economic performance of innovative environmental technologies. As remediation evaluation programs already exist, this activity could be oriented to pollution prevention and control and cleaner technology options. Firms seeking to have their technologies evaluated would pick up most of the costs.

Provide resources to ensure timely dissemination of results, including possible translation into foreign languages.

OPTION 9: Provide seed funds through NSF or the EPA Office of Environmental Education for integration of environmental components into engineering school and business school curricula. The objective should not be to produce new courses labeled pollution prevention (in the case of engineering schools) or business and the environment (at business schools) but to incorporate environmental methodologies into basic curricula.

Issue Area C. Regulatory Reform and Innovation

It is difficult to generalize about the U.S. system of environmental regulations, even when the focus is just on manufacturing firms. However, there are some common characteristics. For example, there continues to be a focus on single media; there tends to be more emphasis on controlling or treating pollution after it has been generated; and there is relatively little direct encouragement for technology development or innovation.

As discussed in chapter 9, traditional approaches to regulation and enforcement sometimes make innovation difficult. Complying firms also can find it difficult to implement the lowest cost approaches.

For example, it has been difficult to integrate the mission of pollution prevention into EPA's operations. (Recent developments, such as the June 1993 pollution prevention policy statement from the EPA Administrator, may speed up the process.)18 Pollution prevention often has been carried out as a separate function, with projects peripheral to EPA's main regulatory and enforcement role. Many regulations and rules reinforce reliance on end-of-pipe technology. Even for performance based regulations, personnel responsible for permitting may not have adequate training to recognize appropriate opportunities for use of pollution prevention alternatives.

Strong environmental regulations and enforcement are essential to encourage firms to adopt pollution prevention and to encourage innovation. However, prescribing pollution prevention practices or techniques could make it difficult for manufacturers to develop pollution prevention solutions that make the most sense for their operations. Better results might be achieved by encouraging (or even mandating) pollution prevention planning, modifying regulations to allow more pollution prevention, and increasing technical assistance and support for technology development.

As long as strong regulation and enforcement are fully maintained, steps could be taken to explore approaches that allow firms to use more cost-effective approaches without jeopardizing environmental goals. Innovative experiments conducted in many places around the country are promising and could be attempted elsewhere. For example, full-facility studies examining all pollutants and waste generated by different types of industrial facilities can be useful for guiding company pollution prevention efforts and helping regulators establish more effective but less costly environmental protection requirements. The Amoco Yorktown study, jointly managed by Amoco Co., EPA, and the Commonwealth of Virginia, identified many pollution prevention and control options that could achieve greater pollution reduction than now required by regulation. Such studies done for other types of facilities, such as pulp mills, or various classes of chemical plants, would be useful.

EPA has been assessing additional steps that might be taken to encourage innovation, such as setting up reinvention laboratories (or pilot projects) staffed by experienced EPA and state permit writers.[19] Concern exists within EPA about its authority to undertake such efforts .20 If Congress wishes to encourage more innovation, it could explicitly authorize and fired options such as those listed for Issue Area C in table 2-3 and discussed below.

OPTION 10: Congress could provide funds to EPA for a pilot project program with industry to demonstrate regulatory approaches that give firms that are first rate environmental performers more choice in the means they use to meet environmental requirements. Firms showing commitment to environmental excellence (e.g., significant pollution prevention efforts, participation in EPA voluntary programs, and willingness to conduct facility-wide environmental and pollution prevention audits) might be eligible for such benefits as:

- coordinated multimedia permitting and inspection (rather than single media permits with multiple inspections),
- facility-wide emission caps, rather than individual source limits,

18 Memorandum of Carol M. Browner, Administrator, to all EPA employees, June 15, 1993, titled "Pollution prevention Policy Statement: New Directions for Environmental Protection."

19 For discussion of this concept and several other steps to encourage innovations, see U.S. Environmental Protection Agency, "Report of EPA's Environmental Technology Team for the National Performance Review,' August 1993, mimeo.

20 Ibid., p. 17.

Table 2-3--Issue Area C. Regulatory Reform and Innovation

				Policy goals promoted[b]		
		Impact on Federal expenditures[a]	Does option require major changes in Federal role?[b]	Enhance overall manufacturing industry competitiveness	Expand markets for U.S. environmental goods and services	Further global or developing country environmental goals
10	Set up an EPA pilot project to experiment with innovative permits for firms that are first rate environmental performers	M	N	Y	?	7
11	Give incentive grants for regulatory reform and innovation projects to States and firms	M	N	Y	?	?
12	Upgrade training of permit and regulation writers	M	N	Y	?	?
13	Set up industry sector Consortia/cluster groups	s	Y	Y	?	?
14	Modify R&D permitting to better accommodate R&D, such as fixed site permits for R&D centers	s	Y	Y	Y	7
15	Set up an environmental cooperation institute and sector cooperation councils	s	Y	Y	?	?

a S=small ($10 million or less); M=moderate ($ I o to $100 million); L-large ($100 million plus); a range indicates that it depends on how the option is implemented.
b Y=yes; P=potentially yes; N=no; ?=effect is unclear

SOURCE: Off Ice of Technology Assessment, 1993,

- use by participating firms of any technical approach that meets environmental standards, and
- accelerated permitting in some circumstances.

OPTION 11: Congress could give EPA funds to make incentive grants for innovative regulatory reform projects, and funds for innovations by State environmental agencies. For example, grants could be used to conduct full-facility studies examining all sources of pollution and pollution prevention options, provide training to implement new approaches, integrate information management technologies into compliance monitoring, and conduct multimedia inspections. In addition, EPA could actively work to encourage coordination, and disseminate information about the States experiences.

* * *

While experience with such approaches as those in Options 10 and 11 is growing, a number of barriers and concerns would need to be addressed before these techniques could be put into widespread use. Assurance would be needed that health and environmental standards would be maintained. Safeguards to guard against, and quickly detect, abuses would be needed. (Hence, new techniques allowing continuous monitoring of emissions would help.) It also would be difficult to develop criteria to use in determining what constitutes a good environmental record for qualifying fins. Concerns exist that flexibility could lead to favoritism or foreclose enforcement options.

For all these reasons, evaluation of the activities undertaken under Options 10 and 11 would be essential to identify the most effective approaches and needed areas for improvement. EPA could be directed to provide for such evaluations, and to provide technical assistance to states seeking to implement these approaches on a wider basis.

Widespread use of these approaches could stress regulatory agencies now organized along media lines for end-of-pipe compliance. The skills needed by permit writers would change from narrow and specialized to broad based, yet the permit writers would need strong technical backgrounds to deal with a more complicated permitting process and to judge whether alternative approaches are appropriate. Provision would need to be made for training.

OPTION 12: Congress might increase EPA's resources to hire or train inspectors and permit writers to recognize and evaluate a variety of technical approaches for meeting environmental standards.

* * *

Regulations and permitting procedures can sometimes impede technology innovation and diffusion. Best available technology (BAT) or similar standards can assure successful environmental technology developers of a market, but can make acceptance of alternative environmental technologies harder, Complying firms may install technologies used as benchmarks by regulatory agencies on the assumption that it is better to stick with proven technologies that seem to be endorsed by the regulations. While BAT standards are favorable for suppliers of approved technology, they may inhibit development of new and innovative technology by other vendors and developers.

Some of the impediments might be overcome if there were closer links between technology developers and regulators, EPA could work with industry-sector technology organizations (e.g., the organizations discussed in Option 5) on environmental issues facing the industry, including the implications of foreseeable regulations for technology priorities, development, and diffusion. This task could be assigned to industry-sector groups at EPA with expertise on a given industry. Better training of permit writers, so that they might more confidently judge innovative alternatives, would also help.

OPTION 13: Congress could direct EPA to expand its industry sector-based activities. EPA could be given resources to develop more sectoral specific expertise at EPA and within the States. With more industry sector expertise, efforts to develop regulations that realistically anticipate compliance problems could be enhanced.

* * *

Firms complain about the complexity, uncertainty, cost, and time required to obtain an innovative environmental technology R&D permit under RCRA or under ad hoc procedures under the Clean Air Act (CAA) and Clean Water Act (CWA). Some technology developers have moved technologies abroad for development and testing. Adjusting procedures to meet the needs of innovators, provide permits for freed R&D and testing facilities, and develop quicker and more predictable permitting might help U.S. innovators, but would need to be done in ways that avoid the potential for abuses.

OPTION 14: Modify permitting in RCRA, CAA, and CWA to better accommodate research, development, demonstration, and testing. R&D permits lack the flexibility required to encourage research; ad hoc administration of innovative technology testing lacks predictability. Congress might therefore institute streamlined and flexible permitting for innovative technology, including permitting of testing centers.

* * *

The options discussed above are intended to help stimulate innovation. However, they would still be controversial. While experimentation with such procedures is already underway, even some demonstrably successful approaches might not win acceptance with industry, environmental organizations, or regulators. Over years of debate about regulations, regulated industries often have concentrated more on reducing levels of regulation than on improving the efficiency of the regulatory system. Many in industry fear that new approaches to regulation, such as pollution prevention, could lead to more burdensome requirements. For their part, many environmental groups have been more concerned with defending existing gains than in making the system deliver equal or even greater environmental benefits at lower costs. Within regulatory agencies, many are reluctant to embrace a new system that departs from accustomed ways of doing things. Also, managers may resist efforts to break down organizational walls, particularly when resources are scarce.

Without a sense of trust and commitment among these key parties, the cooperative basis for developing more effective and efficient regulatory approaches will be limited, Thus Congress might consider ways to build more cooperative relationships between government, industry, and environmental organizations, as in Option 15.

OPTION 15: Congress could fund an Institute for Environmental Cooperation to promote innovative cooperative efforts between industry, environmental groups or other nongovernmental organizations, and government. The institute could be a forum for collaboration, bringing various parties together to explore new approaches and to craft new solutions. Moreover, the institute could study innovative cooperative efforts and disseminate lessons learned from these approaches.

Universities could also serve as forums for consensus building and collaboration. One example is an effort at the Massachusetts Institute of Technology in which industry, nongovernmental organizations, regulators, and academics are examining issues related to industrial chlorine use. Such efforts could be supported as part of an Institute for Environmental Cooperation.

Congress might also want to explore creating sectoral industry councils within EPA. A small number of councils might be formed for those industries with the greatest environmental impacts, with membership from industry and environmental organizations. If EPA moves toward sectorally based, multimedia rulemaking, these councils could support these efforts.

Issue Area D. Export Promotion, Development Assistance, and Environmental Firms

Compared to several competitors, the U.S. Government provides relatively little support for U.S. manufacturing firms for exporting. Recent U.S. laws give new legislative priority to Federal export promotion programs; someplace emphasis on environmental technologies and services specifically. Several bills pertaining to promoting exports of U.S. environmental technologies and services also have been proposed in the 103d Congress.

Responding to a congressional directive, the Clinton administration issued a proposed export promotion strategy with over 60 recommended actions in September, 1993, While many of the proposed steps do not require congressional action, debate about level of funding and support for these new programs will continue. The administration also issued an environmental export strategy in November 1993 just before this report went to press.

While most of the environmental market is in advanced industrial countries, markets in newly industrialized countries are growing rapidly. Most developing countries have limited experience in addressing environmental matters. However, developing country environmental problems are great, and some are beginning to invest in environmental protection. They thus have become a focal point in debate about policies and programs to promote exports of environmental technologies, not only in this country but in other countries with large environmental industries. In this case, alternative governmental roles in promoting exports need to be evaluated in the broader context of encouraging international cooperation to improve the environment, which is the shared heritage of all countries, and in

Table 2-4—issue Area D. Export Promotion, Development Assistance, and Environmental Firms

			Policy goals promoted[b]		
	Impact on Federal expenditures[a]	Does option require major changes in Federal role?[b]	Enhance overall manufacturing industry competitiveness	Expand markets for U.S. environmental goods and services	Further global or developing country environmental goals
Multilateral cooperation for technical assistance:					
16 Work to setup a program to help developing countries identify needed environmental technologies	S	N	?	Y	Y
17 Make cleaner production/pollution prevention a priority in multilateral aid	M	N	?	Y	Y
Bilateral Foreign Assistance/Export Promotion:					
18 Fund EPACT programs for USAID- DOE transfer of innovative energy and environmental technologies to developing countries	L	N	?	Y	Y
19 Increase Trade and Development Agency funding for feasibility studies	M-L	N	?	Y	Y
20 Encourage U.S. firms to emphasize training of developing country personnel in equipment and services contracts	M	N	?	Y	Y
Export Promotion					
21 Conduct early oversight on the Trade Promotion Coordinating Committee's environmental working group strategy and proposed budget	S	N	?	Y	Y
22 Encourage U.S. foreign commercial interactions through:					
• increasing overseas commercial officers or contractors	M	N	Y	Y	P
• increasing outreach to environmental industry associations	M	Y	?	Y	P
• operating through environmental business centers here and American Business centers overseas.	M	N	?	Y	Y
23 Disseminate information about U.S. technologies abroad	S	N	?	Y	Y
24 Provide resources for one-stop shopping and regional centers to help smaller firms access and make use of available export assistance	M	Y[c]	?	Y	P
25 Consider ways to expand export financing while keeping environmental safeguards	L[c]	Y[c]	?	Y	P

a S=small ($ l o million or less); M=moderate ($1 O to $100 million); L-large ($100 million plus); a range indicates that it depends on how the option is implemented.
b Y=yes; P=potentially yes; N=no; ?-effect is unclear
c assumes action is taken after review or evaluation

SOURCE: Office of Technology Assessment, 1993.

furthering developmentally sound progress in the developing world.

Discussed below are three matters that bear on where to draw the line between competition for markets and environmental cooperation: the role of multilateral aid to developing countries; links between development assistance and export promotion; and the Federal export promotion role more generally. A number of options, summarized in table 2-4, are discussed.

This ordering is deliberate: this report finds that efforts by developed countries to promote environmental exports need to take place within a context of bilateral and multilateral actions to improve the environmental capabilities of developing countries.

There is a potential for tensions between development assistance objectives aimed at meeting the needs of developing countries (e.g., for environmentally sound, sustainable development) and the desire of many donor countries to realize commercial benefit from their aid (e.g., encouraging exports of environmental technologies whether or not the particular technology is best suited for the developing country). A background paper prepared for this assessment, *Development Assistance, Export Promotion, and Environmental Technology,* discusses this issue in some detail.[21]

MULTILATERAL COOPERATION FOR TECHNICAL ASSISTANCE

Developing countries have a great need for appropriate environmental technologies and services. Yet few developing countries have the necessary information or technical resources to make the best selections; nor can they be sure of the objectivity of other nations in providing technical help when commercial transactions are involved. These concerns might be addressed through multilateral and bilateral efforts to provide developing countries with technical information and assistance about environmental technologies and services.

As discussed in Option 8, U.S. agency support for independent evaluations of environmental technology could be expanded. Expansion to include more emphasis on evaluation of prevention and control technologies as well as remediation could benefit U.S. firms seeking foreign clients. However, even with independent information, officials in developing countries often do not have enough information about available options. In some cases, relatively simple technologies may suffice. Information and technical assistance provided by national governments or by firms could be suspect. Hence, a multilateral approach could be helpful.

One possibility (see Option 16 at end of section) would be for the U.S. Government (acting through the Department of State, USAID, or another agency) to work with other countries to expand the ability of international agencies like the United Nations Environment Program to provide objective information and technical advice about environmental technologies (including cleaner technology choices).

The costs of needed environmental improvements in developing countries could be great. With end-of-pipe solutions, developing countries might easily need to invest over $50 billion per year (1 percent of their projected gross domestic products in the year 2000) to factor environmental matters into their development plans.

Most of the costs of environmental protection in developing countries will need to be paid for by the developing countries themselves or through resources made available through increased trade and investment. However, bilateral and multilateral aid might serve a catalytic function in prompting action. As discussed in OTA's *Development Assistance, Export Promotion, and Environmental Technology,* industrial countries provided about $5 billion in bilateral and multilateral environmental aid in 1991.[22] This aid has probably increased; Japan claims its 1992 environmental aid was more than twice that in 1991—over $2 billion.

Cleaner technologies and pollution prevention are promising options to keep life cycle costs for environmental infrastructure manageable. Some pollution prevention approaches are very inexpensive, although requiring technical assistance and training of personnel. In other cases, cleaner technologies entail higher front end costs than conventional equipment; however, they can be more attractive than conventional options when operating and maintenance costs are considered. Technical assistance to provide reliable informa-

21 US. 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).

22 Ibid.

tion about alternatives could be useful to developing country decisionmakers. U.S. firms and consultants are among the leaders in providing such services.

The United States offers substantial assistance to developing countries to enhance their environmental management capabilities.[23] If Congress wished to pursue more multilateral activities to help develop information needed for environmentally and economically sound choices, the following options might be considered:

OPTION 16: Support establishment of a technical information program by an international agency such as the United Nations Environment Program, the United Nations Development Program, or the Global Environment Facility to provide objective information and technical advice about environmental technologies to developing countries.

OPTION 17: Through multilateral channels, support cleaner technology and pollution prevention services to developing countries in addition to the existing USAID bilateral environmental pollution prevention project.

BILATERAL ASSISTANCE AND EXPORT PROMOTION

The United States Government now spends about $650 million per year on environmental and related energy aid to developing countries. U.S. aid programs are not as overtly commercial as some other countries' programs are perceived to be. Use of aid to support commercial transfer of U.S. environmental technologies has been limited. However, some forms of assistance can benefit a donor country's commercial goals in ways that are compatible with the development aspirations of developing countries.

Some recently initiated public-private partnerships aim to involve U.S. industry in efforts by developing countries to address environmental problems. The United States-Asia Environmental Partnership (US-AEP), launched in 1992, works with U.S. agencies and firms to encourage use of U.S. technologies and expertise in Asian country environmental efforts. It is too soon to evaluate US-AEP. If it succeeds, US-AEP's regional emphasis might be attempted in other promising market areas. The U.S. Environmental Training Institute (USETI), another recently launched public-private partnership, brings business and governmental decisionmakers to the United States for training through which U.S. firms can showcase their technologies.

Newly authorized programs, such as major new environment and energy technology transfer programs called for in the 1992 Energy Policy Act, emphasize an USAID role with the Department of Energy in transferring technologies to developing countries, in part because of the potential benefits to U.S. firms and the U.S. economy. As indicated in Option 18, Congress might consider fuller funding for these programs.

Helping developing countries with capacity building also can bring commercial benefits to donors. Support for the development of central laboratory facilities-equipment and training—for the environment agencies of developing countries could create preferences for U.S. standards, protocols, instruments, and other equipment. Such laboratories may set nationwide standards for environmental monitoring that may produce further orders for U.S. equipment from private sector and State/provincial/municipal laboratories.[24]

Technical training is another area where a donor's commercial interests and the recipient's developmental and environmental interests may coincide. The United States has an advantage in that many engineers in developing countries have

23 Ibid., pp. 58-61.

24 Japan, for instance, has funded the Environmental Management Center for the Indonesian environmental agency. The Center includes a central reference laboratory that will be outfitted with Japanese instruments. Some expect that provincial and private laboratories might adopt similar Japanese instruments so that they will be compatible with the central government laboratory.

received university education here. programs like USETI offer a way to expose developing country officials in both the public and private sectors to U.S. technology. However, there is also a need to train developing country personnel who will operate and maintain equipment and plants once facilities are constructed. Support for operations training could be an effective way to meet both development assistance and export promotion goals.

Grants to developing countries for project feasibility studies conducted by U.S. firms is another form of support; often, these studies lead to subsequent purchase of technologies or products made in the United States. The U.S. Trade and Development Agency (TDA) contends that its feasibility study grant program generates over $20 in ***U.S. sales*** for every Federal dollar spent. Compared to some other countries, such **as** Japan (over $200 million per year), funding for TDA is low—about $40 million in fiscal year 1993; an increase to $60 million has been proposed. Since many TDA feasibility studies contain environmental components, such an increase would likely encourage more environmental exports. In its recent export promotion strategy, the Clinton administration proposed consolidation of all Federal feasibility studies for major projects primarily intended to promote U.S. exports.[25]

Compared to some donors, the United States provides little aid for capital projects—projects that often involve internationally traded goods and services. If undertaken in a developmentally and environmentally sound way, funding capital projects could create many commercial opportunities for U.S. firms. Some would contend that such a change would ruin months to years of U.S. efforts to encourage other donors to reduce their use of mixed credits and other tied aid loans.

If Congress wishes to place more emphasis on links between foreign aid and environmental export promoting, it might consider several options:

OPTION 18: Fund provisions in the Energy Policy Act of 1992 (Public Law 102-486) that call on the Secretary of Energy, acting through USAID or other Federal agencies, to encourage transfer of environmentally preferable energy technologies to developing countries. Three new programs were authorized: an innovative environmental technology transfer program, a clean coal technology transfer program, and a renewable energy technology transfer program. (The authorized funding level for each of these programs is $100 million per year through fiscal year 1998.) Also fund the developing country training program on renewable energy authorized by the law.

OPTION 19: Increase funding for the Trade and Development Agency for project feasibility studies.

OPTION 20: Encourage U.S. firms to provide training of developing country personnel for use of U.S. equipment and services. This might be accomplished through TDA funds.

EXPORT PROMOTION POLICY AND STRATEGY

The Export Enhancement Act of 1992 gave new emphasis to the need for better coordinated Federal export promotion efforts, including those pertinent to environmental exports. In addition, several environmental export promotion bills had been proposed in the 103d Congress.[26]

The Clinton administration's initial export promotion strategy, prepared in response to the Export Enhancement Act by the Trade Promotion Coordinating Committee (TPCC), was issued in

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25 Trade Promotion Coordinating Committee, *Toward a National Export Strategy* (Washington, DC: U.S. Government Printing Office, Sept. 30, 1993), p. x.

26 See, for example, H.R. 2112, the proposed National Environmental Trade Development Act of 1993, as reported by the House Merchant Marine and Fisheries Committee on June 30, 1992; Hi?. 2096, to promote exports of environmental technology, goals, and services; S. 979 the proposed Greentech Jobs Initiative Act of 1993; and S. 1074, the proposed National Environmental Trade Development Act of 1993.

September 1993.[27] The Act also gave statutory direction for an environmental trade working group as part of the TPCC. The Department of Commerce, the Department of Energy, EPA and some other Federal agencies had just issued an environmental export strategy when this report went to press.[28] Congress could monitor its priorities and implementation plans, including mechanisms for private sector involvement and priorities for the export potential of cleaner technologies (Option 21).

Federal Agency Export Promotion Budget—Several U.S. agencies and programs work to promote U.S. exports. Five agencies, the Commerce Department, Eximbank, the Agriculture Department, USAID, and the Small Business Administration (SBA), account for 90 percent of Federal outlays and most Federal field operations.[29] Other agencies with important roles include TDA and the Overseas Private Investment Corp. (OPIC). Numerous other agencies, including DOE and EPA, may have some involvement.

The Export Enhancement Act charged the TPCC with proposing an "annual unified" Federal export promotion budget. In its initial year under the new Act, the TPCC was unable to accomplish this--deferring development of the budget proposal to the fiscal year 1995 budget process. A particularly thorny issue concerns agriculture's budget share: according to the U.S. General Accounting Office, agriculture, in fiscal year 1991, accounted for 10 percent of U.S. exports, but 75 percent of the Federal export promotion budget.

Private Sector Role--A key question in export promotion generally, and in environmental exports specifically concerns the nature and degree of private sector involvement strategy development and priority setting. Some contend that there needs to be more private sector involvement in developing an environmental export strategy, and have proposed creation of a public private council to prepare an action plan to implement the strategy after it is accepted. The danger is, of course, that such a plan would become a form of special pleading by its private sector members. However, some precedents already exist for industry involvement in priority setting. One example is the Committee on Renewable Energy Commerce and Trade (CORECT) which could become a model for other subsectors.

Financing-Inability to put together an acceptable financing package often limits U.S. fins' ability to secure overseas projects. Moreover, the U.S. Government has few funds available for capital project financing in its aid program. Some other exporting countries offer more accessible and lower cost financial help to their firms in exporting (see ch. 6). The U.S. Eximbank does maintain a War Chest, but it is used defensively to counter unfair financing packages put together with support from other countries. Increased funding for the War Chest was authorized by Congress in 1992; it could be used to help U.S. environmental firms with financing when faced by a competitor with an unfair package. The War Chest also might be used proactively, to help U.S. firms finance projects that are more favorable from an environmental standpoint that might not otherwise be able to compete with lower cost, environmentally less favorable projects.

Another approach would be to give special priority to environmental projects by opening a special window for environmental loans at close-to-market rates at the Eximbank or other financ-

17 *Toward a National Export Strategy*, **op cit.,** footnote **25.**

28 **Ronald H. Brown, Hazel O'Leary, Carol Browner,** *Environmental Technologies Exports: Strategic Framework for U.S. Leadership,* **November 1993.**

29 Statement **of Allan L.** Mendelowitz, **''Export Promotion: Initial Assessment of** Governmentwide **Strategic** Plan,**" testimony before the House Committee on Foreign Affairs Subcommittee on Economic Policy, Trade and**Environment, **September 29, 1993, U.S. General Accounting Office,**GAO/T-GGD-93-48, **p. 9.**

ing institutions. These institutions are now expected to give special attention to projects that are environmentally preferable.

Foreign Commercial Service Representation—The United States & Foreign Commercial Service (US&FCS), part of the Commerce Department, maintains offices in this country and overseas. It is understaffed relative to the commercial offices of several competing countries. (See table 6-6 in ch. 6.) Congress could consider increasing the number of commercial officers. It also could provide resources to improve the timeliness and quality of commercial information from overseas offices to U.S. fins. Such steps might help increase U.S. exports of goods and services generally, not just in the environmental arena.

In some countries, the few US&FCS officers that are available must help sell a great range of American products, from textiles to nuclear power plants. It might help if some commercial officers could specialize in specific industries, such as environmental products where a potentially large market exists-a step authorized by the Export Enhancement Act.[30] While more officers could be assigned overseas, it might be cheaper to employ local nationals or American's living overseas. While increasing environmental officers would be useful in this sector, the more general issue of staffing and resources for US&FCS remains.

A more far-reaching approach would be to set up American business centers in key market areas to facilitate interactions between U.S. firms and potential clients. An environmental trade measure under consideration in the 103d Congress, H.R. 2112, proposes such an approach.

Information Clearinghouses and One-Stop Shopping—Many U.S. companies (including small and medium-sized enterprises) find it difficult to make use of government export assistance programs. They may not know how to obtain information about environmental opportunities in other countries. An information clearinghouse and a one-stop shopping process might help. Such a process would allow a business to tap into all U.S. export promotion and financing programs at a single source. Small companies have special difficulties financing market research in other countries, especially when they are inexperienced with exports.

Many potential exporters are unaware of existing Federal export support services. Better marketing of these services, such as the 1-800-USA-TRADE DOC Trade Information Center, US&FCS regional offices, and the National Trade Data Bank, through advertising in business and industry publications could heighten export awareness.

If Congress wishes to provide more emphasis on environmental export promotion, it could consider several steps:

OPTION 21: Conduct early oversight of the administration's environmental export strategy, including mechanisms for private sector involvement in implementation, and the priority given to export opportunities associated with cleaner technologies.

OPTION 22: Provide resources for US&FCS to hire industry sector specialists, including environmental industry specialists in key countries.

OPTION 23: Call for dissemination of evaluations of U.S. environmental technologies to potential foreign customers (see also Option 8).

OPTION 24: Call for demonstration of one-stop shopping approaches for export promotion, using environmental technologies and services as one area of emphasis. This activity would go beyond the initial efforts by United States-Asia Environmental Partnership and the Committee on Renewable Energy Commerce and Trade to consolidate application forms by providing a range of services to small businesses with limited export experience.

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30 The US-Asia Environmental Partnership has recently opened business offices in a number of Asian capitals as a complement to US&FCS in promoting U.S. environmental business opportunities.

Congress also might direct Federal export promotion programs to take steps to make U.S. firms more aware of available services by advertising in business and industry publications, increasing outreach to industry associations, chambers of commerce, and industry conferences, and increasing support and collaboration with State and local export promotion programs and World Trade Center institutes.

A more far-reaching approach, proposed in H.R. 2112 in the 103d Congress, would be to encourage exports through a network of environmental business centers in the United States and American business centers in countries with promising environmental markets.

OPTION 25: Consider ways to expand export financing while maintaining environmental safeguards. One possibility would be to offset extra costs borne by U.S. firms in designing environmentally preferable projects when going up against a project proposed by a foreign firm with inadequate safeguards.

Issue Area E: International Trade and Environmental Policy

The potential for conflict between environment and trade objectives seems to be increasing. Environmentalists contend that the environmental implications of the Uruguay Round trade discussions at the General Agreement on Tariffs and Trade (GATT) were overlooked by trade negotiators. Trade officials, for their part, are wary that some measures ostensibly taken to protect the environment could be used as means for trade protection.

U.S. positions on trade and environment issues will need to be developed for international discussions over the next few years. Since 1990, the Organization for Economic Cooperation and Development (OECD) has been sponsoring member country discussions about possible trade and environment guidelines. Both trade agencies and the environmental agencies of member countries (mostly, advanced industrial nations) are involved so that the discussions could lead to greater integration. However, some disputes involve developing countries, which are not members of OECD.

GATT, long inactive on trade and environment matters, has begun to review these questions from the trade perspective. A working group is examining trade measures in international environmental agreements, the trade transparency of national environmental regulations, and the trade effects of environmentally oriented packaging and labeling requirements. GATT groups have begun to discuss possible ways to follow up on a recommendation from the United Nations Conference on Environment and Development (UNCED) that multilateral agencies work to make environment and trade mutually supportable in the service of sustainable development. While environmental matters have not been addressed in the Uruguay GATT Round, the possibility of addressing trade and environment questions in a subsequent GATT round has been raised by some trade officials.

An OTA background paper, *Trade and Environment: Conflicts and Opportunities*, discusses some of the difficulties entailed in developing U.S. positions during the initial period of the OECD discussions.[31] The complexity and difficulty of the subject matter, and the number of agencies involved (the United States Trade Representative, the State Department, the Environmental Protection Agency, and several other mission agencies) partly explained the slow progress. More importantly, it was difficult to articulate goals for U.S. negotiating positions, since trade, economic, and environmental perspectives all need to be taken into account in defining U.S. positions. Such differences in perspective continue even when administrations change. To assure adequate formulation of U.S.

[31] 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).

Table 2-5-issue Area E. International Trade and Environmental Policy

		Impact on Federal expenditures[a]	Does option require major changes in Federal role?[b]	Policy goals promoted[a]: Enhance overall manufacturing industry competitiveness	Expand markets for U.S. environmental goods and services	Further global or developing country environmental goals
26	Conduct oversight on U.S. policy development for GATT and OECD trade/environment discussions	S	N	P	P	P
27	Expand efforts to develop multilateral or bilateral agreement on environmental standards to address competitive impacts	S	Y	Y	Y	Y
28	Combine technical assistance with efforts to upgrade developing country environmental standards in advance of trade discussions	M	Y	Y	Y	Y
29	Work for more effective monitoring and enforcement of multilateral environmental agreements	S	N	Y	Y	Y
30	Work to establish a global business charter on environmental standards	S	Y	Y	Y	Y
31	Encourage other countries to require firms to report toxic release inventories	S	Y	Y	Y	Y

a S=small ($10 million or less); M=moderate ($10 to $100 million); L-large ($100 million plus); a range indicates that it depends on how the option is implemented.
b Y=yes; P=potentially yes; N=no; ?-effect is unclear

SOURCE: Office of Technology Assessment, 1993.

policy in this area, Congress may wish to conduct oversight or provide guidance to the administration (Option 26 discussed at end of this section and discussed in table 2-5).

NEGOTIATING ENVIRONMENTAL STANDARDS

Compared to many other countries, the United States imposes relatively strong environmental standards on industry. While there has long been concern about possible competitive impacts of such standards, much of the research conducted in the 1970s and 1980s found only minor impacts. However, recent efforts to liberalize trade and investment rules, and the emergence of several newly industrialized and advanced developing countries as strong competitors, have again brought attention to possible competitive impacts.

Environmental issues were central in the debate about the North American Free Trade Agreement for Mexico, the United States and Canada. Aside from the NAFTA itself, a side agreement addressing environmental matters has been negotiated. (Congress had just approved NAFTA when this report went to press).

Environmental matters will almost certainly arise if other efforts to liberalize trade are undertaken in Latin America, the Asian Pacific region, or elsewhere. With or without trade liberalization, there is special concern about the potential for competitive and investment impacts for the United States when firms in other countries have lower labor costs as well as less strict health, safety, and environmental standards or enforcement.

Given this context, some have suggested that the U.S. Government should do much more to encourage other countries to upgrade their environmental standards as part of a strategy to improve the environment, expand opportunities for U.S. environmental firms, and avoid negative competitive impacts for U.S. firms and workers. (Option 27). Legislation to that effect has been introduced in the 103d Congress.[32]

An aggressive effort to negotiate bilateral and multilateral environmental agreements would be a departure from policies in the 1980s, and would require high level guidance and coordination.[33]

Such an effort would be controversial with developing countries, and is not likely to succeed unless accompanied by help for capacity building and technical assistance. It might also be opposed by those who see such efforts as steps toward global bureaucracy. The strategy would be difficult to carry out without continuing, high level commitment.

As discussed in Options 29-31, the potential for adverse competitive impacts also might be reduced if there were more effective monitoring and enforcement of agreements, if businesses were encouraged to adhere to developed country standards throughout the world, and if other countries took steps such as calling on business to report their releases of toxic substances, as they are required to do in this country.

The approaches set forth in Options 26-31 would be controversial, both here and in other countries. Moreover, past efforts to adopt such policies have had little success. Yet there could be long-term benefits for the environment and quite possibly, a more positive climate in this country for trade liberalization with countries that now have weaker environmental standards.

To some extent, officials in developing nations may believe they are in a prisoners dilemma with regard to environmental regulations. If one country raises standards, it risks losing out on investments by multinational corporations to neighbors with lower standards. As a result, standards may stay lower than they might be otherwise. If companies applied high standards in their facilities around the world, concerns about competitive disadvantage from strict regulation would be eased. While some multinational companies (including a number of U.S. firms) say they do this already, they may well be the exceptions.

Some might argue that there is no competitive reason for such negotiations, because, they claim, strict environmental regulations can lead to increased competitive advantage. Firms within countries having strong regulatory demands on industrial processes can find that aggressive environmental actions, particularly pollution prevention, make them more competitive relative to other domestic competitors. However, as a group, firms within countries with strict regulations will face higher compliance costs relative to foreign competitors in countries with more lax standards and enforcement. When waste disposal costs and requirements are high, firms can sometimes save money by controlling pollution and reducing wastes. However, these actions are usually not justified from an economic perspective alone when waste disposal costs and requirements are zero or minimal. Still, as has been mentioned,

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32 See for example, H.R. 1830 the proposed Global Environmental Cleanup Act, and H.R. 1446, the proposed Western Hemisphere Environmental, Labor, and Agricultural Standards Act of 1993. Other approaches, such as treating the absence of strict standards as an unfair trade practice for which countervailing duties might be imposed, have also been proposed. For discussion on how such approaches might be viewed in the context of the GATT, see *Trade and Environment: Conflicts and Opportunities,* op. cit., pp. 66-68.

33 It should be noted that Congress has required strategies in the past. Section 811 of the 1990 Clean Air Act Amendments (P.L. 101-549) required the President to provide Congress with a strategy for addressing competitive impacts arising from differences in national standards through "trade consultations and negotiations." Although due in May 1992, the strategy had yet to be submitted in September, 1993. Section 6 of the 1972 Federal Water Pollution Control Amendments (P.L. 92-500) directed the President to negotiate international agreements to apply uniform performance standards or uniform controls for some categories of pollutants in order to head off possible competitive impacts. Efforts by the Carter administration in 1978 to raise pollution and workplace health standards in Tokyo Round GATT talks encountered strong opposition from business and foreign countries. See H. Jeffrey Leonard, *Are Environmental Regulations Driving U.S. Industry Overseas?* (Washington, DC: The Conservation Foundation, 1984), pp. 8, 13.

strong domestic regulations are often a key factor in competitiveness of environmental goods and services industries.

Steps Congress could consider include:

OPTION 26: Conduct oversight on development of U.S. positions on trade and environment matters. Several agencies (USTR, State, EPA, etc.) have missions that relate to trade and environment questions; efforts to use interagency discussions to develop positions have been ineffective. Without high level guidance, informed by other high level strategy documents (e.g., a possible administration policy on international environment, trade policy, etc.), it will be difficult for the United States to present appropriate positions at OECD, GAIT, and other forums.

OPTION 27: Call on the administration to expand efforts to develop multilateral or bilateral agreements on environmental standards, not just for environmental reasons but also to offset competitive impacts arising from different levels of regulation. The U.S. Government could encourage other countries to strengthen their domestic environmental standards, and provide technical assistance on how to implement and enforce standards. Such discussions and activities could be carried out in advance of any formal discussions about trade liberalization. This approach would require close coordination among agencies with roles to play in foreign assistance, the environment, international trade, and export financing and promotion.

OPTION 28: Increase emphasis in U.S. development assistance on technical assistance to developing countries for implementing and enforcing environmental standards. (See additional discussion under Issue Area D.)

OPTION 29: Work to develop more effective monitoring and enforcement provisions for multilateral environmental agreements.

OPTION 30: Encourage establishment of a global business charter under which participating multinational companies agree to use home country standards when investing in other nations.

OPTION 31: Encourage other countries to make use of reporting requirements (such as that required for U.S. firms by the toxic release inventory).

Issue Area F: Data and Information Needs for Policymaking

Data on commerce in environmental products and services, and on costs borne by industry to meet environmental standards are often poor, often inconsistent, and frequently not available. The economic consequences of pollution are even less well-documented, though they are real nonetheless.

Trade and production figures collected by the Department of Commerce and foreign equivalents often do not correspond closely to many categories of environmental products. In many cases the distinction between an environmental and nonenvironmental good is difficult to discern--a blower, pump, or measuring instrument may be used in environmental equipment or not—and discruminating between the two types of goods is likely to become more difficult as pollution prevention approaches become more widely used. However, better data gathering is possible. For instance, since 1971 the U.S. Bureau of Census has been collecting yearly data on orders and shipments of selected industrial air pollution control equipment—yet such data series seem not to have been collected for industrial wastewater and waste treatment equipment. Another example comes from the Japan Society of Industrial Machinery Manufacturers, which publishes data on orders for environmental equipment categorized by media (air, water, waste, noise, and vibration) and by user (manufacturing, nonmanufacturing industry, government, and export).

OPTION 32: Improve the collection and analysis of commercially relevant environmental data including production and trade of environmental goods and services, environmental compliance costs for businesses, and economic costs of pollution and environmental degradation. Such

Table 2-6--issue Area F. Data Needs for Policy Making

		Impact on Federal expenditures[a]	Does option require major changes in Federal role?[b]	Policy goals promoted[b]: Enhance overall manufacturing industry competitiveness	Expand markets for U.S. environmental goods and services	Further global or developing country environmental goals
32	Direct pertinent agencies to:					
	• collect and analyze more commercially relevant data on trade and environmental goods and services	s	N	?	Y	Y
	• facilitate flow of commercial information to companies	M	P	Y	Y	Y
	. verify and assess ways to improve pollution abatement cost data	s	N	P	N	N
	. identify and quantify benefits of regulations through study	M	N	?	?	?
33	Call for periodic assessment of competitive effects of differing levels of environmental regulations among countries, and for development of strategies to address any adverse effects	s	N	Y	P	P

a S=small ($10 million or less); M=moderate ($10 t. $100 million); L-large ($100 million plus); a range indicates that it depends on how the option is implemented.
b Y=yes; P=potentially yes; N=no; ?-effect is unclear

SOURCE: Office of Technology Assessment, 1993.

efforts could be coordinated with the OECD and perhaps the UN Statistical Office. As part of this, Congress would:

- Support a small effort at the Census Bureau to verify accuracy of the Pollution Abatement and Control Expenditure Data and to determine ways to improve the data. Support a small effort at the International Trade Commission or the Department of Commerce to improve data and reporting of environmental products and services trade.
- Fund a reasonably large scale study to more carefully identify and quantify the benefits of environmental regulations. Ensure that the findings can be readily incorporated into economic models measuring the impact of regulations on the economy.

OPTION 33: Call for periodic reassessment of the competitive impacts of different levels of environmental standards among different countries. The research could focus on comparison of relative strictness of pollution control and waste treatment actions required of industries in other countries, and identification of competitive effects for business operations in the United States.

These options are listed in table 2-6.

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-

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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.**

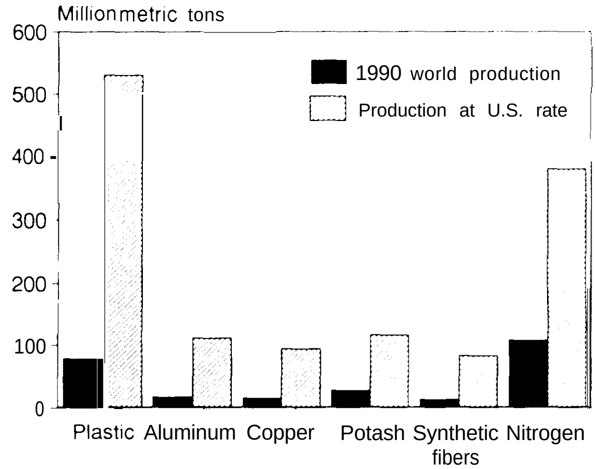
[2] **For discussion, see U.S. Congress, Office of Technology Assessment** *Development Assistance, Export Promotion, and Environmental Technology, OTA-BP-ITE-107* **(Washington DC: U.S. Government printing Office. August 1993).**

[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 t he 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**

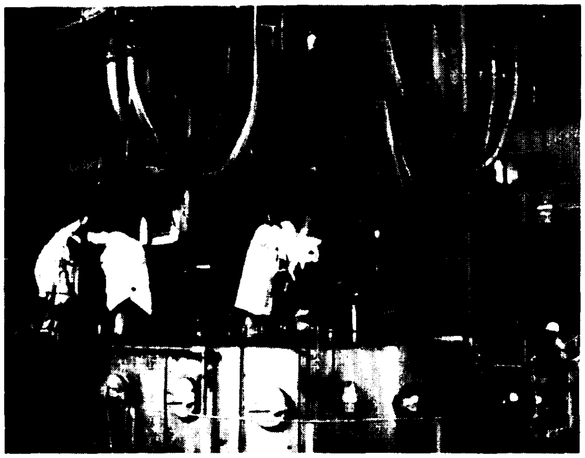
SOURCE: Office of Technology Assessment, 1993.

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**



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.

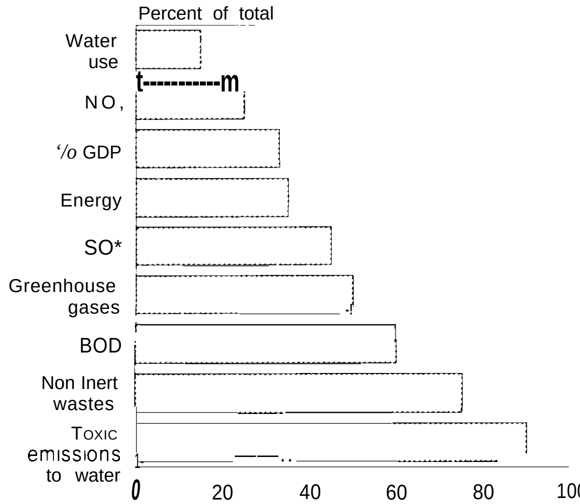
The chapters on competitiveness emphasize manufacturing, as opposed to other sectors, for several reasons. First, concern about U.S. manufacturing competitiveness has assumed center stage in the debate about U.S. economic competitiveness.[13] Second, manufacturing accounts for a disproportionate amount 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]

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.

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



SOURCE: Organisation for Economic Cooperation and Development, 1991.

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.

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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.

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

The Global Environmental Market: Trends and Characteristics[1]

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The global market for environmental goods and services (EGS) is large and growing. The Organisation for Economic Co-operation and Development (OECD) estimates that the global market for environmental services, combined with pollution control and waste management equipment and goods, stood at $200 billion in 1990 and will reach $300 billion by the year 2000.[2] Another calculation of the global market claims the 1992 market was $295 billion and projects a global demand of $426 billion by 1997.[3] These projections do not fully capture business opportunities for preventing pollution through cleaner production. While calculations of environmental market sizes should be viewed with caution due to varying quality of data and definitions of the market, it is clear that the environmental sector is sizable. For comparison, in 1990 the aerospace products industry commanded a global market of $180 billion and the chemical products industry stood at $500 billion.[4]

In order for environmental markets to exist, there must be both the will and resources available to address environmental problems. Regulations and enforcement, including assignment of liability, are the main drivers of environmental markets. Prosperity is an important determinant of environmental market size; contrary to previous expectations, the environmental

[1] This chapter discusses size, trends, and drivers of environmental markets; ch. 5 discusses competitiveness in environmental industries.

[2] Organisation for Economic Co-operation and Development (OECD), *The OECD Environment Industry: Situation, Prospects and Government Policies,* OCDE/GD(92)1 (Paris: OECD, 1992).

[3] Grant Ferrier, president of Environmental Business International, presentation at the Environmental Business Council of the United States meeting, Washington DC, June 8-9, 1993.

[4] OECD, op. cit., footnote 2.

industry is not immune to economic slow-downs. Fiscal incentives now in an early stage of application, such as pollution fees and tradable allowances, may also promote demand. Corporate interest in appealing to the environmental concerns of customers and investors is increasing, particularly where reporting requirements place corporate environmental performance in public view. And opportunities for cost-effective environmental improvement through pollution prevention and improved energy efficiency are becoming better understood; such cleaner production approaches may some day obviate the need for certain end-of-pipe pollution controls.

Environmental priorities differ by country and region. In most low and many middle-income countries, key needs include provision of water, sewer, and refuse services, as well as basic pollution control equipment. In more affluent countries, there is growing demand for more sophisticated equipment and services for pollution prevention, control, and remediation. The largest environmental markets are in the industrialized nations of the OECD, which account for perhaps 80 percent of the international market.[5] The largest single market, about 40 percent of the total, is the United States. However, markets in some non-OECD nations, including a number of rapidly industrializing countries in Asia and Latin America, are poised for rapid expansion.

National markets can be thought of as falling within several broad categories:

- The United States, Japan, Germany, and several other Northern European countries have the most strict environmental regulations. No single country is most stringent for all pollutants or media. Much progress has been made against traditional soot and sewage problems. New problems and those that have resisted previous solution—including smog, acid rain, toxic substances, nonpoint pollution, and climate change—are now being addressed. These countries are at the forefront of environmental management and are sources of demand for new or improved environmental technologies. The United Kingdom, France, Italy, and several other OECD countries form a second tier of countries that have relatively strong environmental standards and enforcement but have not led in environmental management.
- Portions of the European Community (EC), including Spain, Portugal, and Greece, often lack adequate infrastructure for wastewater, solid waste, and hazardous waste treatment. Significant efforts are necessary to bring these countries into compliance with EC standards. Their level of environmental investments will depend on economic growth and EC funding.
- Rapidly industrializing countries in Asia—including the four 'tigers' (Hong Kong, South Korea, Taiwan, and Singapore), Malaysia, Thailand, and the Philippines, and the larger countries of Indonesia, India, and China-are now expending more resources on the environment. This region is probably the fastest growing environmental market, due to investments in water, sewer, and waste disposal infrastructure, and from environmental factors now being incorporated into new investments in energy and industrial production. Economic growth is providing many of these countries with the resources to pay for environmental investments.
- Several Latin American countries also have rapidly expanding environmental markets. Mexico and Brazil are the largest. This region, too, offers strong environmental business prospects. As in the rapidly growing Asian economies, investment in public environmental infrastructure is increasing. Tougher regulation and enforcement are creating markets for pollution control equipment. As more countries develop environmental capabilities, the market for monitoring equipment is also growing.

[5] Ibid.

- Central and Eastern Europe, including the states of the former Soviet Union, have a legacy of environmental mismanagement. Basic controls of air and water pollution and wastes are often lacking or in disrepair. While the potential market is great, the actual market is limited by lack of financial resources. Political and economic uncertainties inhibit foreign investment.
- Many developing countries in Africa, Asia, and Latin America have limited capacities for managing industrial and urban environmental challenges. Development assistance is a key source for environmental investment in these countries.

As discussed in chapter 5, most environmental goods and services are not internationally traded. Even so, substantial trade occurs; estimates of international environmental business transactions range from the low billions of dollars to over $20 billion annually.

American firms face growing challenges from foreign companies both overseas and in the domestic U.S. market for the provision of both traditional environmental products and cleaner technologies (see ch. 5).[6] Germany, Japan, Austria, the Netherlands, Switzerland, Sweden, France, Britain, and Canada have environmental companies that are competitive with U.S. firms on the world market. Foreign firms also are competitive sources for a variety of cleaner production technologies. In countries like South Korea, Taiwan, and Mexico, environmental industries are developing in response to increased regulation and enforcement, although they remain dependent on OECD-country suppliers for many environmental products and services. Examples of sectors and technologies where U.S. firms maintain an advantage and where foreign firms have gained advantage are discussed in chapter 5.

MARKET DRIVERS

Environmental markets arise primarily when regulations are put in place and enforced.[7] Other factors also contribute; for instance, pollution prevention measures are sometimes cost-effective even in the absence of strong regulation, and corporate concerns about public image can promote demand for EGS. However, regulation remains the driving factor. This is because polluters seldom on their own pick up the costs that pollution and environmental degradation place on third parties and society as a whole. In economic terms, pollution is a negative externality and the services nature provides (e.g., cycling air and water, maintaining soils and biological diversity, and so forth) are free goods. These market imperfections diminish the welfare-maximizing force that free markets can theoretically deliver. In short, without regulation (and enforcement), people will pollute excessively. Externalities and public goods as types of market imperfections are classically justified reasons for government regulation.

Environmental laws and regulations create markets for many kinds of goods and services. Obvious examples include pollution prevention, control, and clean-up equipment and supplies, and operation of waste disposal and pollution abatement systems, Analytical instruments to measure contaminants and monitor pollution, and specialized services (including engineering, management consulting, construction, and laboratory analysis) are also needed. Regulations also stimulate demand for environmental impact assess-

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[6] Cleaner production and energy technologies can be found in virtually all economic sectors. A few examples are direct steelmaking, renewable energy technologies, advanced gas turbines, chromium-free leather tanning, chlorine-free papermaking, no-clean soldering, better industrial controls, less polluting paint applicators and formulations, and improved catalysts.

[7] Here regulation includes the use of environmental taxes and charges, marketable pollution allowances, and assignment of liability on polluters, as well as conventional command-and-control approaches that require achievement of performance-based or technology-based environmental standards.

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Routine environmental services such as refuse collection and disposal, while locally provided, can create trade opportunities for equipment suppliers.

ment, legal, and information services. Furthermore, the force of regulation can lead to demand for substitute or alternative products or processes. Examples include alternative solvents, fuel switching, or no-clean soldering.

Sometimes environmental laws and regulations create markets directly by mandating certain standards. In the case of performance-based standards, a number of environmental technologies and practices might allow achievement of standards. In contrast, technology-based standards require installation of particular environmental devices, thus stimulating large markets for those devices. Innovation may suffer because competing technologies and approaches are not sanctioned.[8] Sometimes regulations are formally performance-based, but, in practice, permitting and administrative procedures still favor specific reference technology.

Regulations can promote environmental markets by making pollution and waste very expensive to generators. For instance, the U.S. Resource Conservation and Recovery Act (RCRA), among other things, places stringent requirements on storage, transport, and treatment of hazardous wastes. This not only stimulates expenditures for hazardous waste handling and disposal, but also encourages waste producers to find ways to cut disposal expenses by minimizing waste.

Similarly, pollution taxes and fees may stimulate environmental technology sales. It is not yet clear the degree to which marketable pollution allowances might spur environmental technology innovation and sales by placing real dollar value on pollution. Companies may avoid environmental technology expenditure-for instance, by switching to low sulfur coal instead of buying scrubbers in the case of electric utilities. (Chapter 8 discusses the implications of different environmental regulatory approaches for manufacturing industries.[9]) Other innovative regulatory approaches, such as utility pricing rules that encourage demand-side management (DSM) in electric utilities, have spurred business opportunities in energy efficient products and related services that may be environmentally preferable.

Threats of future liability are an impetus for environmental markets; the U.S. Superfund law that retroactively ascribes liability for contaminated sites is a noteworthy example. Reporting requirements, like the Toxic Release Inventory (TRI) of the U.S. Superfund Amendments and Reauthorization Act (SARA, Title III), can also stimulate pollution prevention and control efforts. TRI requires manufacturing enterprises to publicly disclose information about their production, release, and disposal of several hundred toxic compounds. These reporting requirements led some companies to adopt aggressive waste reduction goals.[10]

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8 Robert Repetto, George Heaton, and Rodney Sobin, *Transforming Technology: An Agenda for Sustainable Growth in the 21st Century* (Washington, DC: World Resources Institute, 1991), p. 23.

9 Another OTA assessment, due for completion in late 1994, is examining new approaches to environmental regulation.

10 See Bruce Smart (~.), *Beyond Compliance: A New Industry View of the Environment* (Washington, DC: World Resources Institute, April 1992) for several examples.

Although the combination of regulation and enforcement has been the most potent driver of environmental markets, it is not the only force, The environmental concerns of consumers and investors are a factor, as is the threat of additional future environmental regulation because of unfavorable public image. These concerns explain the potency of TRI in stimulating environmentally favorable corporate action. They also help explain cases of pressure on corporations from peers, suppliers, and customers as forces for environmental investment and cleaner production. The U.S. Chemical Manufacturers Association's Responsible Care program (which is mandatory for members) and similar chemical industry programs abroad, as well as environmental charters of the Business Council for Sustainable Development, the International Chamber of Commerce and the Keidanren (Japan's major industry association), are among examples of business initiatives to promote improved industrial environmental performance.

Finally, as has been noted, some environmental investments in pollution prevention and especially energy efficiency are cost-effective even in the absence of regulations, Markets may develop as these opportunities become better known.

DEFINING THE INDUSTRY AND ITS MARKET

The previous section refers to EGS, cleaner production, and the environmental industry without crisp distinctions. This is because definitions of the industry and its market are inconsistent and sometimes nebulous, and data are often lacking. The reasons why data are inadequate and the differing definitions of the market used by several studies are discussed below. As is discussed in chapter 3, this assessment does not adhere to a rigid definition of EGS.[11] Instead, it examines markets and competitiveness in a number of traditional environmental areas-air, water, and waste management, including services-with illustrative cases from cleaner production important to the energy and manufacturing sectors.

Information on environmental markets and industry size is inadequate for several reasons:

- Little effort has been made by the United States and other countries to track EGS production and trade. U.S. Standard Industrial Classification (SIC) codes and the international Harmonized Code (HC) do not correspond well with environmental product categories .12 Thus, official data on production and trade are of limited value. (See ch. 5 for discussion of environmental trade.) Many products used in environmental equipment and facilities are also used in other applications. It is often not possible to determine whether the end use of a product is environmental.
- Production data are difficult to obtain because of the industry's structure. It has been estimated that about 200 public companies account for roughly one-third of U.S. environmental revenues but that over 58,000 privately held fins, averaging $1.3 million in annual revenues each, account for the remaining two-thirds.[13] Privately held companies are not required by the Securities and Exchange Commission to publicly divulge financial information. There may be over 10,000 environmental fins, mainly small, in Western Europe.

11 As previously discussed, several important aspects of environmental technologies including agricultural technologies, geophysical and ecological modeling, technologies for assessing health effects, and nuclear-related technologies are not examined in this asessment. Green product design was the subject of another recent OTA assessment, U.S. Congress, Office of Technology Assessment, *Green Products by Design: Choices for a C'/eaner Environment,* OTA-E-541(Washington, DC: U.S. Government Printing Office, September 1992).

12 One exception is SIC 35646/HC 842139, Selected Industrial Air Pollution Control Equipment. Several other categories partially cover EGS products. Further discussion of this issue is found inch. 5.

13 *Environmental Business Journal*, vol. 5, No. 4, April 1992, p. 7. Over 24,000 of these companies are private water utilities averaging .$400.000 in annual revenues.

- Many environmental companies, including large conglomerates, are active in a variety of industrial sectors; they generally do not report their environmental business separately. Engineering and construction companies have provided design and construction management services for environmental projects for many years. Instrument manufacturers produce lines of equipment for environmental monitoring and analysis. Producers of boilers and power generation equipment sell air pollution control equipment (as well as less-polluting combustion systems and turbines). A number of chemical companies have spun off commercial hazardous waste management businesses in addition to producing specialized chemicals for water, air, and waste treatment. And, with the end of the Cold War, many defense contractors are seeking environmental business opportunities ranging from clean-up of Federal facilities to development of electric vehicles.[14] A few companies in other sectors facing tough times, such as the Pacific Northwest forest products industry, are redirecting their efforts toward the environment (see box 4-A).
- Industrial establishments operate in-house air, water, and waste treatment facilities and services. These operations, while recorded as pollution abatement expenditures in corporate accounts, are seldom included in estimates of environmental goods and services. This partly explains why sales by environmental firms differ from national estimates of environmental compliance cost (see ch. 7). Internal corporate environmental expertise and facilities sometimes provide a basis for new businesses. For instance, Amoco, Dow, DuPont, and Rhone-Poulenc are among the chemical concerns that have established hazardous waste management businesses.[15]

Most estimates of the size of the environmental industry focus primarily on clearly identifiable end-of-pipe pollution and waste control, treatment, and remediation. Even here, however, coverage varies, as is shown in the following studies:

- The OECD divided the market into four equipment and related service sectors—water and effluents treatment, waste management, air quality control, and “other’ (which includes land remediation and noise abatement)--plus a separate general environmental services category.[16] Cleaner production or pollution prevention products are not included, although some related consulting services are.
- ECOTEC, a British consulting firm, uses four primary categories: air pollution control, water and wastewater treatment, contaminated land reclamation, and waste treatment and disposal (including consulting and analytical services related to these areas).[17] It does not include municipal solid waste collection, noise abatement, construction of environmental infrastructure, or cleaner production.
- Farkas Berkowitz & Co., a U.S. consulting firm, divides the American environmental industry into air, water, solid waste, hazardous waste, consulting, and “other” (which includes analytical and information services, and landfill liners, among other things).[18] Water supply and solid waste handling equipment (for

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14 For analysis of defense conversion issues, see U.S. Congress, Office of Technology Assessment *After the Cold War: Living With Lower Defense Spending*, OTA-ITE-524 (Washington, DC: Government Printing Office, February 1992), and U.S. Congress, Office of Technology Assessment, *Defense Conversion: Redirecting R&D*, OTA-ITE-553 (Washington, DC: Government Printing Office, May 1993).

15 *Environmental Business Journal*, op. cit., footnote 13, p. 9.

16 OECD, op. cit., footnote 2, p. 5.

17 ECOTEC Research and Consulting, *Opportunities for the Environmental Protection and Waste Management Industry in Europe* (Birmingham, U.K.: June 1990).

18 Farkas Berkowitz & Co., *The Fifth Annual State-of-the-Industry Report* (Washington, DC: 1993).

Box 4-A–Forest Product Supply Firms and Environmental Business Opportunities

In Oregon, some forest products firms and suppliers are pursuing environmental business opportunities in response to declining forest harvesting and processing.[1] For instance, the Eugene-based Ross Corp., a designer and manufacturer of heavy equipment used to extract and transport logs, has capitalized on its experience to develop materials-handling equipment for municipal solid waste disposal and recycling. Examples include balers, conveyors, sorting systems, and scrap handlers. The company also designs municipal recovery facilities: one such facility is operating in Washington State. Offices in Canada and New Zealand support international marketing activities.

Another Eugene-based firm, Bulk Handling Systems, has adapted its materials handling machinery expertise, in this case for the lumber, panelboard, and paper industries, to manufacture handling, sizing, and storage equipment for waste and scrap materials. The company also makes equipment for power plants that use agricultural and forestry wastes as fuel. Phoenix Industrial Park in Eugene was a virgin plywood manufacturing facility until a lack of old growth logs put it out of business. The site now houses a plant for reclaiming and processing urban and industrial wood wastes; also at the site is an oil recycling facility. International Resources Unlimited's engineering consulting business used to concentrate on the forest products sector. The firm now works on a wider variety of structural materials. With U. S., Finnish, and Hungarian collaborators, it is developing a number of products using mixed waste paper and mixed paper, cardboard, and plastic wastes to displace virgin wood in panelboard and fiberboard construction materials.

Contraction of the forest products industry in the Pacific Northwest has parallels to declines in defense-related industries. Redirection of economic development and adjustment assistance are urgently needed by displaced workers and their communities. While opportunities in environmental goods and services, as well as environmentally preferable materials, probably will not cancel out declines in the forest products industry, they do provide some options for economic development and growth. This has been recognized by Washington, Oregon, California, and British Columbia, which have all identified environmental technologies and services as a key sector for development.

1 Eugene F. Davis, president, International Resources Unlimited, Eugene, OR, provided information for this and the following paragraph.

instance, garbage trucks) are omitted but municipal refuse services are included. Recycling of municipal solid wastes and hazardous industrial chemicals are listed but recovery of industrial scrap is not.

- One of the most comprehensive estimates, that of *the Environmental Business Journal,* divides the U.S. environmental industry into 12 categories:[19]
  1. analytical services,
  2. solid waste management,
  3. hazardous waste management (includes remediation),
  4. asbestos abatement,
  5. water infrastructure (water and wastewater treatment equipment and supplies),
  6. water supply utilities,
  7. engineering/consulting,
  8. resource recovery (includes recycling),
  9. instrument manufacturing,
  10. air pollution control,
  11. waste management equipment, and
  12. environmental energy sources (includes renewable energy and cogeneration).

19 *Environmental Business Journal*, Op. Cit., footnote 13.

The journal tracks private companies (publicly and privately held) and publicly owned water and waste utilities. However, the mobile source air pollution control sector is not included.

None of the studies fully account for pollution prevention and cleaner technology-processes and products that use energy and materials more efficiently, that generate less total waste and less hazardous waste, and that decrease use of toxic substances. Unlike add-on environmental technologies, which are additional costs to industry, this mostly invisible environmental sector can sometimes lead to improvements in productivity, efficiency, and product quality. And even when cleaner production and pollution prevention are net costs to business, they are usually less expensive than end-of-pipe pollution control and waste disposal.[20]

Cleaner technologies may be adopted specifically to meet environmental requirements-for instance, replacement of chlorofluorocarbons (CFCs) in light of CFC phase-out laws or new paint applicators stimulated by tough regulations for volatile organic compounds (VOCs)--or they may be chosen for primarily nonenvironmental reasons+. g., low pressure polyethylene production offers advantages (lower cost and avoidance of high pressure reactions) over high pressure polyethylene production while using less organic solvent and saving energy.[21] Environmental performance will remain one of a number of factors--technical performance, cost, consumer preferences, worker safety, and so on—that engineers and managers will consider in production technology choice and product design.

To the extent that cleaner production is not included in estimates of the environmental industry, then environmentally inspired business opportunities will be understated. For instance, in the 1990s, developing country and Central and Eastern European capital investment for the electric power sector may reach $1 trillion.[22] If a study on environmental business opportunities associated with power sector investment were to concentrate on end-of-pipe pollution abatement, waste handling, and restoration of coal mining sites, it would miss very large commercial and environmental opportunities offered by more efficient power generation technologies, electricity and heat cogeneration, cleaner fuels, and renewable energy. A narrow environmental sector definition would also miss the great potential of selling negawatts--or improved energy efficiency—to power users.

In addition, studies that focus only on end-of-pipe technologies may neglect the possibility that such technologies could be displaced by cleaner production approaches. For instance, if organic solvents are replaced by mechanical or aqueous processes (e.g., powder coatings and water-based paints), markets for VOC control devices maybe diminished. As another example, cleaner combustion processes and non-fossil energy sources could dampen long-term demand for add-on emission control equipment, although near-term markets for these devices are robust.

Yet, an all-encompassing definition of environmental technology offers little practical guidance in assessing environmental markets and competitiveness. Nonetheless, the realization that technology-not just environmental goods and services-and environment are intimately bound together has broad implications for the molding of

20 There are also cases where add-on pollution controls can allow manufacturers to maintain high quality products while meeting environmental requirements—for instance, catalytic converters have allowed automobile engines to be optimized for power or fuel economy while decreasing emissions.

21 William H. Joyce, "Energy Consumption Spirals Downward the Polyolefins Industry, " in Jefferson W. Testor, David O. Wood, and Nancy A. Ferrari (eds.), *Energy and the Environment in the 21st Century: Proceedings of the Conference Held at the Massachusetts Institute of Technology, Cambridge, MA March 26-28, 1990* (Cambridge, MA: MIT Press, 1991), pp. 427435.

22 World Bank, *Capital Expenditures for Electric Power in the Developing Countries in the 1990s*, IEN Energy Series Paper No. 21, February 1990, in World Bank, *The Bank's Role in the Electric Power Sector*, Industry and Energy Department, box 5.

technology, environmental, and economic policies.[23] Some long-term technological trends such as ''dematerialization''[24]—which includes the substitution of knowledge-intensive production for resource-intensive production, precision control of processes, and, generally, doing more with less material and energy—have salutary environmental effects. For instance, fiber optics is arguably an environmentally preferable technology because fiber optic cables require much less energy and material per unit of communication than do copper cables (and concommitantly less environmental damage from mining and manufacturing); they have allowed the development of new monitoring and control technologies that can increase production efficiency and decrease waste; and they allow further substitution of communication for transportation.

GLOBAL, REGIONAL, AND NATIONAL MARKETS

The OECD estimates that over 80 percent of the 1990 market for environmental services, pollution control, and waste treatment occurred in the 24 member countries of the OECD.[25] (See table 4-1 and, for European national data, table 4-6.) The remainder is split between Eastern Europe/former U.S.S.R. (7.5 percent) and 'Other' (10.5 percent). The United States is by far the largest national market ($78 billion) followed by Japan ($24 billion), western Germany ($17 billion), and France ($10 billion). The study anticipated higher-than-average growth in Canada, Japan, several European Community countries that need substantial environmental investment to meet Community standards, and the "other' category, which includes the dynamic economies of the Pacific Rim. The lowest growth rates are anticipated in the Nordic countries, Germany, the Netherlands, Switzerland, and Austria, which already possess relatively advanced environmental management capabilities; the U.S. market is expected to expand more slowly than the OECD average. OECD's analysis suggests that Central and Eastern Europe's environmental market will experience above-average growth, although the combined Eastern Europe/former Soviet Union category rate could be below average.

By environmental sector, 24 percent of OECD countries' environmental industry 1990 output was for environmental services, 30 percent for water and wastewater treatment equipment, 20 percent for waste management equipment, 15 percent for air quality control equipment, and 11

Table 4-1--OECD Estimate of Environmental Market Sizes and Growth by Region (in 1990 dollars)

	1990 ($ billion)	2000 ($ billion)	Annual growth (percent)
OECD North America	84.0	125.0	4.1
United States	78.0	113.0	3.8
Canada	7.0	12.0	5.5
OECD Europe[a]	54.0	78.0	3.7
OECD Asia-Pacific	26.2	42.0	4.8
Japan	24.0	39.0	5.0
Australia	2.0	2.8	3.4
New Zealand	0.2	0.3	4.1
OECD total	164.0	245.0	4.1
Non-OECD total	36.0	55.0	4.3
Eastern Europe/ Former U.S.S.R.	15.0	21.0	3.4
Other Non-OECD	21.0	34.0	4.9
World total	200.0	300.0	4.1

a See table 4-6 for European national data.

NOTE: Percentage growth was recalculated from the original source as a compound annual rate.

SOURCE: OECD, *The OECD Environment Industry: Situation, Prospects and Government Polities,* OCDE/GD(92)1 (Paris: OECD, 1992).

23 Heaton, Repetto, and Sobin, op. cit., footnote 11; George Heaton, Robert Repetto, and Rodney Sobin, *Backs to the Future: U.S. Government Policy Toward Environmentally Critical Technology* (Washington DC: World Resources Institute, June 1992).

24 R. Herman, S.A. Ardekani, and J.H. Ausubel, "Dematerialization, " in Jesse H. Ausubel and H.E. Sladovich (eds.), *Technology and Environment* (Washington, DC: National Academy Press, 1989), pp. 50-69.

25 Data for these several paragraphs are from OECD, op. cit., footnote *.

Table 4-2—OECD Estimate of Environmental Markets by Sector (in 1990 dollars)

	1990 ($ billion)	2000 ($ billion)	Annual growth (percent)
Equipment	152	220	3.8
Water/wastewater	60	83	3.3
Waste management	40	63	4.6
Air quality control	30	42	3.4
Other	22	32	3.8
Services	48	80	5.2
Total	200	300	4.1

NOTE: Percentage annual growth was recalculated from the original source as a compound annual rate.

SOURCE: OECD, The *OECD Environment Industry: Situation, Prospects and Government Polices*, OCDE/GS(92)1 (Pans: OECD, 1992).

Table 4-3—Environmental Business International Estimate of the Global Environmental Market

	1992 ($ billion)	1997 ($ billion)	Annual growth (in percent)
United States	134	180	6.1
Canada	10	17	11.2
Mexico	1	2	14.9
Other Latin America	6	10	10.8
Western Europe	94	132	7.0
Eastern Europe/Former U.S.S.R.	14	27	14.4
Japan	21	31	8.1
Australia/New Zealand	3	5	10.8
Southeast Asia	6	13	16.7
Rest of world	6	9	8.4
Total	295	426	7.6

NOTE: Percentage annual growth was recalculated from the original as a compound annual rate.

SOURCE: Grant Ferrier, president of Environmental Business International, presentation at the Environmental Business Council of the United States meeting, Washington, DC, June 8-9, 1893.

percent for other forms of EGS, including contaminated land remediation and noise control (see table 4-2). Within OECD, the highest predicted growth rate is within the service sector and lowest in water and wastewater treatment. Much of the growth in the "other" sector is likely to be based on expanded efforts in contaminated site remediation.

An analysis by Environmental Business International (publisher of the *Environmental Business Journal)* suggests a significantly larger environmental market (see table 4-3). The estimate also is much more optimistic than the OECD about the growth potential of the EGS industry, projecting a 5-year annual average growth rate of between 7 and 8 percent.

These analyses provide only a general indication of the global environmental market, rather than definitive estimates. Furthermore, estimates of national and international environmental markets are not the same as estimates of either environmental compliance costs or the environmental sector's contribution to gross domestic product (GDP). As discussed previously, many environmental expenditures are internal to the firm and do not accrue to the environmental industry. And total environmental firms' revenues do not represent total contributions to GDP because they do not measure final demand or total value added by the environmental industry. Many sales by environmental companies are to other environmental companies; for instance, waste management service companies buy equipment from environmental product manufacturers, and environmental contractors often subcontract jobs to other environmental companies. In other words, total revenues overstate contribution to GDP by double-counting expenditures.

As has been mentioned, pollution prevention and improved energy efficiency are only partly covered in environmental market estimates.[26] An analysis done for the Department of Energy projects annual global energy efficiency export markets at $8.4 billion annually during the years 1990 to 2000, doubling to $16.8 billion annually

26 Environmental consulting related to pollution prevention is often included and the *Environmental Business Journal* includes renewable and co-generated power.

Table 4-4-Environmental Business Journal Estimate of U.S. Environmental Industry Revenue and Growth ($ billions, percent growth)

Segment	1989	1988-1989 growth	1990	1989-1990 growth	1991	1990-1991 growth	1992	1991-1992 growth	1992 Employees
Analytical services	$1.6	23%	$1.7	6%	$1.7	1%	$1.8	3%	20,000
Solid waste management	23.5	14	26.1	11	27.4	5	28.2	3	235,000
Hazardous waste management	12.1	22	13.3	10	13.7	3	14.6	7	127,000
Asbestos abatement	3.8	27	4.0	5	3.0	-25	3.1	3	28,000
Water infrastructure	11.7	7	12.1	3	12.5	3	13.0	4	100,000
Water utilities	18.8	8	20.2	4	21.2	5	21.8	3	136.000
Engineering/construction	10.2	26	12.2	20	13.4	10	14.2	6	158,000
Resource recovery/recycling	14.2	23	17.2	16	15.8	-8	16.1	2	107,000
Instrument manufacturing	1.5	25	1.6	14	1.8	4	1.8	6	15,000
Air pollution control	5.3	-4	5.4	2	5.3	-1	5.4	2	39,000
Waste management equipment	9.8	9	10.4	6	11.0	6	11.5	4	88,000
Environmental energy	1.5	25	1.8	20	2.0	10	2.2	11	20,000
Total	114.6	14	126.0	10	128.7	2	133.7	4	1,073,000
Nominal GDP Growth*		7.0		5.1		2.8		4.8	

•From U.S. Department of Commerce, *Survey of Current Business* and *Statistical Abstract of the United States 1992.*

SOURCE: *Environmental Business Journal,* April 1992 and April 1993.

during the years 2000 to 2010.[27] About half of the market is likely to be in developing countries. OTA has identified improving energy efficiency as an especially valuable opportunity for simultaneously assisting environmental protection and international development.[28] Descriptions of major regional and national environmental markets follow.

United States

Because of the Nation's large size and its relatively strict environmental regulations, the United States is the world's largest producer and consumer of EGS. Many U.S. environmental firms have focused exclusively on the domestic market. However, the size and relative openness of the U.S. market has made it attractive to foreign competitors, and competition is intensifying (as discussed in greater detail in ch. 5).

As previously noted, estimates of the U.S. environmental market vary, due to differences in definitions, methodologies and interpretations. OECD estimated the market to be $78 billion in 1990. The *Environmental Business Journal* reported U.S. EGS industry revenues of $126 billion in 1990 and $133.7 billion in 1992, although mobile source air control revenues—mainly catalytic converters-of about $8.3 billion in 1990 were not included[29] (see table 4-4). Farkas Berkowitz and Co. produced an estimate of $75 billion in 1992[30] (table 4-5). EPA reported U.S. 1990 environmental expenditures tobe$115

27 U.S. Department of Energy, ' 'National Energy Strategy Technical Annex No. 5: Analysis of Options to Increase Exports of U.S. Energy Technologies," 1991/1992, pp. 67-68.

28 U.S. Congress, Office of Technology Assessment, *Fueling Development: Energy Technologies For Developing Countries,* OTA-E-516 (Washington, DC: U.S. Government Printing Office, April 1992).

29 *Environmental Business Journal,* vol. 6, No, 4, April 1993, and vol. 5, No. 4, April 1992; U.S. Department of Commerce in ICF Resources and Smith Barney, Harris Upham and Company Inc., *Business Opportunities of the New Clean Air Act: The Impact of the CAAA of 1990 on the Air Pollution Control Industry,* August 1992, p. I-2.

30 Farkas Berkowitz & Co., op. cit. footnote 18.

Table 4-5--Farkas Berkowitz Estimate of U.S. Environmental Industry Revenue

Segment	Percent
Environmental consulting	12
Hazardous waste and remediation	8
Air pollution control (mobile and stationary)	12
Solid waste	37
Water quality	17
Other	14
Total Estimated 1992 Revenue	$75 billion

SOURCE: Farkas Berkowitz & Co., *The Fifth Annual State-of-the-Industry Report* (Washington, DC: 1993).

billion.[31] However, as noted, these are not identical to environmental industry revenues.

Future environmental market growth in the United States could come from several directions. For instance, an analysis of business opportunities offered by the Clean Air Act Amendments (CAAA) of 1990 estimates that cumulative revenue increases (in 1990 dollars) for stationary and mobile source air pollution control equipment producers will be $35 to $49 billion by the year 2000.[32] Engineering, design, and construction firms could bring in another $2 to $4 billion during this period. Makers of instruments and monitoring systems might see revenues grow $1 to $3 billion over the period. The CAAA also is expected to increase revenues for natural gas, low-sulfur coal, and reformulated and oxygenated gasoline producers. In some cases, the ability to switch to low-sulfur coal or natural gas allows managers of electric power plants and other facilities to avoid installing add-on pollution control equipment. (These revenue estimates are sensitive to assumptions about timing of regulations, scope of facilities regulated, technology choices made by regulated industries, and costs of technologies. A slow economy and uncertainties about CAAA implementation make the air pollution control estimates presented above seem overstated.)

The CAAA tightens emissions control requirements for both stationary and mobile sources. It orders major reductions in sulfur and nitrogen oxides (SO_2 and NO_x respectively) emissions from power plants and other major sources; strengthens controls on volatile organic and toxic air pollutants; requires cleaner vehicles and fuel; expands monitoring requirements for power plants; and regulates disposal of CFCs.

State and local air quality requirements (some of which are required by Federal law) will also affect the market for both traditional EGS and cleaner products and processes. Examples include the South Coast Air Quality Management District's tough regulations to control smog in southern California and California's requirements for development and marketing of low-, very low-, ultralow-, and zero-emission vehicles over the decade. Other States are considering adoption of California's automobile standards. (See box 7-B for discussion of some regulated industry responses to California's air regulations.)

Growth in U.S. demand may occur for other environmental sectors. New drinking water standards under the Safe Drinking Water Act's 1986 amendments and storm sewer management regulations mandated by the Clean Water Act's 1987 amendments are being implemented. The Clean Water Act, Safe Drinking Water Act, Superfund, and the Resource Conservation and Recovery Act are scheduled for congressional reauthorization. If the laws are strengthened, environmental market growth is likely. Meanwhile, State and local regulation of wastes and recycling increases.

Contamination and waste from decades of U.S. military activity and weapons production during the Cold War are now major environmental

31 ICF Resources and Smith Barney, op. cit., footnote 29, pp. I-2, I-3, original estimates in A. Carlin and the Environmental Law Institute, *Environmental Investments: The Cost of a Clean Environment Summary*, EPA-230-12-90-084 (Washington DC: U.S. Environmental Protection Agency, December 1990) were expressed in 1986 dollars and were inflated 15 percent to derive 1990 dollars.

32 ICF Resources and Smith Barney, op. cit., footnote 29, p. IV-3

issues. Many Department of Defense (DOD) and Department of Energy (DOE) facilities are badly contaminated with various wastes, ranging from radioactive byproducts of nuclear weapons production to spills of common fuels and solvents. This hazardous legacy threatens health and the ecology. Decontamination of decommissioned military facilities is important if those lands are to be made viable for civilian use and commercial investment. Some estimates of the costs for clean-up, decontamination, and waste management of the Nation's nuclear weapons complex reach $75 to $105 billion through the year 2010.[33] DOE's estimated fiscal year 1994 outlay for environmental restoration and waste management will be over $5 billion, while DOD's environmental restoration outlays will be about $2 billion .[34]

Canada

According to OECD, Canada's environmental market was $7 billion in 1990, and might grow to $12 billion by 2000 (5.5 percent annual growth).[35] Environmental Business International estimated a $10 billion Canadian market for 1992, and projects $17 billion by 1997 (1 1.2 percent annual growth).[36] Both studies suggest that the annual growth rate for the Canadian market will be above the OECD-country and global average,

Canadian environmental problems and responses have mirrored those in the United States but, at times, with a lag. The national Green Plan, announced in December 1990, calls for a variety of measures, such as antismog actions, acid rain controls, CFC phase-out, stronger toxic effluent and emissions standards, clean-up of hazardous waste sites, reduced urban wastes, and limits on greenhouse gas emissions. Provincial and local authorities will upgrade sewer and waste disposal systems while continuing to promote recycling.

A study for the Ontario Environment Ministry indicated that U.S. regulatory policies often precede and influence practices in Canada.[37] Some Canadian jurisdictions use U.S. experience with environmental technology for regulatory guidance. And many subsidiaries of U.S. companies operating in Canada may adopt parent company environmental practices.

Trade may eventually lead to greater convergence of U.S. and Canadian standards. Surveyed Ontario industrial firms indicated that the United States was the source for most imported environmental products and services.[38] Canadian environmental firms see the United States as their major export market.

Western Europe

The EC and Western Europe can be divided into three major tiers of environmental priorities and capabilities.[39] The top tier countries already possess relatively advanced environmental management systems, including comprehensive legislation, tight standards, capable administration, and good infrastructure. Denmark, Germany, and the Netherlands of the EC, along with Finland, Norway, Sweden, Switzerland, and Austria, fall into this tier.

33 U.S. General Accounting Office, *brig-Term Plans to Address Problems of the Weapons Complex Are Evolving,* GAO/RCED-90-219, September 1990. The GAO also includes $50 billion for modernization of the Weapons Complex.

34 Executive Office of the President, Office of Management and Budget, *Budget of the United States Government,* Fiscal Year 1994, pp. App.-461, App.-462, App.-570..

35 OECD, op. cit., footnote 2.

36 Grant Ferrier, op. cit., footnote 3.

37 Ontario Ministry of Environment, *Study of the Ontario Environmental Protection Industry* (Queen's Printer for Ontario, 1992), pp. 134-35.

38 Ibid.

39 Richard Haines, ' 'Pollution Control Market to Flourish in Post-1992 Europe,' *Pollution Prevention,* vol. 1, issue 2, April 1991, pp. 11-20.

Table 4-6-Western European Environmental Markets ($ billion)

	ECOTEC estimate		Annual rate	OECD estimate		Annual rate
	1990	1995	(percent)	1990	2000	(percent)
Germany (west)	14.4	20.0	6.7	17.0	23.0	3.1
France	6.5	9.5	8.0	10.0	15,0	4.1
United Kingdom	8.9	11.5	10.6	7.0	11.0	4.6
Italy	4.2	6.4	8.7	5.0	7.7	4.4
Netherlands	2.2	2.8	5.3	2.7	3.7	3.2
Switzerland	1.5	1.8	4.8	1.9	2.5	2.3
Spain	1.4	2.5	12.7	1.8	3.0	5.2
Sweden	2.0	2.5	4.8	1.5	2.0	2.9
Belgium/Luxembourg	0.8	1.2	8.4	1.4	2.3	5.1
Austria	1.3	1.8	6.0	1.3	1.8	3.3
Finland	1.0	1.3	3.8	1.0	1.3	2.7
Denmark	0.7	0.9	7.0	1.0	1.2	1.8
Norway	0.7	0.9	5.3	0.7	1.0	3.6
Portugal	0.3	0.6	13.5	0.4	0.7	5.7
Greece	0.2	0.5	14.1	0.3	0.5	5.2
Ireland	0.3	0.4	8.3	0.3	0.5	5.2
OECD-Europe*	44.3	64.4	7.8	54.0	78.0	3.7

•Does not include Iceland and Turkey.

NOTE: ECOTEC's analysis does not include civil engineering work, waste collection costs, and noise abatement included in OECD's estimates. Figures are rounded to nearest $0.1 billion. Percentage growth rates were recalculated from the original sources as compound annual rates.

SOURCE: ECOTEC Research& Consulting, Ltd., and OECD, *The OECD Environment Industry: Situation, Prospects and Government Polices*, OCDE/GD(92)1 (Paris: OECD, 1992).

The middle tier includes Belgium, France, Ireland, Italy, Luxembourg, and the United Kingdom, which now have less rigorous environmental policies. Environmental markets in these countries may grow as they move to meet EC environmental standards.

The bottom tier countries-Greece, Portugal, and Spain-lack sufficient environmental experience, environmental infrastructure, and the ability to enforce strong environmental policies. They need to boost their environmental management capabilities to meet EC standards. Their environmental markets may grow most rapidly of the Western European countries.[40,41]

Two estimates of Western European environmental markets are presented in table 4-6. Table 4-7 presents market estimates by environmental sector. The eastern portion of Germany, an anomolous environmental market where the ruinous environmental legacy of Communist rule meets the economic strength and tough environmental standards of Federal Germany, is discussed in box 4-B.

Western Europe thus includes markets for both cutting edge technologies and catch-up equipment and processes. Both markets may exist even in countries with strong standards. For example, some German air quality standards are more stringent than U.S. requirements; almost all major sources of SO_2 and NO_x in western Germany are well-controlled. Yet Germany is still phasing in automotive catalytic converters, first introduced in Germany 1986 but only now (1993 model year) required for all size classes of new automobiles.

[40] OECD, op. cit., footnote 2.

[41] ECOTEC Research & Consulting, *The European Pollution Control and Waste Management Market: An Overview* (Birmingham, U. K.: January 1992).

Table 4-7—Western Europe's Environmental Markets by Environmental Sector ($ billion)

	1990	1991	1995	Annual growth (percent)
Air pollution control	9.6	10.3	12.8	4.3
Water/wastewater treatment	12.8	13.8	21.3	9.1
Contaminated land reclamation	1.0	1.1	2.3	16.1
Waste management	20.9	22,5	28,0	4.5
Total	44.3	47.7	64.4	8.5

SOURCE: ECOTEC Research & Consulting, Ltd. (ECOTEC's environmental market definition does not include construction work, water supply, or municipal waste collection.)

Most other Western European states have not yet reached western German levels of stationary source air pollution control or American levels of mobile source controls, Both will be areas of market growth. It is also possible that future European policymakers may look toward California-type air standards as a model. Industrial VOC controls are another area of EGS demand in Western Europe.

Water and wastewater treatment technologies and markets are relatively mature in much of Western Europe. Yet lack of infrastructure in the southern EC states—where primary and secondary sewage treatment often is unavailable-and investment needs in the UK are reasons for forecasts of significant capital expenditure in this sector. Due to EC directives, most countries will upgrade systems and improve water quality monitoring. Treatment chemicals and advanced treatment technologies, such as use of membranes and ion exchange, are other areas of growth.[42]

In remediation of contaminated lands and hazardous waste handling, Europe lags behind the United States in experience and policy .43 An estimated 62,000 contaminated sites associated with closed industrial facilities and refueling stations are known, with perhaps many more to be discovered. The 1990 market, primarily in Northern Europe, was estimated at $1 billion a year but could shoot to $2.3 billion by 1995, stimulated by more stringent laws. Likewise, markets to treat or dispose of hazardous waste may triple, from $2.5 billion to $7.6 billion by 2000. This would reflect an anticipated rise in landfilling costs due to capacity constraints, stricter controls, greater quantities of hazardous substances generated,[44] and more waste pretreatment requirements.

As with water and wastewater treatment, municipal and hazardous waste treatment is characterized by poor infrastructure--often open dumps—in parts of Western Europe at the same time other areas are advancing the state of the art.

Western Europe's large environmental market has stimulated a very capable environmental industry in some countries and sectors. In 1990, there were an estimated 10,000 environmental firms in the Western Europe; 65 percent of these companies had annual revenues of under $5 million.[45] About one-fourth of Western Europe's environmental companies are German.[46] Another 15 percent are British, 12 percent are French, and 10 percent are Italian. The number of such firms in the Netherlands (7 percent), Sweden (5 percent), Switzerland (4 percent), and Denmark (3 percent) is small but disproportionately high relative to population or GDP. This reflects the relatively strong and well-established environmental regulations in those countries. Other Western European countries each accounted for between 1 and 3 percent of the total. As illustrated in the following chapter, companies from Ger-

42 Haines, op. cit., footnote 39; ECOTEC, op. cit., footnote 41.

43 Ibid. for data in this paragraph.

44 This will occur partly by definition as more substances are defined as hazardous.

45 ECOTEC Research & Consulting, op. Cit., footnote 41.

46 Another estimate suggests that 9,000 to 10,000 environmental firms may be feud in German y alone. Ariane Genillard, "Industrial Clean-up on a Grand Scale," *Financial Times*, Sept. 16, 1993, p. 12.

Box 4-B-Environmental Needs in Eastern Germany

The "new Laender'-'-the new states of the Federal Republic of Germany--have an environment damaged by decades of abuse under inefficient central economic planning, which gave the environment very little consideration in the course of industrial and agricultural development. The result has been damage to public health and degradation of air, water, soil, and biological resources. One direct environmental consequence of the Cold War is 800 known sites in eastern Germany where old munitions have been buried.[1] Eastern Germany's reliance on low-quality, high-sulfur coal for 75 percent of its energy also produced severe environmental contamination. Emissions of a number of air and water pollutants are comparable to the highest levels occuring in western Germany 20 to 30 years ago; SO_2 emissions are the highest per unit of area of any European country.[2] The Association of German Electricity Producers (VDEW) estimates it will take $25.5 billion over 10 years to bring eastern German power plants into compliance with Federal German environmental standards.[3] Many industries, as well as water supply, wastewater treatment, and solid waste utilities, will require substantial investment to meet Federal German and European Community environmental standards. New facilities must meet Federal standards; existing facilities are subject to a compliance timetable that extends to the year 2005.[4] Some estimates of eastern German environmental needs are great. (See table 4-B-1.)

While the transition of the eastern German economy to a market basis is difficult, the region has an advantage over its eastern neighbors because it is hitched to the most powerful economy in Europe. Even with the German recession of the early 1990s, the flow of money from western Germany, plus the stability of Germany's legal, political, and economic system, make investment and trade with eastern Germany less risky than similar transactions with other former soviet bloc countries in Central and Eastern Europe.

Over $3.5 billion in loans and grants were made by the federal government for improvement of the eastern German environment in 1990 and 1991.[5] The federal government may bear 60 percent of $8.3 billion presumed to be needed for remediation of contaminated eastern sites through 1998, with additional funds provided by states.[6] Much remedial work will be associated with privatization of state-owned enterprises. While some American firms may concede eastern German environmental markets to Germany's strongly competitive environmental industry, the market may still be particularly attractive. American environmental firms could even find that acquisitions and investments in Germany can offer a platform for expansion into Central and Eastern Europe.

Table 4-B-I-Needed Environmental Expenditures for Eastern Germany 1992 Through the Year 2000

	(billion 1992 dollars)		
Environmental sector	Low	High	Best estimate
Wastewater management	33.9	86.0	80.2
Drinking water improvement	10.8	19.2	10.8
Waste disposal	1.9	22.0	22.0
Air pollution	3.2	22.4	14.4
Contaminated site remediation	1.9	44.8	6.8
Noise abatement	1.3	2.6	1.3
Total	53.0	205.7	135.4

SOURCE: IFO Institute for Economic Research in OECD, *OECD Environmental Performance Reviews: Germany* (Paris: OECD, 1993), p. 91.

1 U.S. Department of Commerce, "Market Insight Report: Environmental Market Opportunities in Eastern Germany," March 1992.

2 OECD, *OECD Environmental Performance Reviews:* Germany (Paris: OECD, 1993), p. 88-90.

3 U.S. Department of Commerce cable, Sept. 2,1992, in U.S. Department of Commerce, National Trade Data Bank.

4 OECD, op. cit., footnote 2.

5 Ibid.

6 *Environmental Science & Technology*, vol. 27, No. 8, 1993, p. 1461.

many, Sweden, the Netherlands, Britain, France, Austria, and Switzerland are strong competitors with American and Japanese companies in most of the world, including the domestic U.S. market.

Japan

Behind the United States, Japan has the second largest national environmental market, estimated by OECD as $24 billion in 1990 and expected to grow to $39 billion by 2000.[47] Japan, like the United States, Germany, and several other OECD countries, has stringent environmental regulations. And as in those countries, environmental markets will reflect strengthening of already strict standards in some areas and efforts to match better foreign performance in other areas.

Some air quality markets in Japan are the most developed in the world—Japan operates over three-quarters of the world's stack gas desulfurization and denitrification facilities[48]--yet air pollution control requirements continue to be bolstered. For instance, Japanese diesel truck and bus manufacturers are under pressure to meet NO_x reduction requirements of 17 and 35 percent by 1994-1995 for heavy- and light-duty trucks, respectively, with longer term reduction goals of 38 and 56 percent.[49] However, stationary source VOC emissions and toxic air pollutants are less tightly controlled than under the United States' 1990 Clean Air Act Amendments.

Additional efforts are envisioned in the water and waste sectors. At the end of fiscal year 1990, only 44 percent of Japanese residents were served by centralized sewage treatment, and only 62 percent had flush toilets.[50] The Five-Year Program for Sewerage Construction and Basic Program for Public Investment anticipates sewerage services for 70 percent of Japan's residents by 2000. Meanwhile, improvement of residential septic systems is underway. Although already incinerating three-quarters of its municipal solid wastes, the Japanese waste treatment infrastructure is pressured by lack of space for landfills and for new waste disposal facilities. Recycling and waste reduction-related EGS, and improved incineration and resource recovery are growing needs. Japanese hazardous waste treatment and contaminated land remediation requirements do not appear as strong as those in the United States.

Central and Eastern Europe and the Former Soviet Union[51]

The once centrally planned economies of Central and Eastern Europe and the former Soviet Union have inherited grave economic and environmental problems resulting from decades of grossly inefficient management.[52] The region serves as a cautionary example of the dangers of ignoring the environment when pursuing industrial development. Central planners promoted heavy industry and intensive agriculture, with minimal attention to environmental protection. Therefore, many factories do not have pollution abatement equipment; in other cases, existing

47 OECD, op. cit., footnote 2.

48 Coal Technology Research Institute, "World's Emission Purification Techniques," Japan Ministry of Foreign Affairs, "Japan's Environmental Endeavors," April 1992, p. 10.

49 "Truck Makers Pressed T. Reduce Nitrous Oxide Emissions," *Nikkei Sangyo Shimbun*, Dec. 4, 5, and 6, 1991, in Foreign Broadcast Information *Service, JPRS Report: Environmental issues*, JPRS-TEN-92-001-L, *Mar. 25, 1992*, pp. 17-21. Three-part serial newspaper articles by Hirofumi Tanaka.

50 *Environment and Development: Japan's Experience and Achievement*, Japan's national report to UNCED 1992, December 1991, pp. 32-33.

51 Another OTA assessment on environmental and energy technology transfer to Central and Eastern Europe is underway. U.S. Congress, Office of Technology Assessment *Energy Efficiency Technologies for Central and Eastern Europe*, OTA-E-562 (Washington, DC: U.S. Government Printing Office, May 1993) is the first report of that assessment; a second report, to be released in 1994, will address issues of energy supply and provide additional analysis of energy efficiency.

52 See box 4-B for discussion of the former East Germany.

equipment is often in disrepair. Reliance on poor quality high-sulfur coal is very high, accounting for 80 percent of Polish and 62 percent of Czech and Slovak energy consumption.[53] Sewerage and effluent treatment is usually inadequate-where present. Safe waste disposal sites are lacking. The list of health and environmental impacts is lengthy—diminished lifespans, high rates of lung disease, extremely high heavy metal levels in children's blood, cities blackened with air pollution, dead rivers and lakes, ground saturated with spilt oil, eroded and saline soils, dying forests, Chernobyl, and so on—and is documented elsewhere.[54]

Industrial production itself is hampered by pollution; reportedly 65 percent of the rivers and streams in the Katowice region of southwestern Poland—and 30 percent nationwide—are so polluted that they are unusable for industrial purposes.[55] The major factors of production-labor, capital, and natural resources-have all been impaired by environmental damage, And, contamination inhibits Western investment.

While the needs are great, the resources are modest. Clean-up of Poland alone might require $260 billion over 25 to 30 years, of which $70 billion would be for pollution abatement and most of the rest for restructuring the energy and industrial sectors.[56] The pursuit of a cleaner environment is handicapped by intense economic and political difficulties in moving to market systems of exchange, and from ethnic friction and warfare in some areas. However there remains interest in improving the environment. For instance, Poland committed about $1 billion to environmental investments in 1991, of which all but $60 million was raised in-country, primarily from environmental fees and fines; these locally raised funds were expected to double in 1992.[57] In addition to local currency funds, which might be translated into export commodities such as oil and gas, financial resources come from the European Bank for Reconstruction and Development, the World Bank, the Nordic Investment Bank, the European Investment Bank, EC's PHARE program, and bilateral assistance agencies of the United States and other countries. Still, many environmental products, as well as expertise, must be imported into the region.

Warsaw Pact forces treated their real estate with less care than U.S. and other Western military forces, and the former Soviet nuclear complex is probably an extraordinary challenge to safety and environment.[58]

Water quality is a major environmental priority. Almost two-thirds of Poland's environmental expenditures in 1991 were for the water sector.[59] Polish environmental spending for 1991-1995 is anticipated to reach $1.29 billion for water

53 1989 statistics, United Nations Statistical Office, U.N. Energy Tapes (New York, NY: United Nations, 1991) in World Resources Institute, *World Resources 1992-93 (New* York, NY: Oxford University Press, 1992), T. 5.1.

54 See, for instance, M. Feshbach and A. Friendly, Jr, *Ecocide in the USSR: Health and Nature Under Siege (New* York, NY: Basic Books, 1992); Bedrich Moldan and Jerald L. Schnoor, "Czechoslovakia: Examining a Critically Ill Environment,' *Environmental Science and Technology, vol. 26, No. 1, 1992,* pp. 14-21; Ministry of Environmental Protection, Natural Resources, and Forestry, *The State of the Environment in Poland: Damage and Remedy* (Warsaw, Poland: 1992); World Resources Institute, *World Resources 1992-93 (New* York, NY: Oxford University Press, 1992), Ch. 5; The World Bank, Environment Strategy Study reports for Bulgaria, Poland, and Czechoslovakia.

55 James F. Manji, "Cleaning up in Eastern Europe," *Automation,* May 1991, pp. 20-21.

56 The World Bank, "Poland Draft Environment Strategy Study, " draft summary, conclusions, and recommendations (Washington DC: The World Bank, 1989), p. iii; in World Resources Institute, *World Resources 1992-93 (New* York: Oxford University Press, 1992), p, 57,

57 Marek Nowakowski, Director for International Cooperation, Ministry of Environmental Protection of Poland, presentation at GLOBE '92, Vancouver, BC, Canada, Mar. 19, 1992.

58 See U.S. Congress, Office of Technology Assessment, *Dismantling the Bomb and Managing the Nuclear Materials,* OTA-O-572 (Washington DC: U.S. Government Printing Office, September 1993) for discussion of environmental, health, and safety issues related to dismantling and disposing of military nuclear materials.

59 Kenneth J. Macek and Gregory K. Schwartz, "Domestic Environmental Products and Services Sectors: Poland, " TMS Management Consulting, Framingham, MA, October 1991. Municipal solid waste or equivalent was not a listed category,

supply, $3.05 billion for water protection, $2.67 billion for air pollution, and $360 million for industrial waste. Hungary intends to spend over $1 billion on water supply and sewerage treatment infrastructure out of a total $2.5 to $3.5 billion environmental investment in 1992 -1996.[60]

Air pollution is a very visible problem. Baghouses and other filters, cyclones, and electrostatic precipitators are relatively simple, low-cost, and effective means of controlling the health threats posed by particulate found in smoke and dust. Coal-cleaning technologies can improve combustion efficiency. Heavy reliance on high-sulfur brown coals leads to a market for desulfurization technologies. Control or prevention of NO_x and VOC emissions for both stationary sources and vehicles are additional needs.

The large stock of obsolete and inefficient capital provides an opportunity for the provision of cleaner production and energy efficiency technologies for both retrofit and new facilities. A recent study estimates that six former Eastern Bloc countries (Poland, Hungary, Bulgaria, Rumania, Czech Republic and Slovakia, and the former Yugoslavia) offer a $19.4 billion potential market for industrial-sector energy-efficiency equipment—meters, analyzers, thermometers, steam traps, fluorescent lights, combustion equipment, insulation, and others.[61] This estimate was derived from results of a U.S. Agency for International Development (USAID) energy assistance program in which 48 industrial facilities in these countries had energy audits and were provided with over $1 million of U.S.-manufactured energy-efficiency equipment. The equipment provided was low-cost and was chosen to offer simple payback within 3 years, although most installations yielded much faster payback—in some cases measured in days.

Monitoring and control technologies, including industrial process control and residential thermostats, offer large environmental and commercial opportunities in these countries.[62] For instance, some urban areas are heated from district heating plants, which in principle can offer superior efficiency because of the opportunity to cogenerate electricity and useful steam. District heating also obviates the need for separate heating plants in each building served. However, in Moscow and other cities, apartments lack thermostats, so overheated apartment-dwellers open their windows in mid-winter, while those in apartments further down the steam line have insufficient heat; the result is tremendous energy waste and discomfort.[63] Companies such as Honeywell are investigating opportunities in this area.[64] Business opportunities for energy service companies (ESCOs) may also arise. ESCOs, pioneered in the United States, identify and provide equipment and services for improved energy efficiency to industrial and commercial clients. Their earnings come from a portion of the money saved from clients' energy bills.

In some cases, existing facilities are so inefficient as to be beyond salvage. This leads to the possibility of phasing out dirtier methods of the past-open hearth steelmaking and mercury-consuming chlor-alkali production, for instance—and introducing cleaner production technology, In the long run, gas turbines burning the region's plentiful natural gas may produce electricity more cheaply and with less pollution than existing

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60 Kenneth J. Macek, "Domestic Environmental Products and Services Sectors: Hungary,' TMS Management Consulting, Framingham, MA, January 1992.

61 Mark Hopkins, *Business Opportunities in Eastern Europe for Energy -Efficient Industrial Products* (Washington, DC: The Alliance to Save Energy, January 1992).

62 U.S. Congress, Office of Technology Assessment, *Energy Efficiency Technologies for Central and Eastern Europe*, op. cit., footnote 51, pp. 55, 65-67.

63 Ibid., p. 65.

64 Ibid., pp. 88-89.

plants. Similarly, fluidized-bed combustion and other clean coal technologies are likely to prove superior to air pollution controls on existing power plants. Long-term markets for more economically efficient and environmentally preferable industrial production technologies may far exceed the demand for retrofitted pollution abatement and waste treatment equipment. Some new facilities will be needed before others; for example, capacity to produce unleaded gasoline and low-sulfur motor fuels will bean early need if the region adopts EC-like vehicle standards.

Latin America

Growing environmental awareness and liberalizing of trade are opening up Latin American environmental markets. The region is characterized by a heretofore modest commitment to environmental protection and by continuing poverty in both rural and urban areas. However, the traditional view of environment and development as in opposition is softening. And some countries, have committed growing financial, legal, and administrative resources to environmental matters; for example, the Mexican environment agency's budget grew from $4.3 million in 1988 to $78 million in 1992, essentially doubling yearly in real terms.[65] In April 1992, Mexico, with World Bank aid, began a $126 million program to strengthen environmental management capacity at federal, state, and local levels.[66] Mexico and Brazil are and will continue to be the region's largest environmental markets.

Mexican environmental markets are of particular interest to the United States because of a long shared border, environmental issues associated with the proposed North American Free Trade Agreement (NAFTA), and growth of commercial ties (e.g., American-owned maquiladora plants) and trade. Extreme air pollution in Mexico City and a 1992 disaster in which portions of the Guadalajara sewer system exploded, resulting in significant loss of life, are among the situations that have raised the visibility environmental issues in Mexico and have aroused the interest of EGS exporters and investors abroad. Significant funds are now available for environmental protection; for instance, $4.6 billion is budgeted for a 4-year Mexico City air pollution control program that started in 1991, and $4.5 billion is planned for water/wastewater investments during 1990 to 1994[67] (see tables 4-8 and 4-9). An additional $460 million over 3 years is being committed for the Mexican side of the U.S.-Mexican border

Table 4-8-Mexico City Air Pollution Control Program ($ million)

By category of expenditure	
Clean fuels/fuel substitution	2,153
Rehabilitation & expansion of public transport	1,536
Emissions control and monitoring	639
Reforestation	327
Training and R&D	27
By source of funding	
Mexico	3,671
Japan Overseas Economic Cooperation Fund	689
Japan Export-Import Bank	228
Interamerican Development Bank	46
World Bank	44

SOURCE: Comprehensive Pollution Control Program for the Mexico City Metropolitan Zone, April 1991 in U.S. AID, *Energy and Environment Market Conditions in Mexico* (Washington, DC: U.S. AID, March 1992).

65 Sergio Reyes Lujan, Subsecretary of Ecology, SEDUE (Secretariat for Ecology and Urban Development), Mexico, presentation at GLOBE '92, Vancouver, B. C., Canada, Mar. 19, 1992. The Mexican environment agency is *now* part of SEDESOL—the Secretariat for Social Development.

66 U.S. Agency for International Development *Environmental Market Conditions and Business Opportunities in Key Latin American Countries,* Business Focus Series, (available through USAID, Arlington, VA), October 1992.

67 U.S. Agency for International Development Office of Energy & Infrastructure, *Energy and Environment Marker Conditions in Mexico,* Business Focus Series, (available though USAID, Arlington, VA), March 1992.

68 Jan Gilbreath Rich,' 'Financing Environmental and Infrastructure Costs Under a North American Free Trade Agreement With Emphasis on the Texas-Mexico Border, " draft presented to the Institute of the Americas conference "Latin American Environment and Technological Cooperation' La Jolla, CA, Nov. 17-19, 1991.

Table 4-9—1 990-94 Water Supply and Sanitation Sector Plan ($ million)

	1990	1991	1992	1993	1994	Total	(%)
Water supply	206.1	674.1	695.6	690.8	728.1	2,994.7	(66.5)
Sewerage	63.7	232.6	252.1	247.0	238.0	1,033.4	(23.0)
Treatment	16.0	121.5	107.5	112.9	117.6	475.5	(10.5)
Total	285.8	1,028.2	1,055.2	1,050.7	1,083.7	4,503.6	

NOTE: Does not include Mexico City, Guadalajara, Monterrey, and some U.S.-Mexico Border Plan water and wastewater investments. The inter-American Bank has loaned $300 million for Guadalajara and $325 million for Monterrey that are not included in the figure. Mexican projects in the U.S.-Mexico Border Plan allocate an addition $220 million for "wastewater treatment and recycling projects."

SOURCE: World Bank, 1991 and U.S. AID, *Energy* **and** *Environment Market Conditions in Mexico* (Washington, DC: U.S. AID, March 1992)

region.[68] The World Bank recently signed an agreement with Mexico to provide $1.8 billion in loans, matched by $1.2 billion from the Mexican government, for environmental clean-up during the years 1994 to 1996.[69]

A special facility for financing environmental infrastructure projects along the Mexican-United States border region has been proposed as part of an environmental side agreement to NAFTA. (Congress had not yet voted on NAFTA when this report went to press).

Table 4-10 provides a partial estimate of Mexico's environmental market size. Of an estimated 1992 total environmental market of $614 million, imports accounted for $150 million, of which $85 million (about 56 percent of imports) came from the United States.[70] U.S. Department of Commerce data from 1989 indicate that U.S. companies garnered about a quarter of Mexico's air pollution import market. Other major players included Germany, Japan, and Switzerland. U.S. producers dominated equipment imports for water pollution (60 percent of imports) and solid and hazardous waste (over 70 percent of imports) in 1989; German, Japanese, French, and Swiss firms were prominent rivals .71 Although not included in these figures or table 4-10, a U.S. Department of Commerce analysis found that the Mexican solid waste handling equipment market (garbage trucks, waste compactors, street cleaners, and other equipment) amounted to $500 million in 1991 and was expected to reach $625 million in 1992; U.S. suppliers of this equipment sold $233 million (69 percent) of the $337.5 million Mexico imported in 1991.

Table 4-10—Mexican Environmental Markets ($ million)

	1990	1991	1992 (est.)	1993-95 (est.)
Air pollution	78	90	104	119-157
Water pollution	105	126	400	500-780
Solid/hazardous waste"	83	95	110	127-167
Total"	266	311	614	746-1104

•See text for discussion of environmental products that maybe omitted from these figures,

SOURCE: U.S. Department of Commerce in U.S. AID, *Environmental Market Conditions and Business Opportunities in Key Latin American Countries* (Washington, DC: U.S. AID, October 1992).

There are significant environmental markets elsewhere in Latin America. Tables 4-11 and 4-12 present 1992 estimates of the six largest markets and their imports. Environmental spending is expanding for the provision of public water, sewer, and refuse disposal services as well as for industrial environmental activities. Major buyers of air and water pollution control equipment

[69] Gary Lee, "World Bank, Mexico Agree on Pollution Cleanup Funds, " *Washington Post,* Sept. 29, 1993, p. A18.

[70] U.S. Agency for International Development, *Environmental Market Conditions and Business Opportunities in Key Latin American Countries,* op. cit., foomote 66.

[71] Ibid.

Table 4-1 l—Major Latin American Environmental Markets in 1992($ million)

	Air	Water	Solid/Hazard	Total
Argentina	53	100	15	168
Brazil	120	845	50	1,015
Chile	195	350	15	560
Colombia	20	15	10	45
Mexico"	104	400	110	614
Venezuela	25	9	10	44
Total	517	1,719	210	2,446

•See table 4-10 for details and note.

SOURCE: U.S. Agency for International Development *Environmental Market Conditions and Business Opportunities in Key Latin American Countries* (Washington, DC: October 1992).

Table 4-12—Major Latin American Environmental Import Markets in 1992 ($ million)

	Total imports	Percent of total	Imports from U.S.	Total
Argentina	42	25	11	168
Brazil	190	19	92	1,015
Chile	500	89	200	560
Colombia	35	78	10	45
Mexico	150	24	85	614
Venezuela	43	97	38	44
Total	960	39	436	2,446

SOURCE: U.S. Agency for International Development *Environmental Market Conditions and Business Opportunities in Key Latin American Countries* (Washington, DC: October 1992).

include chemical, petroleum refining, steel, pulp and paper, food, textile, and other process industries. For instance, Brazil's steel, pulp and paper, and cement sectors plan environmental investments that could reach $300 million a year or more.[72] The electric power sector is another important market for environmental equipment. Economic liberalization and loosening restrictions on foreign investment in energy and other industries may assist in the diffusion of cleaner production technologies to the region.[73] Multinational firms from the United States and Europe are major purchasers of environmental equipment and services.

As in Central and Eastern Europe and the former Soviet Union, cleaner production opportunities in Latin America arise from the building of new facilities and introduction of cleaner processes. For instance, the Chilean copper industry is considering investment in new and modernized smelters, copper dryers, and sulfuric acid recovery units that will prevent air pollution.[74] Pemex, the Mexican national oil company, has been adapting refineries to produce unleaded gasoline and low-sulfur fuels.[75] One low-sulfur fuels project, costing $450 million in 1992, involves transfer of technology from U.S. companies (HRI, Texaco, and Foster Wheeler) to several Mexican refineries. Anticipated 6 to 8 percent growth in annual electricity demand in Mexico through 2000[76] could produce markets for cleaner and more efficient electricity generation and end-use technologies as well as for pollution abatement equipment. These examples are illustrative and could apply generally to other expanding industrial sectors throughout the region.

South Korea and Taiwan

South Korea and Taiwan are the two largest of the four East Asian ''tigers,' the other two being Hong Kong and Singapore. These Newly Industrialized Countries (NICs) have engineered sustained high rates of economic growth. Their

[72] Ibid., p. 41.

[73] Birdsall and Wheeler provide limited empirical evidence from Latin America that relatively open economies adopt cleaner technologies more readily than relatively closed economies. Nancy Birdsall and David Wheeler, "Trade Policy and Industrial Pollution in Latin America: Where are the Pollution Havens?, " Patrick Low (cd.), *International Trade and the Environment* (Washington DC: The World Bank, April 1992) pp. 159-67.

[74] U.S. Agency for International Development, *Environmental Market Conditions and Business Opportunities in Key Latin American Countries,* op. cit., footnote 66.

[75] Ibid., p. 27.

[76] U.S. Agency for International Development, *Energy and Environment Market Conditions in Mexico,* op. cit., footnote 67.

Table 4-13—Republic of Korea Environmental Investment Plan 1991-95 ($ million)

	1991	1992	1993	1994-95	Total
Air pollution	$1,384.2	$1,342.5	$598.9	$1,094.0	$4,419.7
Water pollution	622.5	872.0	1,110.4	1,624.7	4,229.7
Waste management	204.7	364.5	493.6	1,890.0	2,952.8
Soil conservation	12.6	15.4	17.7	47,6	93.3
Marine conservation	21.9	25.3	24.0	13.3	84.5
Nature conservation	0.3	0.7	1.3	3.2	5.4
R&D	2.7	12.0	12.7	25.7	53.1
Total	2,248.9	2,632.5	2,258.7	4,698.3	11,838.5

SOURCE: Ministry of Environment (Republic of Korea), *White Paper 7990, 1991,* in Ral Woo Lee, "Perspective of Environmental Industry in Korea," paper presented at GLOBE '92, Vancouver, BC, Canada, Mar. 16-20, 1992. (Categories may not add to total due to rounding off.)

export-led strategies of industrialization are models for other developing countries. Neighboring countries Thailand, Malaysia, and Indonesia aspire to be the next tigers, while other countries in Asia, Latin America, and Africa try to distill the tigers' formulae for success and adapt them to their own contexts. However, the tigers' economic success has occurred with significant adverse impacts on environmental quality.

Inadequate or nonexistent sewerage and industrial effluent treatment facilities, improper handling of municipal and hazardous wastes, and poor control of air emissions affect the health and well-being of Koreans and Taiwanese. Drinking water resources are threatened, as are coastal fisheries (which are also overfished).

Both countries have substantially boosted their environmental protection efforts in recent years. The Korean Ministry of Environment has outlined a $10.5 billion, 5-year program of public and private environmental investment from 1991 to 1995[77] (see table 4-13). The Korean environmental investment plan includes large allocations for SO_2 controls, waste landfills and incinerators, and wastewater treatment. Investments in cleaner fuel infrastructure, such as liquefied natural gas facilities, are part of Korea's air quality investment plans. The plan includes construction of 60 wastewater treatment plants and 55 incinerators by 1995. Thirty-four sanitary landfills may be built over the next two decades.

In 1991, South Korean businesses spent about $732 million on pollution control facilities, of which $375 million was for the water sector, $314 million for air quality, and $37 million for noise abatement.[78] Reportedly, $181 million of EGS were imported to South Korea in 1991, with the U.S. share accounting for 14 percent.[79] As stricter air and water pollution standards come into effect in 1995 for air and 1996 for water, environmental investments could grow from $1.25 billion in 1992 to $4.5 billion in 2000, according to sources from South Korea's Energy and Resources Ministry.[80] Requirements for catalytic converters in new automobiles will create large markets. Growing environmental concerns have led to an expanding Korean environmental industry--over $750 million of environmental projects were

[77] Ministry of Environment (Republic of Korea), *White Paper 1990, 1991,* in Tal Woo Lee, "Perspective of Environmental Industry in Korea, " paper presented at GLOBE '92, Vancouver, BC, Canada, Mar. 16-20, 1992.

[78] "Businesses Spend More on Pollution Facilities in 1991, " Yonhap (S. Korean news agency), Mar. 9, 1992, in Foreign Broadcast Information Service, *JPRS Report: Environmental Issues*, *JPRS-TEN-92-O08,* May 5, 1992, pp. 45-46. Business expenditures on solid waste facilities were not noted.

[79] ' 'Korea Needs U.S. Equipment; Problems Remain, ' *NewsACTION,* vol.7, *No.* 1 (spring 1992), pp. 16-17.

[80] "Businesses Spend More on Pollution Facilities in 1991, ' Op. cit., footnote 78.

Table 4-14-Selected Environmental Projects in Taiwan

Wastewater treatment	$4.7 billion	21 projects
Solids waste disposal	3.5 billion	23 projects
General projects/other	1.6 billion	9 projects[a]
Air and noise pollution	532 million	7 projects
Environmental monitoring	256 million	5 projects
"Environmental sanitation" and toxic wastes	53 million	3 projects

a One project of the Chinese Petroleum Corporation for "Industrial Pollution Control" accounts for $1.3 billion in this category.

SOURCE: International Business Development, Northwestern University. (Peter Hage, "U.S. Execs Hear Details of Taiwan's Hot Market," *NewsACT/ON*, vol. 7, No. 1 (spring 1992), pp. 5-7, published by the International Business Development program, Northwestern University.)

awarded to 631 registered environmental firms in South Korea in 1991.[81]

The Taiwan Six-Year National Development Plan for 1992 to 1997 lists $305 billion of public infrastructure and state-owned industrial projects.[82] Of these 775 projects, 68 (accounting for $10.7 billion) are under partial or complete purview of the Taiwan Environmental Protection Administration or local environmental agencies (see table 4-14). Additional projects of the Taiwan Six-Year Plan that are environmentally significant call for installation of cleaner production technologies, including combined-cycle gas turbine generators for Taiwan Power Co., cogeneration and heat recovery projects for the state oil and steel companies, fuel desulfurization facilities, and various efficiency upgrades in state-owned industrial fins.

Taiwan's environmental market was $907 million in 1991, of which imports supplied 68 percent, including $210 million for U.S. goods and services.[83] Details are summarized in table 4-15.

Table 4-15-Taiwan Environmental Equipment, Instruments, and Services Market and Trade ($ million)

	1989	1990	1991	Est. Real Ann. Growth (percent)
Total market	645	745	907	20-25
Imports	450	520	620	20
Exports	3	5	8	
Local production	198	230	295	
1990 import market share (percent):				
Us.		34		
Japan		29		
W. Germany		17		
Sweden		5		
United Kingdom		4		

SOURCE: U.S. Department of Commerce and American Institute in Taiwan.

India and China

The two most populous nations in the world, China and India, face major challenges in meshing economic development and environmental protection. The two Asian giants suffer from insufficient water, sanitary, and refuse disposal services for their populations. The industrial sectors of both nations are growing fast, including highly polluting sectors such as chemicals, metals, electric power, and cement. Both countries rely on large deposits of cheap coal that create significant pollution problems, particularly when both fuel combustion and energy use are inefficient. These countries are struggling to provide basic environmental services at the same time they face growing toxic and hazardous threats posed by modern industry. The tragic toxic chemical release at Bhopal, India in 1984 focused attention on environmental safety in the growing Indian chemicals sector.

81 "Stricter Guidelines for Environmental Protection" *The Korea Times*, Aug. 18, 1992, in Foreign Broadcast Information Service, *JPRS Reports: Environmental Issues*, JPRS-TEN-92-017, Sept. 21, 1992, p. 29.

82 American Institute in Taiwan, "Listing of Taiwan's Six-Year Development Plan Projects (Partial List) & Status Report on Selected Major Projects," August 1991.

83 American Institute in Taiwan and U.S. Department of Commerce, International Trade Administration Market Research Reports: Taiwan-Pollution Control Equipment, July 1991.

Environmental markets in these two countries are modest by industrial nation standards. The U.S. Department of Commerce estimated that the total Indian market for pollution control equipment in 1990 was $400 million, of which imports accounted for 20 percent ($80 million).[84] The great majority of environmental equipment is made in-country by Indian firms, a number of which are affiliated with U. S., Swedish, and German EGS suppliers via licensing or partnership arrangements. British, Japanese, and Swiss EGS suppliers are also active in the Indian market. About 45 percent of pollution control equipment demand in India is thought to come from the electric power and chemical sectors. Indian environmental equipment markets are projected by the U.S. Department of Commerce to grow 25 to 30 percent annually over the following several years. Estimates of demand for environmental consulting and other services were not available.

China's environmental investments are increasing. The Five-Year Plan for 1991-95 allocates about $15 billion for environmental protection, or about double the spending allocated in the 1986-90 Plan.[85] The government goal is for state spending on environment to reach 0.8 percent of GDP by 1995. Much of the money is likely to be spent on countering pollution from coal-burning by means of fuel switching and improving heating system efficiency, as well as end-of-pipe emissions controls. Japan has targeted part of its Green Aid toward Chinese power plants for leasing and adaptation of flue-gas desulfurization technology.[86] American clean coal technologies might meet some of China's needs.

Water quality spending in China is considerable, with an equipment and instrument market estimated at about $433 million in 1991.87 However, imports accounted for less than $50 million of this market; Japan (40 percent), Austria (25 percent), and the United States (8 percent) were major suppliers.[88] Solid and hazardous waste handling and disposal are also acute needs; China has few landfills or incinerators that can meet industrial country standards for environmental protection. As in the case of India, an indigenous environmental industry is developing. Over 4,000 enterprises with an estimated output of $1 billion comprise the Chinese environmental industry.[89]

Other East Asian Markets

Environmental markets elsewhere in Asia are also expanding. Like Taiwan and South Korea, the Association of South East Asian Nations (ASEAN) countries (Brunei, Indonesia, Malaysia, the Philippines, Singapore, and Thailand) have been experiencing rapid economic growth and industrialization. But environmental degradation accompanying industrialization has become significant and recognition of the problem is only recent. A very rough estimate of the 1993 aggregate ASEAN environmental market is $1.8 billion.[90] (Environmental issues related to for-

84 U.S. Department of Commerce, International Trade Administration, Market Research Reports: India-Pollution Control Equipment in the Chemical & Power Generation Sector, July 1991 for all information in this paragraph.

85 "China Battles Hard To Clean Up Environment," *China Daily,* Oct. *8, 1992,* p. 4, in Foreign Broadcast Information Service, *JPRS Reports: Environmental Issues, JPRS-TEN-92-021, Nov. 12, 1992,* p. *6.*

86 "Japan To Propose China Lease Equipment To Trap Sulfur From Coal-Burning Plants," *International Environment Reporter, May 19, 1993,* p. *375.*

87 U.S. Department of Commerce, International Trade Administration, Market Research Reports: China-Urban Water Sanitation—ISA9109, Dec. 23, 1992.

88 Ibid.

89 Xinhua news agency, "First Market for Environmental Protection Products,' Aug. 9, 1993 in Foreign Broadcast Information Service, *JPRS* Report: *Environmental Issues, JPRS-TEN-93-022,* Sept. *3, 1993,* p. *2.*

90 Jonathan Menes, Acting Assistant Secretary for Trade Development, U.S. Department of Commerce, written testimony before the Subcommittee on Environment and Natural Resources of the House Committee on Merchant Marine and Fisheries, Feb. 25, 1993.

estry are very important in this region but are not discussed in this assessment.)

Singapore has instituted relatively strong environmental requirements, which accompany a relatively advanced economy. The country Ministry of Environment has allocated $609.3 million to environmental programs for 1992 and aspires to take regional leadership in the environmental industry.[91] Unleaded fuels and stricter emission requirements have been introduced, and CFC substitution for the country's electronics industry is underway. Hong Kong, another city-state (and not an ASEAN member), has emphasized landfills and sewage treatment. Browning-Ferris Industries (U.S.), for example, was recently awarded a joint venture contract valued at $400 million over 25 years to build and operate a landfill in Hong Kong.[92] A $15 billion sewerage infrastructure program is in progress, with extensive British business involvement.[93] Hazardous wastes are also a growing concern in this rapidly industrializing region; Hong Kong, Singapore, and Indonesia have integrated hazardous waste facilities in operation or under development by Waste Management International, subsidiary of WMX Technologies (U.S.), and Malaysia has recently awarded a contract for such a facility to I. Kruger (Denmark).

Water and wastewater treatment, including industrial effluent treatment, are priorities through most of ASEAN.[94] River water is often highly polluted, sewerage service and safe tap water are often unavailable. Oil and chemical spills are another concern in this region because of a high concentration of petroleum production and refining facilities. The World Bank and Asian Development Bank have over $2.5 billion of urban water and wastewater projects under development in Indonesia, although that country's 1992 market for water pollution control equipment was estimated at only $23 million.[95] Malaysia's 1991-1995 development plan allocates over $1.5 billion for water resources, of which about a quarter is for sewerage and urban drainage.[96]

Air emissions are also of growing concern. Clean coal and other cleaner energy technologies are important features in Thailand's environment and development plans. Recent Thai utility awards of flue-gas desulfurization contracts to Japanese suppliers and gas turbine power plants to U.S. companies are examples of energy and air quality business opportunities in the area. Vehicles emissions are becoming more problematic and it is not unreasonable to believe that other nations of the region will follow Singapore, South Korea, and Taiwan in adopting cleaner motor fuels and vehicles.

Again, as illustrated in previous sections, rapid development creates opportunities for the provision of both traditional environmental products and cleaner industrial and energy technologies.

Near East

Environmental protection is an emerging concern in the Near East as human populations, industrial activity, and agricultural production increase in scale and concentration. In most countries of the region, environmental regulations are still at an early stage of development.

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91 Vincent Yip and Brian Fliflet, "China, Hong Kong, ASEAN Countries Are Frontier Markets," *NewsACTION*, vol. 7, No. 1 (spring 1992), pp. 14-16.

92 "Browning-Ferris Gets Contract to Operate a Hong Kong Dump," *Wall Street Journal*, June 29, 1993, p. A8.

93 Yip and Fliflet, op. Cit., footnote 91+

94 U.S.-ASEAN Council for Business and Technology, "A SEAN Environmental Markets: Opportunities for U.S. Equipment and Service Companies" (Washington, DC: 1991).

95 U.S.-ASEAN Council for Business and Technology, "ASEAN Wastewater Treatment Markets: Opportunities for U.S. Companies," draft, 1992.

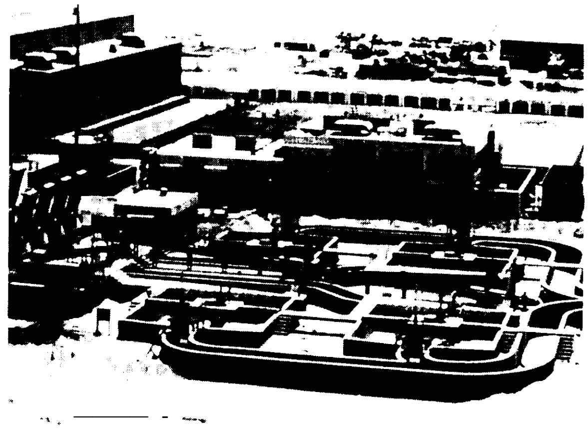
96 Ibid.

Table 4-16—Egypt's Estimated Environmental Market ($ millions)

	1992	1997
Municipal water and wastewater treatment	*350*[a]	*550-700*
Waste recycling	*5*	*8-10*
Industrial wastewater treatmt	*9*	100-150
Air pollution control	NA[b]	100-150
Water purification systems	*30*	50-60
Municipal solid waste	NA	NA
Renewable energy (mainly wind)	12	20
Mobile source air pollution	0	10
Air/water monitoring/testing	6	10
Environmental consulting	15[a]	40
Total	430	890-1,150

a Current spending chiefly from development assistance.
b NA denotes information not available.

SOURCE: Project in Development and Environment and U.S. AID, *Profile of the Environment Business Sector in Egypt* (Arlington, VA: October 1992).


CAMP DRESSER AND MCKEE INT.

Abu Rawash Wastewater Treatment Plant, Egypt. Many newly industrialized and developing countries, and nations in Central and Eastern Europe, plan large investments in water related infrastructure development, often with support of international aid agencies. These projects offer business opportunity for suppliers of equipment and engineering and construction of firms.

Water is the major environmental concern of the region. Estimates of Egypt's environmental market indicate that water and wastewater treatment is by far the greatest priority in that country (see table 4-16). Currently, 90 percent of Egypt's effluents are untreated.[97] Twenty percent of Morocco's 1988-1992 National Investment Budget was dedicated to sanitation.[98] Efficient water use and wastewater recycling are important components of Israeli environmental practice; 66 percent of sewage is reused for irrigation and drip irrigation apparatus is employed to minimize spread of water borne pathogens.[99]

Waste management is a public health concern particularly in urban areas. Greater Cairo has landfill and comporting capacity to handle only 22 percent of wastes generated; most wastes in smaller Egyptian cities are not collected.[100] Turkey reportedly has no modern landfill or waste incineration capacity.[101] With growing industrial production, lack of hazardous waste treatment and disposal capability is also an issue. Air pollution is a major concern in urban areas as industry, motorized transport, and electric power generation increase.

Other Developing Countries

Environmental markets in most of Africa, other parts of Asia, other parts of Latin America, and the small island nations are not well-documented. Environmental needs vary with the level of industrialization and urbanization. For most developing countries, provision of basic water,

97 Project in Development and Environment and U.S. Agency for International Development, *Profile of the Environment Business Sector in Egypt* (Arlington, VA: October 1992), p. 9.

98 U.S. Department of Commerce, Market Research Reports, Morocco--Water Sanitation Equipment, Dec. 23, 1992.

99 Yoram Avnimelech, 'Irrigation With Sewage Effluents: The Israeli Experience,' *Environmental Science & Technology*, vol. *27, No. 7*, July *1993*, pp. *1278-1281.*

100 Project in Development and Environment and U.S. Agency for International Development, Op. Cit., footnote 97, P. 10.

101 International Finance Corporation, *Investing* in *the Environment: Business Opportunities* in *Developing Countries* (Washington, DC: World Bank and International Finance Corporation 1992), p. 16.

sewer, and refuse disposal services are the major environmental priorities. Often in these countries, techniques and technologies appropriate for rural village application (which are not examined in this assessment), such as improved cookstoves, forest management, and improved agricultural practice, are of great importance.

Relative to larger or more industrialized developing countries, these national environmental markets are small. Environmental regulations and enforcement are often weak and the availability of technical and managerial expertise limited. Most less-developed countries must rely on assistance from multilateral institutions and bilateral donors to build their environmental management capabilities and their environmental infrastructure. For environmental product and service providers, aid and foreign investment are likely to be the major funding sources for environmental business.

CONCLUSIONS

Markets for environmental goods and services, including cleaner production technologies, are growing throughout the world. The character of these markets depend on the environmental and economic situations in each country. Perceptions of risk and available resources-financial, technical, and others-determine what environmental markets will be like.

The largest markets are in the industrialized nations. A leading tier of countries (including the United States, Japan, and Germany) continues to toughen their relatively stringent regulations while some other industrial nations play catch-up. Even within the leading tier, regulatory stringency varies-a country may have the strictest regulations for some pollutants and more lax ones for others.

The NICs (South Korea, Taiwan, Singapore, and Hong Kong) and advanced developing countries, including several countries in ASEAN and Latin America (especially Brazil and Mexico), have recently made environment a prominent feature of governmental attention and national investment. The industrialized nations and the more prosperous of the newly industrialized states have the money to spend on environment and will likely dominate environmental market growth in the decade ahead. A number of low-income countries, including China, India, and Indonesia, also present environmental business opportunities.

Central and Eastern Europe and the former Soviet Union have enormous environmental problems and financial resources that are sparse in comparison--except for eastern Germany, which can rely on the wealth, stability, expertise, and strong currency of its western compatriots. While nations like Poland are now dedicating local currency resources and adopting policies (like rational energy pricing) that are more conducive to improved environmental performance, the region's unstable institutions of business, property, law, and governance may dissuade some foreign investment. However, foreign assistance from development banks and bilateral programs is significant, and innovative investors might take returns in the form of oil, gas, fertilizer, and other export products. Political and social unrest make portions of the region financially and even physically unsafe (e.g., former Yugoslavia, the Caucasian republics) for investment. An advantage the region has over much of the developing world is their highly educated workforce and highly trained technical and scientific talent.

Most of the developing world is struggling to deal with the environmental stresses often exacerbated by a lack of basic environmental infrastructure and services, like running water, sewerage, and refuse collection. In less-developed countries, environmental product and service exporters and investors may find profitable options limited to projects financed through foreign assistance. Careful investment, however, may produce successful local enterprises.

U.S. Competitiveness in Environmental Technologies and Services 5

The United States' environmental goods and services (EGS) industry appears to be competitive in most sectors. Environmental industries in Japan, Germany, and several other Western European countries are also strong. They compete with U.S. companies in all sectors of the industry in all parts of the world. Indeed, foreign firms and technologies have garnered noteworthy shares of the U.S. environmental market through direct exports, licensing of technologies, and acquisitions of U.S. firms. Also, newly industrialized and developing countries are building their own capabilities to meet part of their domestic environmental needs and to compete in export markets. Thus, competition is likely to increase.

This chapter discusses international competitiveness in environmental technologies and services. It begins with an overview of the limited data on trade in this area. This is followed by a discussion of competitiveness factors. Most of the chapter consists of brief sector analyses of eight major areas.

ENVIRONMENTAL TRADE

Several estimates of international trade in environmental goods and services are discussed below. Because of data limitations, these estimates should be approached with caution.

Information on EGS trade, profits, and productivity is limited, making analysis of competitiveness difficult. The Standard Industrial Classification (SIC) and international Harmonized Code (HC) systems used to tabulate trade data do not conform well to EGS categories. For example, the United States, the European Community (EC), and Japan put industrial air pollution control devices in different categories, making direct

Table 5-l—Estimates of Environmental Exports ($ billion current dollars)

	OECD[a]	Env. Bus. Int.[b]		EPA[c]	JSIMM[d]
	Net goods, services, & licenses 1990	Total products 1992	Total services 1992	Net equipment 1991	Total equipment 1991
United States	4.0	6.9	3.6	1.11	NA
Germany	10.0	11.0	NA	0,72	NA
Japan	3.0	5.0	NA	0.48	0.35
France	0.5	NA	NA	0.01	NA
United Kingdom	0.5	NA	NA	0.29	NA

SOURCES AND NOTES: NA denotes data not available.

a OECD, *The OECD Environment Industry: Situation, Prospects and Government Policies,* OCDE/GD(92)1 (Paris: OECD, 1992). Includes income from technology licenses.

b Environmental Business International, San Diego, CA.

c U.S. EPA, "International Trade in Environmental Protection Equipment," EPA 230-R-93-006, July 1993. Based on trade categories considered environmental by authors.

d Japan Society of Industrial Machinery Manufacturers, May 1992.

comparison difficult.[1] In some cases, categories include environmental products and nonenvironmental goods.[2] And many products-e. g., pumps, motors, chemicals, measuring devices—have environmental applications not identified in trade statistics. Furthermore, data for existing environment-related categories have only recently become available; EC data prior to 1988 are more highly aggregated, and U.S. data prior to 1989 did not conform to the HC system that permits comparability across nations.[3]

Table 5-1 summarizes trade estimates from 4 sources. The estimate shown for the Organisation Economic Cooperation and Development (OECD) is for net exports of environmental products and services, including income derived from licenses.[4] The study concluded that Germany was the largest environmental exporter, producing $10 billion of trade surplus, of which half came from exports to other European OECD countries. The United States and Japan followed, each with several billion dollar surpluses. Britain, France, the Netherlands, and Sweden were also believed to be net exporters. Major importers of EGS were not identified.

The estimate by Environmental Business International in table 5-1 also ranked Germany, the United States, and Japan as the world's three largest environmental exporters, respectively.[5] Its analysis is limited to product exports for the three

[1] U.S. categories include HC 8421390010 Dust Collection and Air Purification Equipment, 8421390020 Electrostatic Precipitators, and 8421390030 Industrial Gas Cleaning Equipment 'not elsewhere specified or indicated. The European Community has additional categories, whereas Japanese trade statistics combine these categories with 8421390050 Gas Filtering or Purifying Machinery to form an aggregate category containing an unknown proportion that is not related to air pollution control.

[2] HC 8421210000 Water Filtering or Purifying Machinery and Apparatus and 8417800000 Industrial or Laboratory Furnaces and Ovens, Including Incinerators are two examples.

[3] The National Trade Data Bank (U.S. Department of Commerce), Eurostat (EC), and Japan Trade Monthly were consulted.

[4] OECD, *The OECD Environment Industry: Situation, Prospects and Government Policies,* ' OCDE/GD(92)1 (Paris: OECD, 1992). OECD's definition of EGS includes water and effluent treatment, waste treatment and disposal, air pollution control, contaminated land reclamation, noise control, and environmental services. It does not include trade and markets in cleaner production and energy efficiency products or services except for some pollution prevention consulting services explicitly identified as environmental consulting.

[5] Grant Ferrier, Environmental Business International, presentation to Environmental Business Council of the United States conference, Washington, DC, June 7-9, 1993. Environmental Business International is the publisher of the *Environmental Business Journal.*

countries and U.S. environmental service exports.[6] The study, using information from fins, concluded that about 20 percent of U.S. environmental goods production was exported. As for U.S. services, the study concluded that under 10 percent of solid waste management revenues and under 5 percent of revenues for engineering/ consulting, hazardous waste management, and analytical services originated abroad.

An Environmental Protection Agency (EPA) study that examined official trade statistics came to markedly different conclusions.[7] As shown in table 5-1, it concluded that the United States was the largest exporter of environmental goods, earning $1.1 billion of surplus out of total exports of nearly $1.7 billion in 1991. Germany was second with over $700 million in surplus from $1.5 billion of exports. Japan followed, with almost a half-billion dollar surplus from almost $700 million in exports. However, due to data limitations, the EPA study understates environmental trade in some respects and overstates it in others. As discussed above, many trade categories include goods that have both environmental and nonenvironmental applications. For instance, the study did not analyze product categories that include many types of treatment chemicals, analytical and control instruments, refuse handling equipment, and pumps and valves, and other goods. At the same time, trade codes for gas separation and purifying equipment, liquid filtering and purification equipment, and industrial and laboratory furnaces (including incinerators) were included even though industry uses much of the equipment in these categories for nonenvironmental purposes. (EPA did not estimate trade in environmental services or revenue flows from technology licenses; official trade data are not suited to such analysis.)

Table 5-2-Japanese Production and Exports of Environmental Equipment ($ million 1991)

Year	Total production	Exports	Percent Exported
1987	4086.0	160.9	3.9
1988	5211.3	170.1	3.2
1989	5314.0	589.5	11.1
1990	5262.0	365.5	6.9
1991	8054.6	350.2	4.3

SOURCE: Japan Society of Industrial Machinery Manufacturers, May 1992.

The Japan Society of Industrial Machinery Manufacturers collects data on Japanese environmental equipment production and exports but not imports (see table 5-2). Its information indicates that between 3 and 11 percent of Japanese manufactured pollution control equipment (for air, water, wastes, and noise/vibration control or treatment) was exported during the years 1987-1991.[8] For 1991, about $350 million of a total of $8 billion of environmental machinery production was exported. This figure is smaller than EPA's calculation of Japanese exports and is far smaller than estimates from OECD and Environmental Business International.

The U.S. Department of Commerce tracks production of some industrial air pollution control equipment (see table 5-3 and figure 5-l). U.S. production of these items grew from $600 million to $900 million (1991 dollars) from 1987 to 1991.[9] During those years between 10 and 16 percent of production was exported.[10] Unfortunately, similar data series for U.S. water pollution and waste-related equipment trade and production are not available.

[6] License revenues are not included nor were import levels calculated.

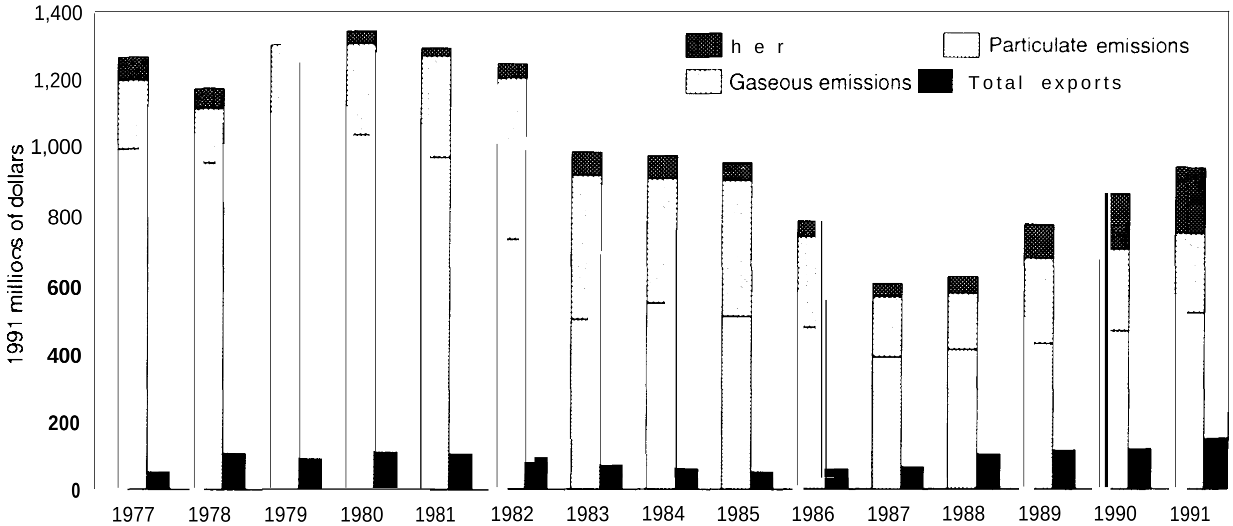
[7] U.S. Environmental Protection Agency, "International Trade in Environmental Protection Equipment: an Assessment of Existing Data, ' EPA 23@ R-93-006, July 1993.

[8] Japan Society of Industrial Machinery Manufacturers, May 1992.

[9] U.S. Department of Commerce, Bureau of the Census, "Current Industrial Reports: Selected Industrial Air Pollution Control Equipment, ' MA35J, various issues.

[10] Ibid., and U.S. Department of Commerce, National Trade Data Bank.

Figure 5-1—Selected Industrial Air Pollution Control Equipment—U.S. Production and Exports



SOURCE: Bureau of the Census and National Trade Data Bank, U.S. Department of Commerce.

Table 5-3-Recent U.S. Production and Trade in Selected Industrial Air Pollution Control Equipment ($ million 1991)

Year	Production	Exports	Imports	Trade surplus
1989	772.2	113.9	78.8	35.1
1990	861.9	119.3	76.1	43.2
1991	936.6	149.0	74.9	74.1

SOURCE: U.S. Department of Commerce, Bureau of Census and National Trade Data Bank.

Data from environmental equipment manufacturers is too limited to compare productivity and quality trends among firms from different counties. The growth in joint ventures, licensing agreements, international acquisitions, and foreign branch operations further complicates national comparisons and efforts to define national policies for environmental industries.[11] Is issuance of a license a strength because it indicates ownership of a technology that will yield royalty income? Or does licensing indicate forgone returns from manufacturing (including exports and export-related jobs)? As in other industries, there are cases of foreign-owned firms employing Americans to make products for export and the U.S. domestic market, and cases of American firms with significant manufacturing operations abroad.

Export Related Employment

From a national perspective, economic benefits of a strong environmental industry include income and jobs that come from exports (or from avoiding imports) and revenues derived from licenses and operations abroad. However, because most EGS is not internationally traded, the export-related employment from growing environmental markets abroad is difficult to estimate. A major portion of expenditures for large environmental projects, such as wastewater treatment plant construction, landfill or incinerator development, or power plant scrubber installation, is for local construction and assembly and for low-value materials that can often be more cheaply provided locally. For instance, estimates from the United States indicate that over half of

[11] For more on the blurring of national corporate identifies, see U.S. Congress, Office of Technology Assessment, *Multinationals and the National Interest: Playing by Different Rules*, OTA-ITE-569 (Washington, DC: U.S. Government Printing Office, September 1993).

municipal wastewater treatment capital expenditure is for construction, as is about three-quarters of public water supply treatment capital spending.[12] In developing countries, where labor is often cheap and capital in short supply, such projects may be more labor-intensive than in more industrialized countries. This, in turn, may limit ancillary exports of construction machinery associated with environmental infrastructure development. Much environmental spending is for day-to-day operation of water and wastewater utilities and refuse collection and disposal. These jobs, too, are staffed locally.

Thus, international trade is centered on relatively sophisticated manufactured goods, engineering and project management services, and technology licenses. The most significant opportunities for growth in U.S. EGS exports probably lie in these areas. While export related growth in the number of jobs in such areas will probably be modest, many of these jobs are likely to be high-wage jobs in management, engineering and other technical professions, as well as some manufacturing jobs.

While most environmental technologies are well-established, a small high-technology sector does exist. The technological trajectories for new approaches such as bioremediation and advanced biological treatment,[13] supercritical fluid extraction and oxidation, new and improved catalysts, and advanced monitoring technology, among others, are hard to discern.

Over time, the environmental technology landscape may shift considerably toward pollution prevention and cleaner production. Business opportunities may expand for producers of cleaner technologies that prevent pollution, supplanting some demand for end-of-pipe pollution control, waste disposal, and remedial clean-up in advanced industrialized countries (see box 3-B for an example). Also, fast growth in industrial production and infrastructure in many developing and newly industrialized countries and reconstruction in Central and Eastern Europe open up opportunities for firms able to integrate cleaner and more efficient processes and equipment into new and replacement capital stock. Designers and equippers of cleaner power plants, chemical works, pulp and paper mills, smelting operations, steel mills, oil refineries, assembly plants, and other industrial facilities can position themselves to benefit from the growing interest in sustainable development.

FACTORS AFFECTING COMPETITIVENESS

The competitiveness of a country's environmental firms is determined by a variety of factors. Some factors are fairly specific to environmental businesses, including domestic environmental regulations and the use of development assistance to promote environmental goals. Other factors are shared with other industries, including cost of capital, export promotion policies, workforce skills, industrial structure, and strength of industry associations.

The U.S. environmental industry enjoys a variety of strengths and suffers from a number of weaknesses that affect its performance in the global marketplace. Emerging threats and opportunities will determine its performance in the future. Table 1-1 in chapter 1 presented a short list of major strengths, weaknesses, opportunities, and threats for the U.S. environmental industry. Several factors impinging on U.S. and foreign

12 William T. Lorenz & Co., *1992 Update—Water Pollution Control Industry Outlook* (Concord, NH: William T. Lorenz & Co., April 1992), pp. 244, 287.

13 See U.S. Congress, Office of Technology Assessment, *Biotechnology in a Global Economy*, OTA-BA-494 (Washington, DC: Government Printing Office, October 1991) ch. 8 for an analysis of environmental applications of biotechnology.

environmental industry competitiveness specifically are discussed below.[14]

Strength of Domestic Regulations

Countries with the strongest regulations and enforcement—which can include environmental liability, reporting requirements, and environmental fees-create markets for new and improved types of EGS. Domestic environmental firms can be in a better position than foreign firms to develop products and services to help domestic industries comply with environmental requirements. If comparable regulations are later adopted in other countries, these companies may be favorably positioned to export to the new markets.

The strength of the United States, Germany, and Japan in environmental technologies-along with the disproportionately strong position of several smaller countries, including the Scandinavian nations, the Netherlands, and Switzerland—supports the thesis that countries with the strongest domestic requirements are the most competitive providers of EGS. The relative growth in strength of Japanese and German firms in (sulfur dioxide (SO_2) and nitrogen oxides (NO_x) control technologies during the 1980s, when their domestic standards became stronger than U.S. requirements, as well as the relatively strong position of American hazardous waste remediation technologies, further supports this point.

But the situation is complex. The strong performance of recently privatized British and French water and wastewater treatment fins, despite tighter environmental requirements elsewhere in Europe and in the United States, is one example. In the automobile catalyst business, two of the largest companies are U.S. fins, as might be expected because the United States has the largest market and, with Japan, the strictest standards. But the single largest firm is headquartered in the United Kingdom, despite a history of much weaker requirements in Britain and Europe. And Japanese firms have smaller market shares despite Japan's strict vehicle emissions standards.

Form of Domestic Regulations

Two countries with the same numerical emissions or effluent standards for a given pollutant may still provide different incentives for companies to develop and market innovative environmental technologies.[15,16] Technology approval and permitting procedures, if lengthy and expensive, can be burdensome to developers seeking to bring new technologies to market. Some American environmental technology developers claim to have gone abroad because of difficulties in obtaining proper permits to continue R&D in the United States (see box 5-A).[17] Uncertainty in permitting innovative technologies may dissuade venture capitalists and other investors from funding environmental technologies in the vital stage between the laboratory and proven commercial application.[18]

Technology-based standards that mandate or favor the use of specific technologies or ap-

14 For discussion of broader factors affecting competitiveness, see U.S. Congress, Office of Technology Assessment Op. cit., footnote 11, and U.S. Congress, Office of Technology Assessment, *Competing Economies: America, Europe, and the Pacific Rim,* OTA-ITE-499 (Washington, DC: *U.S.* Government Printing Office, October 1991).

15 Two reports of the National Advisory Council for Environmental Policy and Technology (NACEPT), an advisory group to EPA, examine the effect of U.S. permitting and compliance policy on environmental technology and innovation: U.S. EPA, "Permitting and Compliance Policy: Barriers to U.S. Environmental Technology Diffusion," EPA 101/N-91/001, January 1991; and U.S. EPA, "Transforming Environmental Permitting and Compliance Policies To Promote Pollution Prevention: Removing Barriers and Providing Incentives To Foster Technology Innovation, Economic Productivity, and Environmental Protection" April 1993.

16 Another OTA assessment is examining characteristics and implementation issues of alternative environmental regulatory approaches.

17 Grant Ferrier, president, Environmental Business International, Inc. and Editor-in-Chief, Environmental Business Journal, testimony at hearings before the House Merchant Marine and Fisheries Committee, Subcommittee on Environment and Natural Resources, Feb. 25, 1993.

18 Dag Syrrist, Technology Funding, testimony at hearings before the Senate Committee on Environment and Public Works May 21, 1993.

Box 5-A-Regulations and Environmental Technology Innovation

How to accommodate research, development, and demonstration of new technologies is an important issue in pollution control and waste treatment laws.[1] If permitting is too easy, enforcement loopholes could develop; if too strict, innovation could be dampened. This can impede the ability of regulated industries to install technology to lower compliance costs (see ch. 9) and diminish incentives for environmental companies to develop and commercialize new technologies in the United States. The U.S. Clean Air and Clean Water Acts have no testing permit provisions and rely on ad hoc administrative procedures that lack predictability. The RD&D permitting provision of the Resource Conservation and Recovery Act (RCRA) are little used. Firms complain that the procedures needed forgetting a permit are time consuming, inflexible, and costly. Commercialization of innovative technologies can also be made difficult by inflexible and costly procedures for demonstrating the efficacy and safety of new approaches.

Some U.S. innovators have taken environmental technologies abroad because of burdensome U.S. regulatory standards. One example is offered by a major company that is developing a vitrification technology that turns wastes into a stable glass.[2] An early use of t he technology is for hazardous fly ash, but it may be applicable to a wide variety of hazardous wastes. Under RCRA rules, any material derived from a hazardous waste is itself considered to be hazardous until the material is delisted following tests to show that it is non-hazardous. This provision is necessary to protect public health and the environment. However, delisting is a lengthy, expensive, and uncertain process often taking 2 to 3 years, or longer. EPA requires separate delisting procedures for each individual type of waste mixture vitrified rather than allowing delisting of a family of materials. Since waste streams often vary in composition, the separate delisting procedures for each mixture likely to be encountered during treatment places an expensive and time-consuming burden on technology innovators. In this company's case, further development of the technology was moved to Europe, where a subsidiary is working with a European firm in what they perceive to be a friendlier climate for hazardous waste treatment R&D. If the technology is successfully commercialized, the foreign partner will benefit from technological expertise and financial gains that might have stayed in the United States.

1 National Advisory Council For Environmental Policy and Technology, *Permitting and Compliance Policy: Barriers to U.S. Environment/ Technology Innovation,* U.S. EPA, EPA 101/N-91/001, January 1991.

2 This paragraph based on discussions with a senior company representative on May 4 and 19, 1993.

preaches for pollution control can have mixed effects on environmental industry competitiveness. For instance, many environmental regulations in the United States, Germany, and Japan are based on best available technology (BAT) or similar criteria. BAT-type standards can guarantee a large market in a short time to vendors of favored technologies and help environmental equipment manufacturers achieve economy-of-scale benefits. However, such standards, if not frequently updated, can freeze existing environmental technologies and discourage innovation. Performance-based standards that do not favor particular types of hardware can allow environmental technology innovation-although even here permitting procedures and administration may still favor a particular reference technology. Also, as in the case of technology-based standards, if performance-based standards are not regularly updated, incentives for innovation may weaken.

Environmental taxes or fees may provide incentives for performance better than standards require and for technical innovation. So might tradable emissions or effluent permits that allow polluters to trade pollution rights. The likely extent of their impact on innovation is difficult to predict. While these approaches might provide incentives for technological innovation, they may also diminish the possibility of large uniform markets for new environmental products and services. Lack of experience with these new regulatory approaches means that empirical data on their efficacy and their effects on innovation are limited. However, they do allow more cost-effective achievement of environmental goals as compared to other regulatory approaches.

The division of environmental standard-setting and enforcement authority among national, regional, and local authorities can affect innovation in environmental technologies and the ability of environmental firms to achieve scale economies. The U.S. federal system places major responsibility on States for administering environmental requirements. The ability of States to sanction flexible regulatory approaches and, in some cases, to impose stronger-than-Federal standards may spur environmental innovation. German states and Japanese prefectures can sometimes require adherence to higher-than-national standards. However, varied standards and permitting procedures fragment the environmental market and can slow the development and diffusion of new environmental technologies.

Fiscal and Other Incentives

The stick of environmental regulation can be supplemented with the carrot of subsidy or other kinds of incentives. To help regulated industries comply with environmental requirements, some countries and states provide tax credits, accelerated depreciation, or low-cost loans for the installation of environmental equipment. (These mechanisms, widely used in Japan, Germany, and the Netherlands, are discussed in ch. 7.) Such incentives can help secure markets for the developers and vendors of environmental technologies. Sometimes they promote innovation. For instance, the Netherlands has a tax-incentive regime (accelerated depreciation) that applies to early installers of listed innovative environmental technologies (both pollution prevention and end-of-pipe controls). As such equipment becomes commercially established, the technology is supposed to be removed from the list. (It is too early to evaluate this approach.)

Incentives can help jump-start industries. In the United States, Federal and State tax credits, combined with high energy prices, stimulated an alternative energy industry in the 1970s. Germany and Japan employ subsidies to build markets for clean energy technologies.[19] The U.S. Public Utility Regulatory Policy Act helped create a market for electric power co-generators. The United States has also pioneered demand side management (DSM) for promoting electricity-use efficiency. State utility commissions, in some cases, allow utilities to make a profit on energy saved. Some utility commissions' costing procedures penalize more polluting energy sources and reward selection of cleaner energy. DSM has stimulated the creation of energy service companies that earn money through improving the energy efficiency of clients.

Another innovative approach is the use of bounties for early developers of technologies that meet new environmentally superior standards. A consortium of 24 electric utility companies, in cooperation with the Electric Power Research Institute, EPA, and Department of Energy (DOE) recently ran a contest in which a refrigerator manufacturer that met future Federal energy efficiency standards and other performance criteria without use of CFCs won $30 million.[20]

19 For example, Japan's Ministry of International Trade and Industry (MITI) has budgeted nearly $40 million for fiscal year 1994 to subsidize two-thirds of the cost of residential photovoltaic systems. MI'IT's goal is 70,000 systems installed by 2000. *Nihon Keizai Shimbun*, Aug. 22, 1993.

20 John Holusha, "whirlpool Takes Top Prize in Redesigning Refrigerator, " New *York Times,* June *30, 1993,* p. D4.

As discussed in the previous section, environmental taxes and tradable pollution allowances might, as supplements to conventional environmental regulations, influence sales and development of environmental technologies.

Firm Size and Financial Strength

Most environmental companies in the United States (roughly 34,000, not including water utilities) and Europe (10,000 or more fins) are small to medium-sized enterprises (SMEs).[21] Some SMEs that offer innovative technologies or services successfully enter foreign markets, often through licensing or joint venture arrangements. However, large, well-capitalized companies have significant advantages in marketing abroad. They can spend significant time and effort investigating foreign markets. They can buy local market access by acquiring local companies or taking large equity stakes in joint ventures. They can afford to conduct R&D (although they might actually do little) or acquire innovations from others. These companies also have better access to capital than smaller fins.

Larger firms can supply customers and clients with integrated services or one-stop shopping. U.S. companies such as WMX Technologies (formerly Waste Management, Inc.) and Air & Water Technologies are attempting to develop such capability. Others offer environmental products and services complementary to core businesses. For example, a number of major international producers of boilers and power generation equipment also sell air pollution abatement equipment. Various engineering and construction firms design and install environmental equipment as part of their general design and construction businesses. Other large environmental companies are divisions of strong multinational conglomerates such as Asea Brown Boveri (ABB), General Electric, Metallgesellschaft, Hitachi, Mitsubishi, and Kawasaki, among others.

Promotion of Techniques and Standards

The respect accorded abroad to domestic standards and technological solutions can contribute to competitive position. The United States is widely regarded as a leader in many categories of environmental technology. EPA is widely respected abroad, and some U.S. professional society standards and guidelines, such as those of the American Water Works Association and the Water Environment Federation, are observed abroad. American firms sometimes contend that EPA's inability or unwillingness to certify their products as meeting U.S. standards leaves them at a disadvantage compared to some foreign firms that claim certifications from their governments. As is discussed in chapter 2, an expanded Federal role supporting demonstration and independent evaluation of American environmental technologies is under consideration. If undertaken, such programs could disseminate objective performance and cost evaluations of U.S. products but avoid potential problems (and, perhaps, loss of credibility) from government endorsement of particular technologies and companies.

Countries sometimes pattern their environmental regulations after those of another country whose environmental firms may thus derive an advantage over rivals that meet somewhat different home country standards. Training programs, technical assistance, and grants and loans for equipment might influence the standards and

21 *Environmental* **Business** *Journal,* **vol. 5, No. 4, April 1992;** ECOTEC **Research and** Consulting, **"The European Pollution Control and Waste Management Market: An Overview,' Birmingham, UK, January 1992. Studies of Japanese environmental industry structure have not been found, The Conference for Promotion of High Technology Pollution Control Equipment, an affiliate of the Japan Society of Industrial Machinery Manufacturers, listed 130 engineering and manufacturing enterprises as members in 1990. Members, including divisions of Japanese conglomerates and affiliates of foreign firms, are certified as being capable of producing EGS that meets Japanese environmental standards,**

practices employed by the recipient country. The United States and other countries have technical assistance and training programs. Japan's funding of environmental research centers in several Asian countries, including the outfitting of Indonesia's central environmental reference laboratory,[22] could affect these countries' environmental standards and practices.

Export Awareness and Support

The very large U.S. domestic environmental market supports a strong U.S. environmental industry, yet it also dampens the desire of many U.S. firms to pursue export markets and attracts foreign environmental fins.

U.S. companies interested in exports frequently face difficulties accessing private finance or Federal assistance. Some companies that win export orders do not cultivate long-term relationships with foreign customers or find partners able to provide service in export markets—thus hurting future export prospects. Export awareness and support in the environmental sector is discussed extensively in chapter 6.

Environmental exports are sometimes impeded by tariff and nontariff trade barriers. Promotion of liberalized trade in the context of the General Agreement on Tariffs and Trade (GATT), the North American Free Trade Agreement (NAFTA), and other trade negotiations may diminish such barriers.

Financing

Project financing is a large factor in the ability of environmental firms to obtain contracts, particularly in cash-strapped developing countries and the restructuring nations of Central and Eastern Europe and the former Soviet Union. The attractiveness of financial packages is often more important than the technological credentials of competing environmental companies. Loan aid or mixed credits from Japan and several European countries is often perceived to be linked to commercial benefits for home country fins. U.S. bilateral assistance places less emphasis on capital projects likely to generate equipment exports than does European and Japanese development assistance. The use of tied aid and mixed credits is a contentious issue discussed in the OTA background paper *Development Assistance, Export Promotion, and Environmental Technology.*[23] The use of official financing sources to win business for a donor country firm in a developing or restructuring country can have long-term competitive implications that go beyond the scope of a specific project. Projects can generate continuing business for spare parts and supplies. Early entrance into an emerging market can establish familiarity and brand loyalty that in turn yield future business.

Appropriate Technologies, Products, and Service

Customers in developing countries often cannot afford technologies designed to meet the more rigorous environmental requirements of the United States, Japan, and Northern Europe. Even if they can afford state-of-the-art technologies, they may lack the financial resources and trained personnel needed for adequate operations and maintenance. Cheaper, more easily maintained technologies can be environmentally preferable to complex technology that is unused or falls into disrepair due to poor operation and maintenance.

Customers in some developing countries admire U.S. environmental technology but regard it as too expensive and complex, a problem that also faces Japanese, German, and other industrial country competitors. Japan has begun a program to adapt flue gas desulfurization technologies for

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22 BAPEDAL (Indonesian Environment Agency) Briefing to U.S. Environmental Technology and Business Mission Participants, Jakarta, Oct. 26, 1992.

23 U.S. Congress, Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology,* OTA-BP-ITE-107 (Washington, DC: Government Printing Office, August 1993).

developing Asian markets.[24] Some technologies available or under development in the United States—for instance, engineered wetland wastewater treatment-are relatively low-cost. Of great potential are pollution prevention and cleaner production technologies that often offer more cost-effective avoidance of environmental damage than do conventional pollution controls. Energy-efficiency improvements-both supply and use-could limit environmental impact, save money, and promote development in less-developed countries.[25] Relatively low-cost options are also available for reduction of wastes and for decreasing use of toxic substances.

However, a tension may develop between sale and transfer of low-cost environmental technologies to developing and restructuring countries, and the desire to increase export income through the sale of more expensive technologies that can also generate more sales of parts, supplies, and service.

Research, Development, and Demonstration

New environmental technologies, whether related to cleaner production, end-of-pipe controls, or remediation, are products of research and development (more thoroughly discussed in ch. 10). A country's private sector, university, and government R&D system can contribute to its environmental industry's competitiveness. The R&D endeavor, however, extends beyond the laboratory bench and the pilot plant to the demonstration and testing needed to convince potential customers of the economy and efficacy of new technologies. And attention to manufacturing technology is important for achieving continuous improvements in product quality and price. As made clear in the recent past, with consumer electronics, automobiles, memory chips, and many capital goods, possession of the most able scientific research establishment does not ensure commercial predominance.[26]

Germany and Japan are this country's principal rivals in environmental technology R&D and related energy technology research. Japanese environmental technology is chiefly under the direction of the Ministry of International Trade and Industry (MITI). German environmental technology R&D is mainly under the Federal Ministry for Research & Technology and its state equivalents. Both Germany and Japan have a history of industrial policies that feature public-private coordination and research consortia. These approaches are less extensively used in the United States.

The U.S. Government provides more than $1.7 billion per year for R&D related to the environmental technologies covered in this report, but this support is scattered and uncoordinated.[27] American public-private partnerships have increased, however. For example, several cost-shared Department of Energy programs support development and commercialization of environmentally pertinent energy technologies and less wasteful industrial processes. EPA evaluates and disseminates information on innovative contaminated site remediation technologies; somewhat smaller programs fund evaluations of municipal solid waste and industrial waste reduction tech-

~ *International Environment Reporter,* "Japan To Work With China in Developing Cheap Desulfurization Units for Plants, " July 29, 1992, p. 497.

25 U.S. Congress, Office of Technology Assessment *Fueling Development: Energy Technologies for Developing Countries,* OTA-B516 (Washington DC: U.S. Government Printing Office, April 1992), pp. 5-12.

26 U.S. Con gress, Office of Technology Assessment, *Making Things Better: Competing in Manufacturing,* OTA-ITE-443 (Washington, DC: U.S. Government Printing Office, February 1990) provides an analysis of manufacturing competitiveness.

27 The Congressional Research Service concluded that Federal environmental technology R&D support amounts to $2.5 to $3 billion annually, but this includes support for areas not addressed in this assessment such as agricultural technology, technology for assessing toxicological and other health effects, and modeling and monitoring of ecological and geophysical processes. U.S. Congress, Congressional Research Service, "The Current State of Federal R&D: Environmental Technologies, 92-675 SPR, Aug. 25, 1992.

nologies. Other examples are discussed in chapter 10. However, R&D consortia among environmental fins, regulated industries, and government to address widespread environmental problems by industrial sector remain uncommon in the United States.

SECTOR DESCRIPTIONS AND ANALYSES

These are only a few of the factors that affect the competitiveness of the American environmental industry. As is shown in the brief case studies that follow, these factors weigh differently on different EGS sectors and technologies. Some of the cases pertain to environmental technologies that are capital-intensive, while others are not. Some technologies are new and changing rapidly, while others are mature. In each case, the role of tough regulations, technological sophistication of companies, and access to capital will have varying effects on firms in the industry. It is often difficult to say which countries' industries are ahead.

Design and Construction Services[28]

Such environmental projects as wastewater infrastructure, waste treatment facilities, and large air pollution abatement installations require substantial design and construction management. A large international business exists to provide such design and construction services.

Engineering firms are not only important for designing discrete add-on pollution controls and waste disposal facilities. The engineering consulting industry also could play a key role in incorporation of pollution prevention and cleaner production into whole plant design and process engineering (see box l-B). Although explicit waste minimization and pollution prevention activities now make up less than 5 percent of U.S. environmental engineering consulting business, this segment is likely to grow quickly .29 Cleaner production may increasingly be integrated into engineering design such that the proportion of design activities attributable to environmental concerns becomes more difficult to identify.

American companies are strong competitors in providing design services. This can have ramifications for U.S. manufacturers, as they may have a better chance of winning orders for American-designed facilities than for foreign-designed projects. This may not be because of any explicit preference for American goods by U.S. designers so much as their greater familiarity with those goods.

U.S. design firms are internationally prominent in environment-related projects; a long list of companies are involved.[30] Some of these companies provide a wide range of architecture and engineering services. Others specialize in environmental projects such as wastewater system design.[31] Subsidiaries of other environmental firms such as Metcalf & Eddy (part of Air & Water Technologies), Wheelabrator, and Rust International (both part of WMX Technologies) also perform international engineering services. There are overlaps between the design and contracting categories, as some construction firms also provide engineering services.

As for construction contractors, U.S. firms (including a U.S.-based ABB subsidiary) are the

28 This section does not discuss engineering design conducted by manufacturing industries for their product and process development. National Research Council, *Improving Engineering Design : Designing for Competitive Advantage* (Washington DC: National Academy Press, 1991) assesses the state of engineering design in U.S. manufacturing industry. U.S. Congress, Office of Technology Assessment, *Green Products by Design: Choices for a Cleaner Environment,* OTA-E-541 (Washington, DC: U.S. Government Printing Office, September 1992) discusses environmental aspects of product design.

29 "E/C Firms Position for Prevention," *Environmental Business Journal, vol. 6, No. 8,* August 1993, p. 1.

30 *Environmental Business Journal,* vol. 6, No. 4, April 1993.

31 Even more specialized engineering design is provided by some vendors of proprietary air pollution control and wastewater treatment technology. In some cases, technology vendors have no in-house manufacturing at all; their products are engineering and intellectual property.

Table 5-4-Largest Winners of International Contracts in Selected Market Sectors

	Sewer/waste	*Hazardous waste*
1.	Bouygues (France)	Parsons Corp. (U. S.)
2.	Parsons Corp. (U. S.)	Bechtel Group (U. S.)
3.	Mitsubishi Heavy Industries (Japan)	ABB Lummus Crest (U. S.)
4.	Bilfinger+Berger Bauaktieng.(Ger)	Bouygues (France)
5.	Foster Wheeler (U. S.)	Foster Wheeler (U. S.)
6.	NCC Internation (Sweden)	The Badger Co. (U. S.)
7.	Consolidated Contractors (Greece)	CEGELEC (France)
8.	Kajima (Japan)	Jacobs Engineering Group (U. S.)
9.	Skanska International Civil Engineering (Sweden)	Bilfinger+Berger Bauaktieng. (Ger.)
10.	The Badger Co. (U. S.)	Spie Batignolles (Italy)
	Water	*Power*
1.	DUMEZ (France)	CRSS (U. S.)
2.	Bechtel Group (U. S.)	Mitsubishi Heavy Industries (Japan)
3.	Fiatimpresit (Italy)	Spie Batignolles (Italy)
4.	SGE Group (France)	Bechtel Group (U. S.)
5.	Impresit-Girola-Lodigiani IMPREGLIO (Italy)	DUMEZ (France)
6.	Bouygues (France)	ABB SAE Sadelmi (Italy)
7.	Hochtief (Germany)	Guy F. Atkinson (U. S.)
8.	Girola (Italy)	John Brown/Davy (U. K.)
9.	GTM-Entrepose (France)	CEGELEC (France)
10.	Morrison Knudsen (U. S.)	Ansaldo (Italy)

SOURCE: *Engineering News Record*, Aug. 24, 1992, p. 37.

eight largest winners of international contracts.[32] In four categories relevant to environmental infrastructure, several U.S. firms are among the top 10 winners of contracts (see table 5-4). U.S. firms also appear in the top 10 four and eight times, respectively, in the manufacturing and industrial/petroleum markets.[33] French, British, Italian, German, and Japanese contractors are the largest rivals. Swedish and Greek firms also appear on these listings.

Beyond the top 10 listing, there are many other U.S. construction companies with significant international presence engaged in environmental projects or projects with major environmental components. 34

Among the more important issues affecting the competitiveness of firms in this industry is the availability of financing. This is particularly important for projects in developing countries and the cash-poor nations of Central and Eastern Europe and the former Soviet Union. Bilateral development assistance and loans from the World Bank and other multilateral lending institutions are important sources of funds in these markets. As has been mentioned, significant controversy surrounds the use of tied aid and mixed credits as means for countries to link development assistance to sales by home country businesses. These issues are discussed extensively in the previously cited OTA background paper, *Development As-*

32 "The Top International contractors," *Engineering News Record*, **Aug. 24, 1992, p. 38.**

33 **"Firms Set Sail For Hot Markets,'** *Engineering News Record*, **Aug. 24,** 1992, **p. 37,**

34 Environmental Business *Journal*, vol. **5, No. 4, April 1992, p. 3;** *Engineering News Record, Aug.* 24, 1992, **PP. 38-45.**

sistance, Export Promotion, and Environmental Technology .35

Some in the engineering industry point to the U.S. Trade and Development Agency (TDA) support for project feasibility studies as being particularly useful in their pursuit of opportunities abroad. Other countries also recognize the value of feasibility and prefeasibility studies—which can help determine which firms win bids for project development, Japan allocated $226 million for this function in 1992, while TDA's fiscal year 1993 budget was $40 million.[36] The United States and other countries have created special funds attached to the World Bank for feasibility studies that some believe help win World Bank contracts for contributing nation fins. Use of feasibility studies is further discussed in chapter 6.

Stationary Source Air Pollution Control

This sector of the environmental industry includes designers and manufacturers of devices to control air emissions from power plants, incinerators, and industrial facilities. American companies remain competitive but are struggling against very strong air quality industries that have developed abroad. In addition, foreign companies, directly and through licensing, have made significant inroads into the U.S. domestic market. Air pollution control technologies-particularly sulfur and nitrogen oxide controls-illustrate how the competitiveness of different countries' environmental firms can be affected by differences in regulations.

The timing and stringency of air regulations in the three major air pollution control markets-the United States, Japan, and Germany-have determined the sequence of air pollution control technology development. In the mid-1970s, U.S. regulations to control sulfur dioxide (SO_2) created a market for flue gas desulfurization (FGD) scrubbers. Soon, however, the domestic market for scrubbers stagnated, as most existing industrial and utility sources of SO_2 were shielded from the need to retrofit with FGD and new powerplant construction slowed from weak electricity demand growth.

Although early FGD had cost and reliability problems, the approach was adopted abroad. Japan embarked on a strong program of FGD installation and retrofit in the 1970s and 1980s. This was followed in Germany in the mid-1980s by requirements ensuring that virtually all major sources of SO_2 in former West Germany would be outfitted with FGD within the decade. German standards (called TA Luft) for SO_2 and other air pollutants are periodically updated to reflect new state-of-the-art control technologies. They are models for air regulation in Switzerland, Denmark, Italy, and the Netherlands.[37]

The FGD market is again growing in the United States as the 1990 Clean Air Act Amendments are implemented. FGD accounts for about 32 percent of U.S. stationary source air pollution control equipment revenues in 1992, about $1.7 billion.[38] The law requires that SO_2 emissions in 2000 be half of what they were in 1980. According to an analysis for EPA, a cumulative revenue increase of $1.6 to $4.8 billion will accrue to SO_2 control equipment suppliers over the years 1992-2000 because of the Amendments.[39] However, the estimate is sensitive to a number of assumptions

35 U.S. Congress, Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology, op. cit.,* footnote *23.*

36 ibid., p. 43.

37 *International Environ merit Reporter,* "New National Guidelines Available for Setting Emissions Limits for Industry," July 15, 1992, pp. 466-467.

38 Environmental Business International, 1993 Survey of APC Equipment Manufacturers, San Diego, CA.

39 ICF Resources, Inc. and smith Barney, Harris Upham and Co., Inc., *Business Opportunities of the New Clean Air Act: The Impact of the CAAA of 1990 on the Air Pollution Control Industry* (Washington, DC: ICF Resources, Inc., August 1992), p. III-38.

about the cost of control, the use of low sulfur coal, and other factors. Continued sluggishness of the economy may slow the rate of investment in FGD by utilities and industrial polluters.

In 1993, American companies continue to produce their own proprietary FGD technologies but no longer dominate the global market. German, Scandinavian, and Japanese suppliers aggressively compete with U.S. providers internationally, including growing Asian and Central and Eastern European markets. They are also advancing into the U.S. market. While the largest and third largest FGD suppliers to the U.S. market, Babcock and Wilcox and General Electric, are U.S.-based and use U.S. technology, the Swedish-Swiss conglomerate ABB is the second largest supplier.[40] ABB combines the assets of Flakt, a Swedish air pollution control subsidiary, with Combustion Engineering, a major U.S. supplier of FGD and other air pollution controls, which it purchased. Numerous other U.S. suppliers license FGD technology from Japanese and European firms, and there is a U.S.-Japanese joint venture marketing Japanese-developed FGD technology. Innovative foreign-developed FGD technologies are being demonstrated in DOE's Clean Coal Technology Program and, in one case, was installed in Poland via a U.S. licensee with Federal support.[41,42,43] Foreign technologies licensed by U.S. firms can yield income and jobs in the United States. For instance, Joy Technologies (U. S.) won a contract worth over $100 million to install four FGD units in Taiwan.[44] The technology, which Joy has also sold in Canada, was developed by a German firm.[45]

Control of nitrogen oxides (NO_x), a precursor of smog and acid rain, from stationary sources did not receive major attention from U.S. regulators in the 1970s and 1980s. Thus, markets for selective catalytic reduction (SCR)---a U.S. invented technology-and other NO_x control technologies did not materialize in the United States. Instead, the frost commercial market for SCR materialized in Japan. Japan claims to operate over three-quarters of the world's stack gas denitrification and desulfurization facilities.[46] Germany is the second largest market for SCR as that country's power plants and industrial boilers retrofit NO_x controls. As with SO_2 controls, the 1990 Clean Air Act Amendments are spurring U.S. markets. California air quality requirements are an additional impetus. Some of the earliest U.S. installations of SCR are in California, although the current national NO_x control market only accounts for 2 percent of 1992 U.S. stationary source air pollution equipment revenues (on the order of $100 million).[47]

Japan is the dominant provider of SCR technology. Several Japanese conglomerates, including Kawasaki, Mitsubishi, Hitachi, and Ishikawajima Harima, license SCR to U.S. and European air pollution control companies.[48] There are also a number of joint ventures between U.S. and Japanese fins. However, SCR is one of the more expensive NO_x control options available. U.S. companies have been developing Selective Non-Catalytic Reduction (SNCR) and other technolo-

[40] The McIlvaine Co., "A is Pollution Management: Utility Air Pollution Awards Scorecard," No. 116, November 1992.

[41] Daniel Kaplan, ''Georgia Power Begins Tests On Innovative Fiberglass Scrubber," *Energy Daily, Nov. 9, 1992,* p. 4.

[42] Daniel Kaplan, ''TVA, DOE Test promising Scrubber Alternative," *Energy Daily,* Oct. 28, 1992.

43 Daniel Kaplan, ''DOE, Poland Asks Industry for CCT Help,' *Energy Daily*, Sept. 22, 1992, pp. 1-2.

44 *Waste Tech News*, vol. 5, No. 4, Jan, 25, 1993, p. 9.

45 *Waste Tech News*, vol. 4, No. 15, July 13, 1992, p. *9.*

46 " World's Emission Purification Techniques," Coal Technical Research Institute, in Ministry of Foreign Affairs, 'Japan's Environmental Endeavors," April 1992, p. 10.

47 Environmental Business International, 1993 Survey of APC Equipment Manufacturers, San Diego, CA.

48 *panorama of EC Industry*, "The Environmental Services Industry, " p. 139.

gies that are less effective but also less expensive than SCR. Combustion modifications, such as low-NO_x burners, are the lowest cost control options. While Japanese dominance of SCR is a concern, particularly as North America and Europe try to clean up their smoggiest regions, U.S. providers may be at par or ahead on a number of lower cost control technologies that may garner a large proportion of the NO_x control market in areas not requiring as strict measures.

The competitive situation in some other air pollution control sectors is less clear. Particulate control, often using fabric filters and electrostatic precipitators, is a relatively mature technological sector in which U.S. companies remain active and successful sellers abroad. In the United States, particulate controls constitute 55 percent of stationary source air pollution control equipment revenues.[49] In most other countries that proportion would be higher because fewer controls are needed on other types of emissions.

In contrast to particulate controls, control of VOCs and toxic air pollutants is relatively new and the market is immature. U.S. and German regulations are more stringent than Japanese requirements for these pollutants; California's regulations may be the strictest. Activated carbon adsorption, incineration, and catalyst-based systems for VOC control are available in the United States and Europe from major vendors. Calgon Carbon (U. S.) and Lurgi (Germany) are among major suppliers of activated carbon systems. Biofilters for VOC and odor control are very new approaches under investigation in Germany, the Netherlands, and the United States.

Licensing, joint venture, and multinational operations make assessment of competitiveness and national economic benefits difficult. The snapshot of growing U.S. use of foreign technologies should be understood in the context of growing technological interdependence. German and Japanese companies license environmental technologies to each other as well as to U.S. firms. American companies do sell air pollution control technology in the home markets of major competitors and derive benefits from ownership of subsidiaries in those markets. It is difficult to generalize about the economic implications of foreign ownership of American air pollution control firms. The American subsidiary may be limited by the parent in its export opportunities, or conversely, the parent company might open new export markets for its U.S. subsidiary. Employment implications of licensing and joint ventures in air pollution control maybe relatively modest—most FGD and other large pollution abatement projects involve large amounts of local fabrication and construction that do not involve much international trade. However, profits, royalties, and income from engineering design work conducted in the home market can be substantial. Some air pollution control company executives suggest, as a rule-of-thumb, that perhaps 30 percent of expenditures for major installations are for internationally tradable engineering services and sophisticated components, while 70 percent is for local materials and assembly.[50]

Controlling air pollution from large power plants and other large facilities entails major expenditures. Hence, availability of financing is often an important determinant of successful sales to developing countries. Japan's MITI, through its Green Aid Plan, has targeted Asia for technical and financial assistance in air pollution control including FGD. The Plan will include adaptation of FGD to lower cost and removal efficiency levels appropriate for some countries.[51] MITI has also announced plans to lease air pollution control equipment to address acid rain problems. However, a number of American companies already

[49] Environmental Business International, 1993 Survey of APC Equipment Manufacturers, San Diego, CA.

[50] OTA staff discussions with air pollution control company executives.

[51] *International Environment Reporter*, "Japan to Work With China in Developing Cheap Desulfurition Units for Plants," July 29, 1992, p. 497.

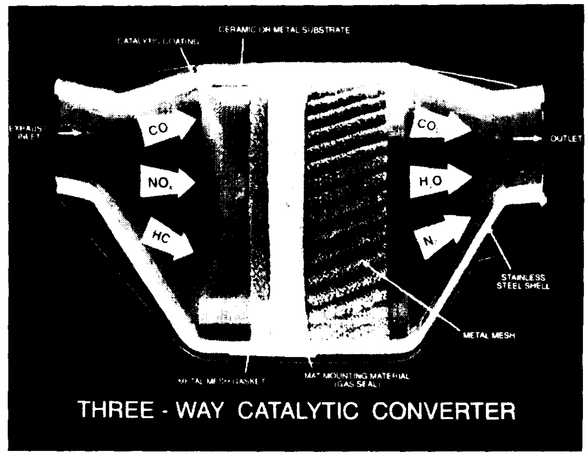
produce less expensive lower efficiency control technologies.

Competition in the air pollution control sector comes not only from rival producers of air pollution abatement products but also from alternative technology developers and vendors. In the stationary source area, cleaner production technologies, including low-NO_x burners, gas turbines, several clean coal technologies, and recovery and replacement of organic solvents in industrial processes, may limit or even obviate some types of air pollution control equipment. Some issues related to competitiveness in clean energy production are discussed in a subsequent case analysis.

Mobile Source Air Pollution Control

Estimates of the U.S. mobile source control market range from $6 billion to $8.2 billion.[52,53] The global vehicle emissions control market has been estimated as $12.5 billion and may grow to $29 billion by **2000.**[54] The market includes catalytic converters, diesel filters, inspection and maintenance equipment, evaporative emissions controls, and some engine controls. U.S. manufacturers are active exporters and also have subsidiaries and licensees abroad. U.S. members of the Manufacturers of Emission Controls Association reported that they sold $250 million of catalyst and filter technologies outside the United States and Canada in 1992; these firms projected such annual sales to reach $400 million by 2000 which could add 2,000 new jobs.[55]

The United States pioneered strong vehicle emissions controls. The introduction of the cata-



JOHNSON MATTHEY

First required by the United States in the 1970s, use of catalytic converters to control automotive emissions has become a worldwide business. The three-way catalytic converter shown here is used in a growing number of countries. Recent tightening of U.S. standards may require further developments in the technology.

lytic converter, removal of lead from gasoline (necessary for catalytic converter operation), and desulfurization of diesel fuel were undertaken in the 1970s in response to emissions standards of the 1970 Clean Air Act. Japan quickly adapted some of its requirements to meet U.S. standards, in part to qualify Japanese-made automobiles for export to the United States. Both countries required oxidation catalysts starting in model year 1975 and then, several years later, required more effective three-way catalysts.

It was not until the late 1980s that more than a handful of other countries required catalytic converter use.[56] By 1993, the European Community had adopted EC-wide catalytic conversion

52 Farkas **Berkowitz & CO., "The Fifth Annual State-of-the-Industry Report,' Washington** DC, 1993.

53 U.S. **Department of** Commerce **in** ICF Resources **and Smith Barney, Harris** Upham **and Company** Inc., *Business Opportunities of the New Clean Air Act: The Impact of the CAAA of 1990 on the Air Pollution Control Industry,* **op. cit., footnote** *39,* **p.** I-2.

54 Michael **P,** Walsh, ''Motor Vehicle **Pollution Control: The** Global Market—Summary, " Arlington, **VA, Oct. 5, 1993.**

55 Bruce Bertelsen, **"Clean Air Act Spurs Growth of U.S. Motor Vehicle Emission Control Industry,"** *Clean Air Technology News* **(published by the Institute of Clean Air Companies and Manufacturers of Emission Control Association) summer 1993, pp. 2-3.**

56 H&W Management **Science** Consultants, 'International Mobile Source Emissions Controls Market Study: Update **No. l," prepared for the Manufacturers of Emission Control** Association, **August 1990. Australia, Austria, Canada,** Denmark, **Norway,** Sweden, **and Switzerland adopted catalytic converters in the late** 1980s.

requirements, although delays were permitted for a number of member states, and larger cars had to meet an earlier 1989 deadline. Two NICs, Taiwan and South Korea, adopted these requirements by 1991. Mexico is phasing in catalytic converters and unleaded gasoline. Over the course of the 1990s a number of other countries in Central and Eastern Europe, Asia, and Latin America will likely adopt similar requirements. Diesel emissions controls using catalysts and particulate traps are also a growing market as the United States, EC, and other countries compel their use.

The most significant force for improving catalytic conversion technology is the set of California vehicle emissions regulations that will be phased in over the next two decades. While the ultimate goal of the California program is commercialization of zero emission vehicles—to account for 10 percent of in-state automobile sales by 2003—intermediate standards for low emitting, very low emitting, and ultra-low emitting vehicles might be met by improved catalytic converters used in conjunction with gasoline or alternative fuels. Several other States may follow suit with these requirements. California regulations and proposed Federal requirements are also driving catalytic converter development for small engines (e.g., lawn mowers, chain saws, snow blowers); limited application has already occurred in Europe.[57]

A handful of major producers dominate the global catalytic converter business. The largest supplier of catalysts is Johnson Matthey, a British firm with major U.S. operations, estimated to have a 27 to 28 percent market share.[58] Two American suppliers, Allied Signal and Engelhard, each garner about a fifth of the market with domestic and overseas plants. Degussa of Germany (which has an American plant) is estimated to have less than 10-percent share, with the remainder split among a number of Japanese and Taiwanese companies. W.R. Grace (U.S.), which supplies industrial catalysts, and other companies are trying to enter the market by developing devices that will meet future California requirements. The substrates on which catalysts lie—usually ceramic or stainless steel—are made by a number of U. S., Japanese, and European firms. Corning is a major producer of ceramic substrate with a plant in Germany and a license to a Japanese manufacturer. Several American companies including Donaldson Co., Corning, and 3M, and the Canadian firm Engine Control Systems are active in the diesel control markets.

American producers are strong competitors in the catalytic converter market and strict California standards may drive them to produce more effective catalysts that could become national and foreign standards. However, other automobile producing nations also have strong incentives to develop emissions control systems that will meet tightening U.S. Federal and State standards so that their exports qualify for the American market. Japanese, German, Swedish, and Canadian companies and governments have significant R&D programs for vehicles powered by alternative fuels, fuel cells, and electricity. Some foreign companies have been working on projects designed to address California's automotive requirements.[59] Some of these alternative vehicle technologies could eventually obviate emissions control technologies.

USCAR, a collaboration involving the U.S. Government, the Big Three U.S. automobile manufacturers (General Motors, Ford, and Chrysler), and component suppliers, is an important effort toward creating the clean car while revitalizing the U.S. automobile industry (see ch. 10). The Advanced Battery Consortium and a low-emissions vehicle initiative are components of USCAR.

57 Julie Edelson Halpert, "Cleaner Garden-Variety Engines," *New York Times*, Sept. 26, 1993, p. F1O.

58 Stephen Lipmann, "U.S. Environmental Companies' Competitive Strategies: Eleven Case Studies,' OTA contractor report, March 1993.

59 South Coast Air Quality Management District, Technology Advancement Office, 1992 Progress Report, July 1992.

U.S. companies' strength in this sector has benefited the United States through export earnings, license royalties, and profits. The employment benefits are less clear when catalytic converters are often imported into the United States already attached to the automobiles.

Water and Wastewater Treatment Technologies

The U.S. water and wastewater treatment market is relatively mature, yet in much of the world basic water sanitation is an acute need. The provision of drinking water and treatment of domestic and industrial effluents are not only prominent in the plans of less developed countries but are also important priorities for environmental investment in the rapidly industrializing countries of the Pacific Rim and Latin America. As discussed in chapter 4, multibillion dollar water and sewer projects are underway or planned in many of these countries. A high priority on water is evident in the environmental plans of Central and Eastern European countries. Even within the OECD countries, there is some room for improvement in the water and wastewater treatment sector. For instance, centralized sewage treatment is provided to only 44 percent of Japanese residents[60] versus 75 percent in the United States. A number of EC countries will need to make significant investments to meet EC water standards. And U.S. regulations continue to tighten.

OECD estimated the global market for water and wastewater treatment goods and related services at $60 billion in 1990.[61] Most spending related to water and wastewater projects is for locally provided construction labor, lower value materials, and operations. In the United States, about 75 percent of municipal water treatment and over 50 percent of municipal wastewater treatment capital expenditures are for construction; the remainder are for engineering and equipment.[62] Of the portion of water industry-related expenditures that is likely to be internationally traded, much will accrue to engineering and construction firms for design and construction management. However, there is significant commerce in equipment and supplies such as aerators, falters, pumps, flow meters, monitoring instruments, and chemicals for treatment systems. This section centers on competitiveness of suppliers of such goods and technologies. There is an overlap with the engineering/construction industry and water supply utilities-firms in both of these service sectors have major interests in equipment manufacturing fins. Also, because of site-specific conditions, engineering services are often integral to equipment sales.

U.S. drinking water and wastewater standards are among the world's most demanding; German, Dutch, French, and Scandinavian country standards are also high. Standards of U.S. professional associations, including the Water Environment Federation and American Water Works Association, are used abroad. And U.S. water technologies are respected abroad. The Water and Wastewater Equipment Manufacturers Association row), an industry association with about 70 member firms accounting for nearly $1 billion of annual sales, reports that the majority of its members sell abroad—mainly secondary and tertiary wastewater treatment equipment and disinfection systems.[63] U.S. companies, among them Nalco Chemical, Betz Laboratories, and

60 *Environment and Development: Japan's Experience and Achievement,* **Japan's National Report to the** United **Nations** Conference **on Environment and Development** (UNCED), **December 1991, pp. 32-33.**

61 OECD, **op. cit.,** footnote **4.**

62 William **T.** Lorenz **& Co., op. cit.,** footnote 12.

63 Dawn Kristof, President, Water and Wastewater Equipment Manufacturers Association, personal communication, **June 2, 1992.**

W.R. Grace, are major international providers of water treatment chemicals and services.[64]

Over the last decade Swiss, Swedish, French, and British companies have been active in acquiring U.S. water and wastewater equipment companies.[65] Of the 10 largest U.S. providers of treatment equipment, 5 are European-owned.[66] And while U.S. companies license technologies abroad, some observers believe that there is a net influx of foreign water and wastewater treatment technologies into the United States.[67] European firms also export directly into the U.S. market.

Despite good reputation and interest in exporting, a number of factors impede the U.S. water and wastewater equipment industry's competitiveness. The 70 members of WWEMA average under $15 million in annual sales and operate with low profit margins.[68] The estimated 2,400 or more other companies in the sector are yet smaller.[69] Low profit margins leave limited resources for R&D and for exploring foreign markets. In some regions, such as Southeast Asia, local environmental firms feel that the United States has been late in entering the market and that Japanese and European firms have the advantage of greater familiarity.[70] Some of these firms believe Japanese and European providers offer better after-sales service than U.S. suppliers. As in other environmental sectors, U.S. companies have difficulty competing in developing country markets against some foreign suppliers with superior access to confessional aid finance.

With multibillion dollar projects planned or underway in a number of developing countries (see ch. 4), aid can serve as a lever to shift business--both equipment supply and engineering/construction services-to a donor country's fins. The lever may be the formal or informal tying of aid to spending in the donor country or it may be training, technical assistance, and other support that makes recipients more familiar with-and more likely to choose-technologies and vendors from the donor country. Except for projects in Egypt ($2 billion over 14 years in the water sector),[71] recent U.S. development assistance has not emphasized large capital projects that can generate exports, unlike aid from Japan and several European countries.[72] Japan's reported commitment of $1 billion to a $4 billion, 10-year Brazilian clean-up of Rio de Janeiro's Guanabara Bay,[73] its funding of environmental centers in Indonesia and other Asian countries, and other forms Green Aid may yield commercial benefits to Japanese fins. The United States and European countries also consider potential commercial benefits of aid.

64 Rick Mullin, "Water Treatment Chemicals and Services," *Chemicalweek*, May 13, 1992, pp. 32-40; Michael Roberts, "Europe: New Laws, New Markets," *Chemicalweek*, *May 13, 1992*, pp. 46-47.

65 Dawn Kristoff, op cit., footnote 63.

66 "EBJ's Top Water/Wastewater Equipment Companies," *Environmental Business Journal, vol. 6, No. 3,* March 1993, p. 5. The listing does not include revenues from treatment chemicals, instruments, pipes, and valves.

67 "Water/Wastewater Markets Remain Diverse," *Environmental Business Journal,* vol. 6, No. 3, March 1993, pp. 1,3-5.

68 Dawn Kristoff, op. cit., footnote 63.

69 *Environmental Business Journal*, vol. 5, No. 4, April 1992, p. 7. Twenty-five publicly traded companies averaged $259.5 million in 1991 revenues and 2,500 privately held companies averaged $2.4 million.

70 Environmental Management and Research Association of Malaysia, Briefing for Participants of U.S. Environmental Technology & Business Mission, Kuala Lumpur, Malaysia, Oct. 30, 1992.

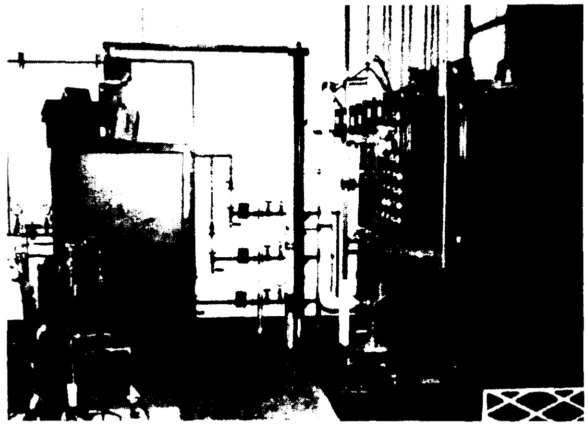
71 Project in Development and the Environment, *Profile of the Environmental Business Sector in Egypt* (Washington, DC: October 1992), p. 19.

72 U.S. Congress, Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology*, Op. cit., footnote 23.

73 U.S. AID, *Environmental Market Conditions and Business Opportunities in Key Latin American Countries*, Business Focus Series (Arlington, VA: October 1992), p. 50.

Judging form the limited data that is available from the U.S. Department of Commerce,[74] the performance of U.S. water and wastewater equipment exporters in emerging markets has been mixed. U.S. and Japanese firms each supply about a third of Taiwan's import market. U.S. suppliers provide the majority of Mexico's imported water and wastewater equipment but fare no better than German, Swedish, and British rivals in the Brazilian industrial wastewater market. The correlation between aid and exports can explain the strength of U.S. suppliers in Egypt, Japanese companies in China, and French firms in Tunisia; in each case the largest aid donor is the largest provider of imported water-related goods and services.

Among foreign competitors in the water and wastewater market, the French and recently privatized British water utilities have emerged as particularly important players. Compagnie Generale des Eaux-Dumez and Lyonnaise des Eaux from France, and several British companies (Severn Trent, Northwest Water, Wessex, and Thames Water among the largest) have utility operating experience and healthy financial positions. They offer customers integrated water industry services ranging from equipment to design to operations. Some of these companies also provide construction services. They have diversified into the waste disposal sector and have been active acquirers of companies in the United States and elsewhere. In contrast, it is difficult for the American water and wastewater industry to match the integrated services. The U.S. water and wastewater industry is more fragmented-most designers and contractors do not operate water facilities,[75] water and sewer utilities are usually local government entities or small private firms that only operate in a limited service area, and



U.S. DEPARTMENT OF ENERGY

Advanced water treatment technologies such as this ultraviolet/ozone disinfection unit are at an early stage of deployment.

equipment suppliers often lack operating experience.

Competition is very tough for American firms providing water and wastewater equipment, and continues to increase as newly industrialized and developing countries expand their environmental industries' capability for providing water-related equipment for their domestic markets and for export.

Advanced systems; Advanced water and wastewater systems may move toward alternatives to chlorine disinfection, such as ozonation and ultraviolet irradiation. New biological methods for sewage and industrial effluent treatment could find growing application. The use of polymer water treatment chemicals is increasing. Ion exchange for metals recovery and membrane-based systems (ultrafiltration and reverse osmosis) will likely find greater industrial uses for some add-on treatment and in-process waste minimization and water conservation. Organic contaminant destruction by incineration or other oxidative processes may expand as controls on VOCs and air toxics tighten. Engineered wetlands

74 Various industry sector analyses from the National Trade Data Bank, Department of Commerce country desk officers, and U.S. AID Business Focus Series reports are sources for market share data.

75 There are some exceptions. Some U.S. environmental firms, including Metcalf & Eddy (part of Air & Water Technologies) and Wheelabrator Technologies (affiliated with WMX Technologies) do operate a few facilities in addition to offering engineering services.

and similar nature-based aquatic treatment systems offer low-cost options for small communities in both industrialized and developing countries; however, the employment and income associated with export of the know-how to build such systems is likely to be quite modest.

Advanced water technologies may not be limited to markets in advanced industrialized countries. For instance, RMA Dornier, a subsidiary of Deutsche Aerospace, is introducing ion exchange in Malaysia as a cost-effective alternative to conventional treatment and disposal of metal-laden effluents from that country's growing electronics industry.[76] In another example, new bacterial degradation technology from Micro-Bac International (a Texas based firm) is used by a quarter of Brazil's chicken processing industry for wastewater treatment, as well as by a number of sewage systems; applications for individual buildings and households and for toxic wastes are under development.[77]

The competitive situation in advanced and alternative treatment approaches is hard to assess, for the market is at an early stage. Even in countries with the most stringent regulations, effluents are regulated using traditional indicators of water quality such as pH, turbidity, biological and chemical oxygen demand (BOD and COD), and total dissolved solids. Regulation of toxic chemicals is still evolving and markets are immature. U. S., German, and other European companies are competitive suppliers of ion exchange resins. Calgon Carbon and Nalco Chemical are among major U.S. suppliers of activated carbon systems for removal of many organic compounds from water and air. Lurgi, a major German competitor in air pollution control, is also a large supplier of activated carbon, providing systems in 50 countries.[78] Membrane systems, ultraviolet and ozone disinfection, ion exchange, real-time monitoring of effluents, engineered wetlands, and other newer developments are only in the early stages of use.

Solid and Hazardous Waste Industry

The waste sectors consist of service companies that collect, treat, recycle, and dispose of wastes, and firms that produce and market the equipment and technologies needed by waste service companies. Types of technologies and equipment used in the industry range from garbage trucks and balers to sorting machines for mixed recyclable to incineration technology and specialized treatment technologies for hazardous wastes.

Among service providers, the U.S. domestic solid waste industry has undergone significant consolidation over the last two decades, as many small local refuse collectors and landfill operators were acquired by large waste service companies. WMX Technologies (formerly Waste Management, Inc.) and Browning Ferris Industries (BFI) are the two biggest U.S. solid waste service fins. Laidlaw (Canada) and Attwoods (U.K.) have significant U.S. operations. Europe is also developing a more concentrated waste service industry, comprised of companies whose main business is waste handling and disposal and firms that are waste subsidiaries of major water (e.g., Compagnie Generale des Eaux, Lyonnaise des Eaux, and Severn Trent) and electric (e.g., RWE, the largest German electric utility) utilities.

WMX and BFI are part of the consolidation trend abroad. Out of WMX's $8.6 billion in total 1992 revenues, almost $1.7 billion arose from operations outside of the United States. WMX has waste services in 20 countries in Europe, Asia, and Latin America, including hazardous waste facilities in operation or under construction in the Netherlands, Hong Kong, Singapore, and Indonesia. The firm recently acquired a 90-percent

76 EnviroPro '92 Conference and Trade Show, Kuala Lumpur, Malaysia, Oct. 30, 1992.

77 International *Environment Reporter,* "U.S. Biotechnology Used to Treat Sewage, Industrial Waste in Brazil," Sept. 23, 1992, pp. 599-600.

78 Metallgesellschaft AG, 1990/91 Annual Report.

interest in Sweden's largest hazardous waste company.[79,80] BFI is the second largest American international waste service competitor, although its services are limited to nonhazardous wastes. It has operations in nine foreign countries and is pursuing additional international opportunities.[81] The large U.S. waste service companies bring to the international market their extensive experience in operating facilities and handling diverse wastes under strict U.S. regulations. Both WMX and BFI have significant financial strength and good access to capital. WMX is attempting to reorganize itself into an integrated environmental service company incorporating air, water, and waste services under one roof.

Another American waste service competitor of note is Safety-Kleen. It is the largest recoverer of used solvents and motor oil in the United States and believes itself to be the largest solvent recycler in the world.[82] Collected solvents and oils are recycled, rerefined, or burnt for energy in industrial furnaces. The company is also a major provider of parts cleaning equipment, particularly to the automotive repair industry. Safety-Kleen has brought its recovery services to several European countries and has several licensees in the Pacific Rim, including Japan. The company owns Germany's largest solvent recycler and biggest parts-cleaning service firm.[83]

Smaller hazardous and specialized waste-related companies in the United States have been entering foreign markets. U.S. companies may have the advantage of operating under tough toxic waste regulation for longer than foreign rivals. The Resource Conservation and Recovery Act of 1976 was the first comprehensive U.S. Federal law regulating hazardous wastes, The later passage of Superfund legislation further propelled the U.S. hazardous waste industry by making improper disposal of hazardous wastes a very expensive risk for companies. No other country imposes hazardous waste liability burdens as great as those under Superfund. Interestingly, growth of the hazardous waste industry may ultimately be limited by increasingly stringent hazardous waste standards. As the costs of disposal and liability grow, generators have increased incentives to practice pollution prevention through avoidance of toxic compounds and minimization of hazardous residuals. Some waste service firms also offer waste minimization services.

Although the U.S. waste service industry is highly competitive worldwide, it is not without rivals. Canada's Laidlaw has a noteworthy presence in the United States and has entered Europe. The Danish firm I. Kruger, a subsidiary of Compagnie Generale des Eaux (France), was chosen over a U.S. company to establish an integrated hazardous waste facility in Malaysia. Berzelius Umwelt-Service AG, a subsidiary of Metallgesellschaft of Germany, is a major recycler of industrial materials, including metal-laden wastes, plastics, and used foundry sand. The firm has a 45-percent stake in Horsehead Resource Development Co., the largest U.S. recycler of electric arc dust.[84] Although the United States and Japan host significant recycling R&D efforts, growing German recycling requirements and disposal regulations, which could be adopted by other European countries, may further propel German expertise and technology in the area. Japanese firms do not appear to be prominent in providing waste services internationally.

In the equipment and technology sector of the waste industry, American suppliers face tougher

79 Lipmann, op. cit., footnote 58.

80 *Waste* Tech *News*, vol. *4, No. 19,* Sept. 7, 1992, p. 9.

81 BFI was recently awarded a $400 million 25-year joint venture contract to build and operate a landfill in Hong Kong. "Browning-Ferris Gets Contract to Operate a Hong Kong Dump," *Wall Street Journal,* June *29, 1993,* p. A8.

82 Lipmann, op. cit., footnote 58.

83 Ibid.

84 Metallgesellschaft 1990/91 Annual Report.

competition. Swiss, German, and French firms successfully market comporting and recycling machinery in the United States. European and Japanese companies are major providers of waste incineration technology. With less land available for landfills, Europe and Japan incinerate more of their waste than does the United States. Von Roll of Switzerland and Martin of Germany are major international providers of incineration technology. Deutsche Babcock licenses incineration technology in Japan.[85] Japan has numerous incinerator builders; Ebara, a major engineering-construction concern and an important provider of fluidized bed incinerators, maybe the largest.[86] Numerous U.S. waste-to-energy firms rely on European-licensed technologies .87

There have been some U.S. successes in the equipment field; for instance, Detroit Stoker's grate system is a significant U.S. contribution to incineration technology.[88] Wheelabrator is building a facility in Germany. Basic Environmental Engineering has licensed combustion technologies that will be used in a tire burning waste-to-energy facility in Britain.[89] U.S. companies are also successfully marketing recycling and waste-handling equipment and landfill liners abroad.

For hazardous wastes, new treatment technologies may provide viable alternatives to conventional incineration and treatment. With a number of alternative technological approaches in various stages of development and early commercialization, it is difficult to predict commercial leadership. Supercritical fluid extraction and oxidation—which uses carbon dioxide or water at high temperature and pressure to remove or destroy organic materials-is one approach under study in the United States. Molten Metal Technologies (U. S.) is developing a molten iron bath system for destroying wastes and recovering materials. A U.S.-Mexican joint venture enterprise is considering this technology for a planned Mexican hazardous waste treatment facility.[90] Vitrification—turning materials into a glassy substance—is still another approach. A number of innovative treatment technologies being developed for contaminated site clean-up (see next section) may be applicable for waste treatment.

Contaminated Site Remediation

The United States has more experience than any other country in dealing with contaminated land and groundwater. Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund) of 1980 to bring some order to Federal laws on toxic substance clean-up and compensation.[91] The law applied joint and several liability retroactively on site owners, former operators, waste generators, and waste haulers associated with hazardous wastes found in abandoned or inactive sites. A Hazardous Substance Response Fund (Superfund) was created to clean up sites in cases where parties responsible for contamination cannot be located or are unable to pay. A number of States have adopted mini-Superfunds. Although subject to extensive criticism as inefficient,[92] the

85 Kawasaki Heavy Industries, 1992 annual report.

86 Masato Ishizawa, ''Fluidized Bed Incinerators Drawing Interest, ' *The Nikkei Weekly*, Sept. 12, 1992.

87 William T. Lorenz & Co., *1991 Update—Solid Waste Control Industry Outlook* (Concord, NH: William T. Lorenz & Co., June 1991) p. 486.

88 Ibid., p. 446.

89 *Waste Tech News*, vol. 4, No. 19, Sept. 7, 1992, p. 6.

90 ''Mexican, U.S. Businessmen Plan to Build Treatment Plant in Mexico, " *International Environment Reporter*, Jan. 15, 1992, p. 7.

91 Frederick R. Anderson, Daniel R. Mandelker, and A. Dan Tarlock, *Environmental Protection: Law and Policy* (Boston: Little, Brown and Co., 1984), p. 568.

92 See, for instance, U.S. Congress, Office of Technology Assessment, *Coming Clean: Superfund Problems Can Be Solved,* OTA-ITE-433 (Washington, DC: U.S. Government Printing Office, October 1989).

Superfund Act propelled the emergence of a hazardous waste remediation industry. Other specialized remedial services have sprung up in response to regulations and concerns about leaking underground storage tanks, asbestos, and lead paint.

America's focus on remedial environmental clean-up has heightened in the last several years as it has become clear that it will require billions of dollars in annual expenditures for many years to manage environmental contamination at various Department of Energy (DOE) and Department of Defense (DOD) installations. DOE's estimated fiscal year 1994 outlay for environmental restoration and waste management will be over $5 billion, while DOD plans to spend about $2 billion for the same purpose.[93] Federal site contaminants range from common fuels and solvents often found at civilian sites to radioactive substances, explosives, and propellants.[94]

European and Japanese remediation laws and programs are less extensive than those of the United States. Hazardous waste remediation experience in Europe has thus far been limited to Germany, France, Great Britain, the Netherlands, Denmark,[95] and perhaps other Nordic countries. Japan and Western Europe are still assessing the extent of soil and groundwater contamination in their countries. Germany's eastern states, the restructuring countries of Central and Eastern Europe, and the former Soviet Union offer formidable remediation challenges and, if money can be found, business opportunities.

Competitiveness is hard to assess in this sector, where there are many technologies to handle many types of contaminants. Incineration and solidification are conventional techniques, but newer innovations-including bioremediation, vitrification, vapor extraction, thermal desorption, soil cleaning, and chemical treatment, among others—are vying for markets.[96] Site characterization technologies, including monitoring technologies and groundwater modeling systems, are also being advanced.

Firms in the U.S. industry range from very small, technology-based entrepreneurial firms to large waste and engineering companies. Despite new technologies, much remediation work involves labor-intensive activity such as earthmoving and construction. U.S. technologies appear to fare well as international markets arise. Japan's Environment Agency plans soil contamination research using U.S.-developed technologies.[97] Terra Vac Corp., an early developer of vapor extraction technology, is an example of a small U.S. firm exporting remediation services. The company has joint venture partners and business activities in Western Europe, Japan, and the Czech Republic.[98] WMX's European and Asian hazardous waste facilities may be positioned to serve remediation markets.

Foreign competitors are now emerging, however. For example, Metallgesellschaft (Germany) established a remediation and hazardous waste management subsidiary in 1989. It has won industrial and military site decontamination con-

93 Executive Office of the President, Office of Management and Budget, *Budget of the United States Government*, Fiscal Year 1994, pp. App.-461, App.-462, *App.-57O.*

94 See U.S. Congress, Office of Technology Assessment, *Complex Cleanup: The Environmental Legacy of Nuclear Weapons Production, OTA-O-484* (Washington, DC: U.S. Government Printing Office, February 1991) for discussion of clean up of DOE's nuclear weapons facilities.

95 ECOTEC Research& Consulting, "The European Pollution Control and Waste Management Market: An Overview, " January 1992, p. 24.

96 See U.S. EPA, 'Cleaning Up the Nation's Waste Sites: Markets and Technology

tracts within Germany and, in partnership with Messerschmitt, is seeking munitions site decontamination business in Russia.[99] Heidemij Reststoffendiensten, a Dutch company, is operating an 80,000-ton-a-year soil washing facility in the Netherlands.[100] The plant could be the world's largest. German technology is being tested by a U.S. firm for cleaning up groundwater at March Air Force Base in California.[101] As their remediation markets grow, European and Japanese competitors are likely to expand their remediation technology capabilities, using their own technologies or adapting and improving those developed in the United States.

The strong U.S. emphasis on remediation has created an environmental industry sector that has the potential to export its products, services, and technologies. But, in much of the world, including developing and newly industrialized countries, Central and Eastern Europe, and the former Soviet Union, it is not clear whether or when clean-up of existing contaminated sites will receive much emphasis. The Environmental Action Program developed by the OECD and World Bank for environmental aid to the former Eastern Bloc places high priority on air pollution, drinking water, and nature conservation; the absence of remediation as a priority is striking.[102] The plan was adopted by almost 50 environment ministers from Europe, the United States, Canada, and Japan. However, privatization of state-owned enterprises in eastern Germany and other parts of Central and Eastern Europe may propel some remediation markets as authorities seek to make facilities more attractive to investors, Many developing countries have had a relatively short history of hazardous chemical-intensive industies and activities, so they may have few sites requiring remediation. While particular sites could present extraordinary hazards or have leaked chemicals and fuel that may be recovered for use, remediation will usually be a lower priority than prevention and control.

Cleaner Energy Technologies

Energy extraction, conversion, and use is the major contributor to a wide variety of environmental ills, ranging from the global build-up of greenhouse gases to regional acid rain and smog to local air pollution and oil spills. Demand for energy and requirements for energy-related investment are likely to increase substantially over the next two decades. For instance, an analysis done for the U.S. National Energy Strategy in 1991/1992 projects that over $2 trillion of investment, amounting to over 1,000 gigawatts of capacity, in the electric power supply sector will occur outside the United States during the years 1991-2010.[103] A little over half of this investment may occur in developing countries, about a quarter in OECD countries (other than the United States), and the remainder in Central and Eastern Europe and the former Soviet Union,

The World Bank estimates that non-OECD electricity capital investments may reach $1 trillion during the 1990s.[104] Whether or not growth in demand for electricity or energy occurs at such a rapid pace, there is greater realization of the need to address the environmental problems caused by energy development. Business opportunities will arise for pollution abatement equipment, more efficient and cleaner energy extrac-

~ Metallgesellschaft Annual Report 1990/91.

100 *Waste* Tech *News*,, vol. 4, No. 24, Nov. 16, 1992, p. 6.

101 Environmental Science& Technology, vol. 27, No. 10, October 1993, pp. 1957-1958.

102 Marlise Simons, "West Offers Plan To Clean Up East," *New York Times, May 4, 1993,* p. A13.

103 us. Department of Energy, "National Energy Strategy Technical Annex 5: Analysis of Options to Increase Exports of U.S. Energy Technology," 1991/1992, p. 7.

104 World Bank, ''Capital Expenditures for Electric Power in the Developing Countries, " KEN Energy Series Paper No. 21, February 1990, in World Bank, "The Bank's Role in the Electric Power Sector, ' draft, Industry and Energy Department, Box 5.

tion and conversion technologies, and more efficient energy end use.

This section discusses competitiveness in cleaner energy technologies, in particular electricity supply, and features several classes of electric power technologies including gas turbines (also called combustion turbines), advanced coal technologies, and several renewable energy technologies. While some of these technologies offer certain advantages even in the absence of environmental benefits, their environmental attributes can spur their development and use. For example, gas turbines and combined cycle power plants that combine steam and gas turbine cycles can offer advantages in cost, efficiency, and flexibility of use over conventional steam plants; however, significant advantages also accrue from their cleaner performance, including lower pollution abatement costs, easier permitting, and less difficult facility siting. These environmental benefits are major factors in the adoption of these technologies and could be viewed as environmental business opportunities.

COMBUSTION OR GAS TURBINES

New gas turbine technologies offer extensive environmental and operational advantages over conventional steam turbine power plants. For more advanced models and configurations, such as combined cycle (linking gas and steam turbine cycles), steam injected, and intercooled steam injected, electrical generating efficiencies of 45 to over 50 percent are possible, in contrast to 30 to 35 percent for conventional steam plants.[105] Net energy efficiencies may exceed 80 percent if cogenerated heat is recovered. Improved efficiency translates into less environmental damage per unit of electrical generation or capacity; carbon dioxide emissions are less than those from conventional power plants, while particulate, VOC, and SO_2 emissions can be very low. (Controls for NO_x may still be necessary.) Gas turbines can be economically and quickly installed in small increments-in contrast to large, capital-intensive, centralized steam plants. Advanced gas turbines may have the flexibility to be configured for both peaking-power and base-load performance. Natural gas, oil, and gasified coal and biomass can be used as fuels.

There are about 15 manufacturers of gas turbines in the world; [106] the United States fares well in this business. General Electric (GE) is the largest supplier, with roughly half the U.S. domestic market and, with its European and Japanese business associates, who assemble turbines using key GE components, about the same proportion of the world market.[107] The company has had success in selling gas turbines in the home markets of competing nations; 56 percent of European orders in 1991 accrued to GE and its associates log and Japan has been a good GE gas turbine customer. Pratt & Whitney and Westinghouse are other U.S. gas turbine suppliers. So far GE and Pratt& Whitney dominate the production of aeroderivative gas turbines (derived, in part, from jet engine technology) that are expected to be in growing demand. [109] Major foreign competitors include ABB, Siemens (Germany), and Rolls Royce (U.K.), which have been increasing their U.S. market share.

International partnerships and licensing arrangements are proliferating. GE's overseas associates include major Japanese and European engineering firms and machinery manufacturers,

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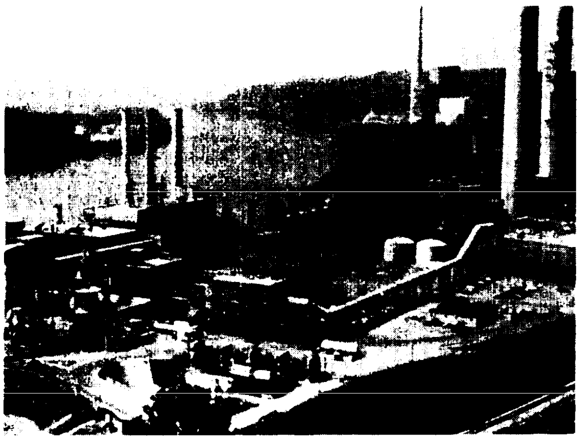
105 Oak Ridge National Laboratory, *Energy Technology R&D: What Could Make a Difference?,* vol. 2 (ORNL-6541/V1/P2) December 1989, pp. 41-46; and R.H. Williams and E.D. Larson, "Aeroderivativc Turbines for Stationary Power,' *Annual Review of Energy,* vol. 13, 1988. pp. 429-489.

106 U.S. Department of Energy, op.cit., footnote 103, pp. 46-47.

107 Eugene Zeltman, General Electric, personal communication, Feb. 3, 1993.

108 'GE Forms New European Marketing Arm," *Energy Daily,* Oct. 21, 1992, p. 4,

109 Jim Clarke, "EPRI Official: Interest in Advanced Turbines Increasing," *Energy Daily,* June 26, 1992, p. 4.



Ohio Power Co. Tidd Plant, Brilliant, Ohio. Pressurized fluidized bed combustion is one of a variety of technologies being demonstrated under DOE'S Clean Coal Technology Program. Clean coal technologies may have growing markets as coal-dependent countries around the world address environmental concerns.

Westinghouse has partnerships and agreements with Rolls Royce, Mitsubishi, and Fiat Avio (Italy). Rolls Royce has a separate partnership with ABB in Europe. And Pratt & Whitney has a partnership with Siemens. General Electric Co. of Great Britain is linked with Alsthom of France. Competition has intensified as the number of gas turbine manufacturers has grown. Several of the partnerships just noted were forged to challenge GE's and Pratt & Whitney's position in the aeroderivative market. Firms in newly industrialized countries might enter the market as well.

ADVANCED COAL COMBUSTION AND CONVERSION TECHNOLOGIES

Fluidized bed combustion (FBC) and coal gasification are two major types of clean coal technologies that may see considerable market development as ways are sought to make coal use more compatible with environmental protection. Along with several other new cleaner combustion technologies, they are being developed and demonstrated under the U.S. Department of Energy's Clean Coal Technology Program. The program is a Federal-private cost-sharing effort to demonstrate new ways of using coal cleanly, including precombustion coal cleaning, advanced combustion and conversion, and postcombustion cleanup. Over $2.7 billion of Federal money is committed to five rounds of demonstrations from fiscal year 1986 through fiscal year 1995.[110] Of $4.6 billion committed to 41 projects at the end of 1992, 40 percent was from DOE and 60 percent from industry.[111] Other DOE and Electric Power Research Institute (EPRI) research has been important in advancing combustion technologies in the United States.

Two major variants of fluidized bed combustion are Atmospheric FBC (AFBC) and Pressurized FBC (PFBC). Both can effect high rates of sulfur removal and are alternatives to conventional pulverized coal plants using flue gas desulfurization. AFBC has been employed for biomass and waste combustion, and can use low quality fossil fuels like lignite and oil shale.[112] PFBC, a less mature technology, offers higher efficiency in less space than either conventional or AFBC plants. These technologies may be viable for repowering existing plants as well as for new installations.

U.S. vendors of AFBC systems face considerable competition from Europe and Japan. India and China are developing AFBC for their domestic needs. Less complex variants of AFBC have been built mainly for biomass burning and waste incineration. For larger utility scale applications, the emphasis has been on more advanced circulating AFBC. Lurgi (Germany) and Ahlstrom/Pyropower (Finland) have led with 40 and 30 plants, respectively, in operation or under con-

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110 U.S. Congress, Congressional Research Service, "DOE's Clean Coal Technology Program: Goals and Funding," CRS Issue Brief IB88071, updated July 20, 1993,

111 Daniel Kaplan, "DOE Looks to Future in Final Clean Coal Technology Solicitation' *Energy Daily*, Dec. 10, 1992, p. 4.

112 E. Stratos Tavoulareas, "Fluidized Bed Technology, " *Annual Review of Energy and Environment,* vol. 16 (1991), pp. 25-57.

struction by 1990.[113] Two Swedish companies are prominent competitors; one has licensed its technology to U. S., Japanese, and Spanish fins. Keeler/Dorr-Oliver and Foster Wheeler are the major U.S. providers of AFBC technology. Combustion Engineering, a U.S. subsidiary of ABB, is another supplier and a participant in DOE's clean coal technology demonstration program. [114] Other AFBC variants are being developed by U.S. and German companies.[115]

PFBC is an immature technology that is not yet commercially available. ABB has dominated the field as supplier of all three major PFBC demonstration projects (in Spain, Sweden, and the United States).[116] Demonstration units have been sold to Japan and the former Czechoslovakia. ABB hopes to sell commercial-sized facilities in the United States and Japan. Deutsche Babcock (Germany), Foster Wheeler, and Air Products and Chemicals are working together to demonstrate a PFBC system in DOE's clean coal technology program. [117] Ahlstrom/Pyropower, using Finnish technology, hopes to become a PFBC supplier, with a U.S. demonstration plant planned for completion later in the decade.[118]

Integrated gasification combined cycle (IGCC) is another clean coal approach. Gas is derived from coal while polluting ash and sulfur are left behind, The gas, like natural gas, can be burned relatively cleanly and at high efficiency in a combined cycle power plant. Most existing coal gasification projects produce gas for chemical feedstock rather than for electric power production. The gasification process may be adaptable for gasification of biomass as well. IGCC produces far less waste than fluidized bed combustion because sorbents are not needed to absorb sulfur from the combustion chamber. This is also an advantage over FGD on conventional power plants. There are only a handful of gasification processes in competition from U. S., German, Dutch, and British firms.[119] Japan's government and electric utilities are working together to develop coal gasification and liquefaction technologies. [120] The major processes that appear to be making commercial inroads are from Texaco, Dow, Shell (Netherlands), and British Gas/ Lurgi. [121] The Texaco process seems to be most used; there are facilities in the United States, Japan, and Germany using the process, mostly for chemical feedstock production. Texaco has received contracts in China and Italy, and is working with Venezuela to promote IGCC use with heavy Venezuelan oil for the U.S. and Caribbean markets. [122] Several DOE clean coal demonstrations feature IGCC.

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[113] Ibid.

[114] S. B, Alpert, ''Clean Coal Technology and Advanced Coal-Based Power plants, ' *Annual Review of Energy and Environment,* vol. 16 (1991), pp. 1-23.

[115] Ibid.

[116] Robert Smock, ' 'Pressurized Fluid Bed Demonstration Units Operate Successfully, " *Power Engineering,* vol. *97, No. 3,* March *1993,* pp. *42-45.*

[117] R.C. Rittenhouse, "Clean Coal Technology: Where Does It Go From Here?,' *Power Engineering,* Vol. 97, no. 7, July1993, pp. 17-22.

[118] Ibid.

[119] Oak Ridge National Laboratory, Op cit., footnote105, p. 27.

[120] Agenc, for Industrial Science and Technology, *Shikenkenyusho Kenkyu Keikaku 1992 (Oct. 1992), as reported in Foreign Broadcast Information Service, Foreign Media Notes, FB* PN 93-330, July 28, 1993.

[121] Alpert, op. cit., footnote 114, p. 20.

[122] George Lobenz, "Texaco, Venezuela Sign Accord Linking Orimulsion, IGCC,'' *Energy Daily,* June 18, 1992, p. 3,

RENEWABLE ENERGY[123]

Renewable energy sources, other than hydroelectric, make up only a small portion of commercial electric power generation today. However, that proportion is likely to grow, perhaps rapidly. Technological improvements that have lowered costs, concerns about greenhouse gas emissions, and continuing worries about the safety of nuclear power add to renewable energy's appeal. Renewable energy is key for pursuit of sustainable development. Photovoltaic cells (PVs) and wind turbines are among the renewable energy technologies that might make important contributions to power supply in coming decades.

The United States pioneered development of PVs, which found early applications in space as satellite power sources. Today, PVs are being used for remote location power production—which is particularly important in developing countries without widespread national power grids-and are being evaluated for some utility applications. U.S. PV manufacturers face very strong competition from their Japanese, German, and other European counterparts. The world's largest manufacturer of PVs is Siemens Solar Industries, a U.S. subsidiary of Siemens (Germany), which recently bought ARCO Solar in the United States.[124] The company accounts for over half of U.S. production, of which it exports 75 percent.

U.S. and Japanese producers each garnered about one-third of the global market in 1992; up from one-quarter for U.S. producers and down from half for Japanese producers in 1986.[125,126] European production grew from about 15 percent to nearly 29 percent in that period. Some Asian competitors have built up production experience by making PVs for calculators, watches, and similar devices. They now produce cells and modules for remote sites, residential use, and utility demonstration in competition with U.S. manufacturers. There are at least a dozen U. S.-owned PV manufacturers. Several, including Solarex (an Amoco subsidiary), Mobil Solar, and Texas Instruments, are parts of large companies. Energy Conversion Devices (ECD) has formed a partnership with Canon (Japan), called United Solar Systems Corp., to manufacture PVs in the United States.[127] ECD has separate PV joint ventures in India and the former Soviet Union. The United States, Germany, and Japan are the leading funders of research, development, and demonstration of PV technology; several European countries have lesser efforts.

Wind turbines are providing utility power today, with most installations in California, Hawaii, and Denmark. Several improvements in design, materials, and siting may make wind a cost-effective electric power source in a large area of the United States and abroad.[128] DOE's goal is to achieve price reductions from a current average of 8 cents per kilowatt-hour to 5 cents by the mid-1990s, a cost similar to that of a new fossil fuel plant. U.S. Windpower (a subsidiary of Kenetech) claims to have already achieved this goal with a new variable speed turbine.[129] U. S., Danish, Belgian, Dutch, Japanese, German, and British companies make utility-scale wind turbines. By the late 1980s, several Danish manufacturers were supplying over 50 percent of U.S.

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123 A forthcoming OTA assessment, Renewable *Energy Technology: Research, Development, and Commercial Prospects*, will analyze technological and commercial aspects of renewable energy including competitiveness issues.

124 Mark Crawford, "Sevm Companies Awarded DOE Solar Grants, " *Energy Daily*, Apr. 24,1992, p. 3.

125 *Photovoltaic* News, vol. 12, No. 1, January 1993, p. 1.

126 *Photovoltaic News*, vol. 11, No. 2, February 1992, p. 1.

127 Lipmann, op. cit., footnote 78.

128 Carl J. Weinberg and Robert H. Williams, "Energy From the Sun," *Scientific American*, vol. 263, No. 3, September 1990, pp. 146-155.

129 "NREL Launches Solar Projects" *Energy Daily*, Nov. 4, 1991, p. 4; Kimberly Dozier, "USW Touts Wind Turbine Breakthrough," *Energy Daily, Nov. 6,* 1991, pp. 1-2.

wind-based generation capacity.[130] Mitsubishi entered the U.S. market in 1987. Belgian and British machines also operate in the United States. While there are a number of U.S. wind turbine manufacturers, U.S. Windpower has been the dominant U.S.-based supplier of utility-scale machines, accounting for over 90 percent of U.S. manufactured machines.[131] U.S. Windpower has been working on projects in Europe, Latin America, Egypt, and New Zealand. At least nine other U.S. companies are working with DOE's National Renewable Energy Laboratory on cost-shared wind energy technology development projects.[132]

Pioneers in commercialization of renewable energy technology do not necessarily enjoy commercial success. In California, LUZ International developed several solar thermal electric power plants. The technology uses mirrored troughs to focus sunlight on tubes containing liquids that are then used to generate steam for electric power production; natural gas is used as a supplemental fuel. The LUZ facilities are the largest commercial solar thermal electric plants in the world. The company achieved economies of scale as its facilities grew; its latest 80 megawatt units generate power at 8 cents per kilowatt hour versus 24 cents for its first 15 megawatt unit in 1984.[133] However, despite this progress, the company has gone bankrupt. Research, development, and demonstration of other solar thermal systems continues in the United States and abroad.

The American renewable energy industry is technologically strong and competitive-but so are foreign suppliers. As in other arenas of environmental technology competition, some foreign suppliers obtain more favorable financing

CYNTHIA CHEAK/KENETECH

U.S. manufactured wind turbines at the Altamont Pass, California. Technical advances are making renewable energy sources more economically viable. U.S. producers of such technologies face tough foreign competition in the U.S. and international markets.

from home governments than do U.S. firms. This is particularly important in developing countries, which are an important export market for U.S. renewable energy products.

Help for manufacturing R&D and development of domestic markets can be important determinants of competitiveness. Japan and Germany have strong programs for R&D, demonstration, and evaluation of renewable and other alternative energy technologies. They also employ tax incentives and subsidies to encourage installation of renewable energy and other environmentally preferable energy technologies (e.g., fuel cells). For example, Japan's Ministry of International Trade and Industry (MITI) has earmarked nearly $40 million for fiscal year 1994 in a multiyear program to subsidize two-thirds the cost of household PV installations; the goal is to have

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130 Oak Ridge *National* **Laboratory, op. cit.,** footnote 105, **pp.** 145-147.

131 Ibid

132 **"NREL Launches Solar Projects,"** *Energy Daily, Nov.* 4, *1991,* **p.** 4; "NREL **Funds Wind Turbine R&D Efforts,"** *Energy Daily,* **Dec.** 4, 1992, p. 4.

133 Michael Lotker, "Barriers **to Commercialization of Large-Scale Solar Electricity:** Lessons **Learned From the** LUZ **Experience,"** Sandia **National Laboratory contractor report,** SAND91-7014, **November 1991.**

70,000 systems installed by 2000.[134] **The 70,000** systems would amount to about 340 percent of the world's current annual PV production capacity. These countries' technology policies balance efforts for improving the supply of new technology (R&D) and demand for new technology (market creating incentives).

DOE is cooperating with renewable energy technology manufacturers, electric utilities, and other industries to promote manufacturing R&D and utility applications of renewable. (See ch. 10.) The PV Manufacturing Technology Program's goal is to prevent loss of the PV industry to Japanese and German manufacturers by helping domestic companies improve their manufacturing capability. PVUSA—Photovoltaics for Utility Scale Applications-is helping to develop utility PV markets through testing of various manufacturers systems and identification feasible utility applications. Other cost-sharing U.S. government-industry programs exist for wind and geothermal R&D. A number of State utility commissions' rules for incorporating social costs of pollution could help the U.S. market and industry.

END-USE ENERGY EFFICIENCY

Improvement of energy use efficiency as an international market opportunity is still in a nascent state. The energy efficiency sector is very diverse, including products ranging from instruments and controls to high-efficiency appliances, heating, lighting, cooling, and motors to insulation and improved windows. Although highly uncertain, global trade in energy efficiency products and services is estimated at $8.4 billion per year during the period 1990 to 2000, doubling to $16.8 billion annually in the decade leading to 2010; about half of that market is expected to be in less-developed countries.[135] U.S. AID estimates that U.S. companies can realistically capture only about 8 percent of the global energy efficiency export market and 10 percent of the annual exports to developing countries.[136] Japanese and European firms provide tough competition for American companies.

Japanese and German producers are already strong exporters of many capital goods, some of which incorporate energy efficiency improvements that have helped those countries' industries achieve higher energy efficiencies than some American sectors. More often than U.S. companies, Japanese and European companies have already established substantial presence in developing countries.[137] Low-cost manufacturers in Taiwan, South Korea, and other rapidly industrializing countries provide additional competition for U.S. companies, or, at least, U.S.-based manufacturing. Indeed, the United States is itself a net importer of some energy-efficient products, such as compact fluorescent lighting ballasts.[138] As in other environment and energy sectors, the availability of financing affects the performance of U.S. vendors vis-à-vis foreign competitors in developing country markets. U.S. suppliers are expected to be most competitive in supplying higher technology energy efficiency products including industrial process controls and instrumentation, as well as industrial and residential energy load management systems and controls (e.g., thermostats). However, German and French suppliers are also competitive in these sectors.

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134 *Nihon Keizai Shimbun*, Aug. 22, 1993, as cited in Foreign Broadcast Information Service, *pacific Rim Economic Review*, vol. *2, No.* 18, Sept. *8, 1993,* p. *7.*

135 U.S. Department of Energy, op. cit., footnote 103, pp. 67-6*.

136 Ibid., pp. 68-69.

137 Ibid., p. 69.

138 International Institute for Energy Conservation, *Seizing the Moment: Global Opportunities for the U.S. Energy Efficiency Industry* (Washington, *DC:* International Institute for Energy Conservation December 1992), p. 4.

Industrial Pollution Prevention and Cleaner Production

As in the case of energy end-use efficiency, this business is less a sector than an agglomeration of providers of many types of goods, services, and technologies that are usually integrated into production processes and are often hard to tease out as separate items. Nonetheless, as discussed earlier in this chapter and in chapter 8, pollution prevention and cleaner production present important environmental market opportunities.

In some cases, equipment and technology used for pollution prevention is similar to some forms of conventional add-on environmental controls. For instance, activated carbon, ion exchange, and membrane-based technologies may be used for in-process pollution prevention, for recovery of materials for recycling, or for end-of-pipe or remedial separation of pollutants for destruction or disposal. The same vendors provide their products for application across this continuum of environmental activities. In other cases, the pollution prevention technology may only be weakly associated with conventional environmental products; extended cooking in the paper and pulp industry or improved process controls in most industries are examples, The design of many other industrial products and processes are strongly affected by environmental concerns and, thus, are environmental business opportunities. For example, environmental considerations are leading to changes in painting and coating technologies including development of high efficiency paint sprayers; powder coatings; ultraviolet, infrared, and microwave paint curing; and alternative paint formulations.

While assessment of competitiveness in cleaner production as a whole is difficult, because the area is so broad, assessments could be made of particular components such as cleaner painting, metal cleaning, pulp and papermaking, or as described above, electric power generation. As in most of the sectors discussed, the United States, Germany, and Japan are the major players with competition from several smaller Northern European states. Regulations have certainly propelled many cleaner production development activities. The phase-out of CFCs has inspired searches for alternative solvents, for solvent-free options, and for closed-loop processes that avoid solvent release; the United States appears to be a strong contender in this area. California's stringent air pollution regulations have spawned partnerships among government, energy utilities, and industry for low emissions processes and fuels. The winners in clean production innovation-in addition to public health and the environment--can be both the regulated industry that seeks cheaper ways to comply with regulations and suppliers of cleaner production technologies that may find growing markets for their innovations domestically and abroad.

CONCLUSION

The strength and form of environmental regulations in the home market are major determinants of environmental industry competitiveness. However, a variety of other factors, including development assistance policies, export promotion, support for R&D and technology demonstration and diffusion, and industrial structure also influence environmental industry competitiveness.

The United States is competitive in many environmental industry sectors but faces growing competition from foreign companies, most seriously German and Japanese fins. The internationalization of environmental industries and lack of data, and the early stage of deployment for some environmental technologies, make definitive assessments of competitiveness difficult, In a number of sectors, including stationary source air pollution control and wastewater treatment, foreign companies are making significant inroads in the U.S. domestic market through exports, technology licensing, and acquisitions of U.S. fins. In addition, newly industrialized and developing countries are increasing their environmental industry capability. Pollution prevention, cleaner technology, and energy efficiency provide significant business opportunities that can often allow higher degrees of environmental protection at lower cost than many end-of-pipe environmental controls; such opportunities should not be overlooked in policies for environmental industrial support.

Export Promotion Programs[1] 6

The U.S. environmental industry faces a number of challenges in exporting. Some of these challenges are fairly specific to the industry whereas others are shared with other exporting industries.

U.S. firms in general export much less, as a percentage of total sales, than firms in many counties that are members of the Organisation of Economic Cooperation and Development (OECD) (table 6-l). This is not surprising. For several decades, the United States' large domestic market often made exporting unnecessary for a fro's success. In addition, the United States is far away from markets of comparable size, making exports often seem not worth the bother. A tradition of exporting is ingrained in European culture. National markets are smaller, making exports more often necessary; similarly sized export markets are right at hand. Japan, too, has a long tradition of exporting. It has traditionally thought of itself as an island nation, poor in natural resources, that must export to pay for the imports it needs. In recent decades, exports have been central to its strategy for economic growth and development.

As discussed in chapters 4 and 5, data on environmental goods and services (EGS) export patterns are limited. Some estimates suggest that key sectors of the U.S. environmental industry are much less export-intensive than those of Japan and Germany: environmental product exports, as a percentage of environmental *products and services* production, is much less in the United

[1] Parts of this chapter that pertain to the export promotion effect of foreign assistance programs are discussed more fully in OTA'S background paper: U.S. Congress, Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology—Background Paper*, OTA-BP-ITE-1O7 (Washington, DC: U.S. Government Printing Office, August 1993).

Table 6-l—Export Intensity of Selected OECD Countries, 1991

Country	Exports as a percentage of Gross Domestic Product
Belgium	69.3
Ireland	68.7
Netherlands	54.1
Norway	44.8
Austria	40.9
Denmark	36.9
Germany	38.5
Switzerland	35.1
Portugal	36.6”
Sweden	28.1
United Kingdom	23.4
Canada	24.4
France	22.7
Greece	22.6
Finland	22.3
Italy	18.0
Australia	17.7
Spain	17.3
United States	10.5
Japan	10.4

a Based on 1990 data.

SOURCE: Derived from data on exports of goods and services, and on GDP, in International Monetary Fund, *International Financial Statistics*, vol. XLVI, No. 4, September 1993.

States (table 6-2). One factor that could inhibit U.S. exports is that the industry has so many small fins. One analysis estimates that in 1991 the U.S. environmental industry consisted of 207 public companies averaging $198.3 million revenue each ($41.0 billion total revenue) and 58,700 privately held companies each averaging $1.3 million in revenue ($78.4 billion total).[2] Smaller companies have a harder time exporting, and are often reluctant to try.[3] There is some inconclusive evidence that EC environmental firms are larger; data for Japan are lacking. Environmental industry structure is discussed further in chapter 4.

Without exporting more, some U.S. environmental sectors could become less competitive in time. Foreign firms are increasingly penetrating the relatively open U.S. environmental market (ch. 5). Without expanding exports, U.S. firms could lose out in sales and experience compared with foreign firms. Lost sales mean reduced funds for market development and R&D, reduced economies of scale, and reduced payoff for improved production efficiency. Lost experience means less feedback for improving product or service quality.

U.S. exports might increase if there were greater industry commitment and more effective assistance by government or industry associations. Firms that are serious about exporting must invest substantial time and resources to explore markets and cultivate business relationships abroad. While government programs can provide market information and facilitate contacts abroad, government commercial officers and company marketing brochures are no substitute for face-to-face contacts between would-be exporters and potential customers. In many cultures, business is conducted on the basis of personal relationships that seldom jell from a single encounter at a trade show. Partnering with local firms is often required, sometimes by law, to do business. Once an order is won, a continuing presence (via a local partner if not directly) is needed to provide parts and service and to cultivate additional business. Differences in language, culture, business practices, standards, and legal requirements can be big challenges to U.S. firms (particularly smaller ones) new to a market. Exports also require arrangements and expenses for shipping, fmanc-

[2] *Environmental Business Journal*, vol. 5, No. 4, April 1992, p. 7. However, 24,000 of these were water supply utilities (not normally export candidates) averaging $400,000 in annual revenue.

[3] William E. Nothdurft, *Going Global: How Europe Helps Small Firms Export* (Washington DC: Brookings Institute, 1992), esp. pp. 12-19. Personal communications with: Donald Connors, Environmental Business Council, Massachusetts, October 1992; Arthur Chu, Vice President, Technical and Strategic Development, Ebasco Environmental International, Inc.; Robert Driscoll, U.S.-ASEAN Council for Business and Technology, Nov. 5, 1992. Joseph Harrison, Director of Office of Capital Goods, International Trade Administration, Department of Commerce, as quoted in William Maggs, “Commerce Looks to Boost Green Technology Exports,” *Environment Week*, Sept. 9, 1991.

Table 6-2—Environmental Production and Exports, 1992

	Production of environmental products and services ($ billion)	Exports of environmental products ($ billion)	Product exports as a percentage of products and services production
Japan	21	5	24
Germany	36	11	31
United States	134	7	5

SOURCE: Presentation by Grant Ferrier, Environmental Business International, at Environmental Business Council of the United States meeting, June 7-9, 1993, Washington, DC.

ing, and insurance, beyond those required for domestic sales. Given the large domestic market for environmental products and services, many U.S. environmental firms may feel that exporting is not worthwhile.

The U.S. Government provides some assistance, as do State and local governments. However, firms often find U.S. export assistance difficult to access and poorly coordinated. Moreover, U.S. policymakers disagree about whether export promotion is a desirable government function.

The situation in some other countries is different, with the result that:

- Major foreign competitors dedicate proportionately more resources to export promotion services than does the United States. They also perform more high level advocacy, in which ministers or even heads of state promote their national firms to foreign governments.
- U.S. firms appear to have more difficulty obtaining export financing compared to rivals in some other countries. Also, exporters in some other countries have more access to confessional financing that their governments offer developing countries. Small businesses often can not export without financing. Also, as is discussed in chapter 5, financing can be important in winning export contracts for many large projects with an environmental component.

Recent Congressional and Executive Branch actions, however, emphasize a stronger Federal role in promoting exports. In 1992, Congress called for a national strategy to promote exports; in September 1993, the Clinton administration delivered its first report aimed at framing such a strategy.[4]

In addition to the overall export strategy, Congress also called for a national environmental export strategy. The Clinton administration's initial environmental strategy is expected to be issued in the fall of 1993. In addition, as is discussed in chapter 2, several bills to give added emphasis to environmental export promotion have been proposed in the 103d Congress.

Some specific areas of government policy are especially pertinent to promotion of environmental exports:

- As discussed in chapter 5, demand for environmental goods and services is driven largely by regulations and enforcement. Technical assistance offered as part of foreign aid can help recipient countries build environmental management capacity, which often stimulates demand for environmental goods and services (EGS). If the recipient adopts the donor's approach, the assisting country's firms may

[4] Trade Promotion Coordinating Committee, *Toward a National Export Strategy,* report to the United States Congress, Sept. 30, 1993.

gain some advantage in supplying technologies known to meet the requirements. Promotion of voluntary and professional standards of environmental management may also help stimulate environmental product demand.

- Foreign customers, particularly in developing and newly industrialized countries, are often unsure about the performance and suitability of environmental technologies offered. Technology performance evaluations and verifications by the Environmental Protection Agency (EPA) (or other credible third parties) can help U.S. environmental firms and foreign customers alike without compromising EPA's reputation for objectivity. Indeed, they could also help diffuse new technologies in the domestic market. Technology demonstrations done abroad can also help U.S. technology developers.
- Aid plays an important role in developing countries' environmental projects, which often involve government and require outside assistance. Apart from confessional financing, aid programs can promote exports in several ways. For example, grants for feasibility studies by national firms can help national firms win follow-on projects. Training grants can sweeten national fins' bids. Aid personnel can pass on to national firms information about recipient countries' upcoming projects and procurements, as well as information about possible multilateral funding sources. Some other countries' aid programs seem more attuned to these commercial considerations.

Some efforts to coordinate assistance for environmental exports are already underway.

For example, the Committee on Renewable Energy Commerce and Trade (CORECT), setup in 1984, works to facilitate interaction between government officials and private industry to promote renewable energy exports; its concept might be transferable to other subsectors of the environmental field (box 6-A).

In 1992, the Bush administration launched the United States-Asia Environmental Partnership (US-AEP) which seeks to help developing countries in the Asia-Pacific region solve environmental problems by using U.S. environmental goods and services. Federal agencies can use US-AEP (a public-private partnership) to coordinate environmental export activities to the region, and to provide one-stop-shopping. US-AEP has recently, through the National Association of State Development Agencies (NASDA), given $700,000 in matching grants to assist small and medium-sized firms in exporting.[5]

Another public-private partnership launched in 1992, the United States Environmental Training Institute (USETI), brings developing country decisionmakers to the United States for training. U.S. vendors have the opportunity to showcase environmental technologies.

EFFORTS TO DEVELOP U.S. STRATEGY

As indicated in figure 6-1, Federal export promotion and financing responsibilities are divided among many agencies. The Department of Commerce, the Export-Import Bank of the United States (Eximbank), and the U.S. Trade and Development Agency (TDA, formerly the Trade and Development Program) all have export promotion as a major mission. The Overseas Private Investment Corp. (OPIC) has the mission of encouraging investment abroad, which often leads to exports. The Office of the U.S. Trade Representative (USTR), the Department of State, and the U.S. Treasury develop trade policy and conduct international negotiations. The Department of Agriculture promotes U.S. agricultural exports. Other agencies also participate in trade promotion. Several U.S. Agency for International Development (USAID) programs and activities encourage U.S. private sector involvement in development assistance. The Department of En-

[5] "Environmental Grants a Success: Promise of More to Come," *The NASDA Letter*, Sept. 27, 1993, p. 4.

Box 6-A-Committee on Renewable Energy Commerce and Trade: A Possible Model for Promotion of Environmental Technology Exports

CORECT was setup in 1984[1] to coordinate Federal policy and programs to promote exports in the renewable energy field. Chaired by the Secretary of Energy, CORECT includes 14 Federal agencies and industry, often represented through the United States Export Council for Renewable Energy (ECRE), a consortium of 9 U.S. renewable energy trade associations.[2]

CORECT's structure encourages a close relationship among Federal agencies and industry. Industry representatives meet frequently with Federal agency officials to ask for Federal help with specific export promotion efforts. Meetings are held separately for four market regions, and involve working-level staff with detailed knowledge of market opportunities. Once a task is identified as meriting support, each agency can commit resources depending on its own mission and expertise. CORECT also receives funds directly from Congress for project seed money and administration; for fiscal years 1992-1994 this funding has been $2 million per year.

It is difficult to evaluate the impact of CORECT on exports of U.S. renewable energy technologies, because public trade data are incomplete and the industry reveals little about its trading activities. A recent U.S. General Accounting Office report[3] notes that CORECT did not meet a congressional deadline to formulate a plan for increasing renewable energy exports. Still, it has identified barriers to export, investigated markets, and sponsored trade promotion events, which could comprise basic components of a trade plan. CORECT and ECRE have established a uniform application form to make it simpler for firms in the renewable energy field to apply for financing from USAID, Eximbank, the Overseas Private Investment Corp. (OPIC), and TDA. GAO also concluded that CORECT has been successful in pulling together financial resources from Federal agencies and industry for trade development activities, as well as from multilateral institutions, and has been instrumental in developing new financing mechanisms. U.S. renewable energy technology firms still, however, encounter very competitive foreign financing and subsidization schemes.

DOE is trying to form a parallel group for energy efficiency, the Committee on Energy Efficiency Commerce and Trade (COEECT). As of October 1993, COEECT had not yet met because no representative consortium like ECRE existed for the energy efficiency industry. The fiscal year 1993 funding has been used for efforts to build such a consortium. It is possible that the CORECT approach could work for still other specific subsectors of the environment industry (for example, air pollution control), though no such proposals have been made.

1 Renewable Energy Industry Development Act of 1983, Public Law 98-370, as amended by the Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989, Public Law 101-218.

2 The factual description of CORECT in this box is based largely on U.S. General Accounting Office, *Export Promotion, Federal Efforts to Increase Exports of Renewable Energy Technologies,* GAO/GGD-93-29 (Gaithersburg, MD: U.S. General Accounting Office, December 1992), and on discussions with CORECT staff.

3 Ibid.

ergy (DOE) and the Small Business Administration (SBA) are involved in export promotion to further specific agency missions. Other agencies, such as the Environmental Protection Agency (EPA), may become involved because of their special expertise or responsibilities.

With so many programs and agencies, there has been growing recognition that Federal export promotion programs are poorly coordinated and often duplicative, and that a strategy to guide Federal activities has been lacking. In addition to specific initiatives mentioned above for coordi-

Figure 6-1—Selected Federal Programs That Can Promote EGS Exports

Activity Department/Program[a]	Export education	Market info.	Financing & insurance	Trade missions & travel	Feasibility studies	Overseas presence	Technology training & cooperation
Agency for International Development							
American Business Initiative		x			x		
Bureau for Private Enterprise		x					x
Market and Technology Access Project							x
U S -Asia Environment Partnership	x	x		x	x	x	x
Energy Technology Innovation Project				x	x		x
Energy Training Project					x		x
Environmental Credit Program			x				
Environmental Enterprises Assistance Fund			x				
Energy Efficiency Centers in E. Europe						x	x
Private Investment and Trade Opportunities		x		x		x	x
Project in Development & the Environment		x			x		x
Environmental Improvement Project		x			x	x	x
Capital Development Initiative		x			x		x
Department of Commerce							
U.S. & Foreign Commercial Service	x	x		x	x	x	
Eastern Europe Business *Info.* Centers		x		x		x	x
L. Am./Carib. Business Development Center		x		x		x	x
E. Europe Enviro. Business Consortium		x					
Nat'l. Enviro. Technologies Trade Initiative		x		x			x
Department of Energy							
Export Initiative Program		x					x
Coal and Coal Technology Export Program		x		x	x		x
Support to Energy Efficiency Centers						x	x
Committee on Renewable Energy Commerce and Trade		x		x	x	x	x
Federal International Trade and Development Opportunities Program					x		
Environmental Protection Agency							
Office of International Activities		x		x		x	x
U.S. *Environmental Training Institute*				x			x
Regional Environment Center (Budapest)		x				x	x
Caribbean Environm't. & Developm't Instit.		x				x	x
Clearinghouses		x					x
Technical Information Packages							x
Export-Import Bank			x				
Overseas Private Investment Corp.		x	x	x			
Global Environmental Emerging Markets Fund, L.P. (not yet capitalized)			x				
Small Business Administration	x		x	x			
Trade & Development Agency		x		x	x		x

a Programs in italics involve substantial interagency, State or private sector participation in managing the program.

SOURCE: Office of Technology Assessment, 1993.

nated government action (CORECT, US-AEP), Congress and the executive branch have taken some recent actions to improve program coordination and develop a more strategic emphasis for all government export promotion efforts, and for environmental export promotion as a whole sector, as discussed below.[6]

Trade Promotion Coordinating Committee

The interagency Trade Promotion Coordinating Committee (TPCC), chaired by the Secretary of Commerce, was set up in May 1990 by President Bush to consolidate and streamline Federal export promotion activities. In the Export Enhancement Act of 1992, Congress formally established TPCC as a permanent institution.[7] The Act directs TPCC to set strategic priorities, eliminate duplicative activities, improve interagency coordination, and propose to the President an annual unified trade promotion budget. One strategic priority issue is the share of funding given to agricultural vs. industrial export promotion. In 1991, the Department of Agriculture received 74 percent of total government outlays for export promotion, although only 10 percent of all U.S. exports were agricultural.[8] Whether an interagency process alone can effectively identify priorities for a meaningful budget is uncertain.

TPCC delivered an initial report in September 1993.[9] That report does not set strategic priorities or propose a unified budget, although it commits to doing both in time for the fiscal year 1995 budget.[10] The report lists four goals for Federal export promotion:

- Create a more customer-focused, coherent, and effective USG-wide export promotion strategy within existing resource constraints to assist the private sector in creating jobs and fueling economic growth.
- Leverage US government resources by strengthening city/state and public/private partnerships domestically and in our overseas networks.
- Remove or reduce government-imposed obstacles to exports wherever appropriate.
- Seek to reduce foreign export credit subsidies through multilateral negotiations and level the playing field, when appropriate, by countering foreign competitors' efforts in financing.[11]

The report also lists 65 concrete recommendations covering resource allocation, export promotion services (including domestic field services, Washington-based services, overseas services, coordination with State export promotion activities, and advocacy), financing, and regulatory obstacles to exports. Many of these address the issues of duplication and coordination identified by Congress.

The Export Enhancement Act also directs TPCC to "provide a central source of information for the business community on Federal export promotion and export financing programs."[12] TPCC has set up an information clearinghouse, the Trade Information Center. The Center, which has a toll-free phone number, receives 200

[6] Both the specific initiatives and the Trade Promotion Coordinating Committee (below) are also discussed in U.S. Congress, Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology,* op. cit., footnote 1, app. B.

7 Export Enhancement Act of 1992, Public Law 102-429, sec. 201. A predecessor to the TPCC, the Interagency Task Force on Trade, was never established by statute. Headed by a Director of the Export-import Bank of the United States, the Task Force was dissolved when the Director left office. U.S. General Accounting Office, *Export Promotion: Federal Programs Lack Organizational and Funding Cohesiveness,* NSIAD-92-49 (Gaithersburg, MD: U.S. General Accounting Office, Jan. 10, 1992), p. 7.

[8] U.S. Congress, General Accounting Office, *Export Promotion: Federal Programs Lack Organizational and Funding Cohesiveness,* op. cit., footnote 7, p. 5.

9 Trade Promotion Coordinating Committee, *Toward a National Export Strategy,* op. cit., footnote 4.

[10] Ibid., pp. 9-10.

11 Ibid., p. 6, These four goals are quoted directly from the source.

12 Export Enhancement Act of 1992, op. cit., footnote 7.

inquiries a day from new-to-export and new-to-market fins, and directs them to appropriate Federal agency programs for assistance. Since companies must still apply separately to the individual agencies for assistance, the Center does not provide one-stop-shopping.

Environmental Trade Promotion Working Group

The 1992 Export Enhancement Act declared that it is the "policy of the United States to foster the export of United States environmental technologies, goods and services. In exercising their powers and functions, all appropriate departments and agencies of the United States Government shall encourage and support sales of such technologies, goods, and services."[13] Toward this end, the law directed the President to establish an Environmental Trade Working Group as a subcommittee of TPCC, to include representatives from all TPCC member agencies and EPA. The subcommittee is charged to be comprehensive and strategic; it is "to address all issues with respect to the export promotion and export financing of United States environmental technologies, goods and services, ' and ''to develop a strategy for expanding United States environmental technologies, goods and services.''[14]

An environmental section was included in the TPCC's September 1993 report. That section identifies 11 problem areas, which could be grouped as follows:

the need for more strategy:

1. No agency has identified or targeted the most attractive export promotion opportunities.
2. There are "conflicting or uncoordinated policies toward developing and middle-income markets, which may require long-term market development efforts; issues include ''the appropriate role of development assistance in favoring U.S. commercial interests (e.g., tied aid), investment in training, financing of demonstration projects, and establishing regulatory and testing protocols favorable to U.S. industry.

the need for better coordination and data:

3. "Export promotion activities are poorly coordinated.
4. "At virtually all USG agencies there is a lack of knowledge of existing programs relating to environmental technologies. '
5. "There is no single coherent source of information available to the public about the range of government activities in environmental technologies or industry data collected by the government. '
6. "No data exists for tracking and understanding the industry.''[15]

the need to consider the effect on exports or export potential when fashioning policies on:

7. Environmental technology development, especially at DOE and EPA.
8. U.S. regulatory standards.
9. U.S. positions in negotiations for international standards and multilateral environmental treaties.

the need to better reach smaller fins:

10. Small firms new to exporting.
11. Small and medium-sized firms in need of financing assistance.

The TPCC report was followed in November 1993 by an environmental technologies export

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[13] Ibid., sec. 204.

[14] Ibid.

[15] The report noted that it is "unclear to what extent this lack of data is perceived as a problem by the industry. ' However, such data would help government in setting strategic priorities and evaluating the success of its efforts.

strategy issued by an interagency group established by President Clinton.[16]

State Efforts

Although not discussed in detail here, efforts by State governments and private sector organizations to promote environmental exports merit notice. More and more States are providing export promotion services. In 1992, the States appropriated a total of $97 million for international activities, and had 546 domestic and 303 overseas full-time-equivalent staff, of which 392 domestic and 178 overseas full-time-equivalent were devoted to export promotion.[17] In 1992, 39 States did in-house market research.[18] Some States have environmental export promotion programs.

Private Sector Efforts

Private organizations, such as the United States-ASEAN[19] Council for Business and Technology, the Environmental Business Council of the United States (EBC), and the U.S. Environmental Technology Export Council (ETEC), are working to facilitate U.S. exports of environmental technologies.

A complicating factor in developing a Federal policy is that the environment industry consists of many separate sectors and subsectors. Currently, no industry groups represents the entire industry, though two groups, EBC and ETEC, are seeking that role. There are also several other industry associations for particular subsectors of the industry.

U.S. EXPORT PROMOTION PROGRAMS IN INTERNATIONAL CONTEXT

Countries provide several kinds of assistance to help their firms export. The following sections will briefly describe U.S. and foreign efforts in four areas: assistance for export planning and marketing, technology verification and demonstration, use of foreign aid, and financing. This section gives some overall comparisons.

Level of Funding

Japan and many European countries fund export promotion (especially nonagricultural export promotion) at a higher level than the United States, As discussed below, this is true for export planning and marketing, and export financing. In addition, Japan, France, and Germany, when compared with the United States, structure their foreign aid programs in ways that tend more to promote exports.

Level of Expectations and Importance

In some ways, other countries seem to have higher expectations for, and place higher importance on, government's role in export promotion. (Often the higher expectations go hand-in-hand with higher funding.) Some examples, discussed below, include: more ambitious assistance with export planning; larger staffs posted abroad, capable of rendering more assistance; more high-level advocacy to influence foreign government procurement; a ''needs' versus ''entitlements' approach to export financing; and a more aggressive use of tied aid credits.

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16 Ronald H. Brown, Hazel O'Leary, Carol Browner, *Environmental Technologies Exports: Strategic Framework for U.S. Leadership*, November 1993. In an April 1993 Earth Day address, President Clinton directed the Department of Commerce (DOC) to lead an Interagency Working Group on Environmental Technology. With EPA, DOE, and other agencies participating, this group was to develop strategies to further environmental exports, environmental technology development and domestic diffusion of environmental technology.

17 National Association of State Development Agencies, *NASDA State Export Program Database (SEPD): 1992* (Washington, DC: NASDA, not dated), tables 6, 9. International activities can include export promotion, attracting foreign investment, promoting tourism, and other activities. While staffing figures are available broken down by these purposes, budget figures are not. Ibid., p. 9.

18 Ibid., table 14.

19 ASEAN is the Association of Southeast Asian Nations.

Degree of Centralization[20]

The U.S. approach to export promotion is decentralized, with several agencies having important roles, as discussed later in this chapter. Japan's approach is also decentralized;[21] and Germany limits Federal Government involvement, with trade associations playing a major role. France and the United Kingdom have a centralized approach.

Strategy

The United States has lacked a strategic plan for promoting exports of nonagricultural goods.[22] The September 1993 TPCC export strategy report is a first step toward a strategic plan. Japan and Germany lack a strategic plan, though in Japan some individual agencies (e.g., MITI) have strategic priorities. France and the United Kingdom each have a strategic plan.

Private Sector Involvement

In Japan, France, Germany, and the United Kingdom, private sector organizations (including chambers of commerce and industry associations) play a major role in helping firms (especially smaller firms) to learn about and to use government export promotion services. In some cases, this private sector involvement stems from traditions and institutions not necessarily transferable to the United States. In Germany, local chambers of commerce, financed by mandatory dues, are the primary point of contact to connect firms with government services, overseas chambers of commerce, and other relevant government and private organizations. Overseas chambers of commerce serve functions similar to those of the Commerce Department's United States & Foreign Commercial Service (US& FCS). The German Industry Council for Exhibitions and Trade Fairs (Die Ausstellungs-und Messe-Ausschuss der Deutscher Wirtschaft, or AUMA), a private organization, coordinates domestic and overseas trade events. In France, local, regional, and overseas chambers of commerce play important roles, as does the Federation of Small and Medium-Sized Industries. Local chamber of commerce membership is mandatory in some cases. Chambers of commerce play an important role in the United Kingdom, and trading companies and industry associations play important roles in Japan.

In the United States, the private sector role in assisting access to Federal programs is more limited. However, some environmental industry associations play this role to some extent, including the U.S.-ASEAN Council for Business and Technology, the United States Export Council for Renewable Energy, ETEC, and EBC. American Chambers of Commerce and American Business Councils abroad can potentially play an increased role.

ASSISTANCE FOR EXPORT PLANNING AND MARKETING

Export planning and marketing services include educating firms about the export process; gathering and disseminating market information; helping firms to make contacts in foreign markets, such as by sponsoring trade fairs and trade

20 The discussion of degree of centralization, strategy, and private sector involvement is drawn in part from U.S. Congress, General Accounting Office, *Export Promotion: A Comparison of Programs in Five Industrialized Nations,* GGD/92-97 (Gaithersburg, MD: U.S. General Accounting Office, June 22, 1992), pp. 16-22; U.S. Congress, Office of Technology Assessment *Development Assistance, Export Promotion, and Environmental Technology,* op. cit., footnote 1, pp. 55-69.

21 Major functions are performed by the Japan External Trade Organization (JETRO), the Small Business Corporation (SBC), and the Export-Import Bank of Japan (JEXIM). Aid functions with export promotion effect are performed by the Japan International Cooperation Agency (JICA) and the Overseas Economic Development Fund(OECF). These functions are all performed pursuant to policies formed by the Ministry of International Trade and Industry (MITI), Ministry of Finance(MOF), Economic Planning Agency, and Ministry of Foreign Affairs (MOFA). Several other agencies have significant roles.

22 As used here, a "strategic plan" is a plan that sets priorities for what exports to promote (normally by industry sector and geographic region), to guide all agencies' programs.

Table 6-3—U.S. General Accounting Office Estimates of 1990 National Government Export Promotion Outlays, Excluding Agriculture

	Spending ($ million)	Spending ($) per $1,000 exports	Spending ($) per $1,000 GDP
France[a]	417	1.99	0.35
Germany	93	0.22	0.062
Italy	309	1.71	0.284
United Kingdom	298	1.62	0.305
United States	231	0.59	0.043

a French officials were unable t. separate the agricultural spending from the total but stated that most of the total shown is for nonagricultural programs.

NOTE: Exchange rates used (average for t990) are: U.S. $1 equals 5.7 FF (France), 1.7 DM (Germany), 1254.3 L (Italy), 0.592 (UK).

SOURCE: U.S. Congress, General Accounting Office, *Export Promotion: A Comparison of Programs in Five Industrialized Nations,* GGD/92-97 (Gait hersburg, MD: U.S. General Accounting Office, June 22, 1992), p. 24. Based on GAO analysis of information provided by government officials.

missions;[23] and high-level advocacy to influence foreign government procurement. Judging from three U.S. Government reports--one by the General Accounting Office (GAO), and the other two by the Department of Commerce (one published in 1992 and the other in 1988)24—the United States appears to have spent proportionately less on such services than several competitor countries (at least in the period 1987-1990). This difference appears more pronounced when agricultural export promotion is excluded. Together, these reports paint the following picture: the U.S. Government, by many measures, spends less, often many times less, than every major competitor studied, except for Germany, which by some measures the United States outspends. In addition to spending less overall, the United States allocates funds lopsidedly to agricultural (rather than industrial) exports compared to the four other countries for which such data are available.

The GAO Report (table 6-3) covers five countries: France, Germany, Italy, the United Kingdom, and the United States. It is restricted to spending at the national government level, and, except for France, excludes spending on agricultural export promotion. French officials did not break out the agricultural portion but stated that the majority of the spending shown was for nonagricultural export promotion. The table shows that, for nonagricultural export promotion, the United States spends far less per $1,000 exports, and many times less per $1,000 Gross Domestic Product (GDP), than France, Italy, and the United Kingdom. The United States is closer to Germany, spending more per $1,000 GDP but less per $1,000 exports. However, in Germany the role of entities other than the national government (including officially sanctioned chambers of commerce) is relatively large; when these are included (as in the 1988 DOC report, discussed below), Germany's expenses appear somewhat larger.

The 1992 DOC Report, restricted to national government budgets, shows the U.S. commitment as many times less than those of the European countries per $1,000 Gross National Product (GNP) and per total national government budget, and far behind the European countries per $1,000 exports and per capita (table 6-4). (Again, Ger-

23 Trade missions are marketing trips by a number of firms together to foreign countries; trade fairs are exhibitions at home or abroad of products and services by many vendors to potential customers.

24 Citations to the reports are given in tables 6-3 through 6-5. For the information discussed here, both DOC reports relied p rimarily on 1987 data. However, the 1987 data presented in these two DOC reports do not appear to agree. The GAO report is based on 1990 data.

Table 6-4--U.S. Department of Commerce Estimates of National Government Budgets for Export Promotion in 1987

Country	Budget ($ million)	Budget ($) per $1,000 exports	Budget ($) per $1,000 GNP	Export promotion budget as percentage of total national government budget	Budget ($) per capita
Canada	432.9	4.75	1.17	0.47	16.97
France	189.1	1.27	0.21	0.11	3.44
Germany	61.5	0.21	0.06	0.041	1.01
Italy	196.9	1.69	0.26	0.58	3.36
Japan[a]	285.0	1.04	0.10	0.061	2.30
South Korea	54.2	1.14	0.42	0.030	1.29
United Kingdom	190.9	1.41	0.28	0.122	2.81
United States[b]	257.2	0.88	0.06	0.002	1.05

a Uses 1989 data. Consists of JETRO's budget ($91 million) plus MITI's and the Ministry of Foreign Affairs' budget for commercial services.

b Consists of US&FCS budget ($57.8 million), Commerce and State Departments' budgets to promote industrial exports, and Department of Agriculture's budget ($157 million) to promote agricultural exports.

NOTE: A footnote to the original table states, "Numbers from 1987 Department of Commerce study unless otherwise indicated." OTA infers that 1987 refers to the year studied, though it could instead refer to the year in which the report was published.

SOURCE: U.S. Department of Commerce, *Foreign Government Commercial Services.' A Comparative Study,* undated, table 2. This report appears to be the final version of a draft report of the same title, dated April 1992, issued by the U.S. & Foreign Commercial Service as Strategic and Technical Reviews Working Paper SR 91-15, although a DOC staff contact could not verify this.

many is an exception.) This study includes Canada, South Korea, and Japan, which the other two studies do not. Canada's budget far exceeds even the European budgets; South Korea shows the same pattern as the European countries. Japan's budget, while not providing as sharp a contrast with the United States, still is substantially greater per $1,000 exports and per $1,000 GDP, over twice as great per capita, and over 30 times greater as a fraction of the national government budget.

The 1988 DOC Report presents spending by the United States and seven European countries.[25] In some ways it is the most detailed and complete of the three reports. It includes, separately stated, spending by the national government, local governments, quasi-governmental agencies, and co-operating nongovernmental organizations (table 6-5). The inclusion of all of these spending entities makes Germany's spending appear somewhat larger compared to the United States than it does in the other two reports, which cover only national government spending (or budgets). Of the eight countries studied, the United States was lowest in total export promotion spending per $ 1,000 GNP, per total national government spending, and per capita; it was sixth (ahead of Germany and Belgium) in total export promotion spending per $1,000 of exports. As in the two other studies, foreign spending figures were often many times the corresponding U.S. figures.

For Belgium, France, Italy, the United Kingdom, and the United States, the 1988 DOC report also separates agricultural from industrial export promotion, both in absolute spending and in spending per $1,000 of that type of export. The

25 The Commerce Department noted that "Japanese totals are not provided, due to major gaps in available spending data."

Table 6-5—U.S. Department of Commerce Estimates of Total Export Promotion Spending in 1987a

	Spending by National government ($ million)	Spending by local government ($ million)	Spending by quasi-gov't agencies ($ million)	Spending by cooperating non-gov't organizations[b] ($ million)	Total spending ($ million)	Total spending for agricultural export promotion ($ million)	Total spending for industrial export promotion ($ million)	Total spending for agricultural export promotion per $1,000 agricultural exports ($)	Total spending on industrial export promotion per $1,000 industrial exports ($)	Total spending per $1,000 total exports ($)	Total spending per $1,000 of GNP[c] ($)	Total spending (on export promotion) per $1,000 total national government spending ($)	Total spending per capita ($)
Belgium	45.8	0.5	16.6	NA	62.9	4.5	58.4	0.46	0.74	0.71	0.40	1.09	6.35
Canada	484.3	60.7	0.0	1.8	548.8	43.7	503.1	NA	NA	6.00	1.48	6.02	21.44
France	330.1	NA	2.5	8.1	340.7	2.5	338.2	0.09	2.01	2.18	0.47	1.95	6.19
Germany	61.5	12.6	9.2	18.8	102.1	5.1	97.0	NA	NA	0.35	0.11	0.68	1.67
Italy	209.3	NA	10.0	NA	219.3	30.7	188.6	9.30	1.78	2.00	0.29	0.64	3.74
Sweden	10.0	1.5	60.0	0.9	72.4	2.2	70.2	NA	NA	1.65	0.46	1.33	8.72
United Kingdom	190.9	NA	2.7	0.5	194.1	2.7	191.4	0.29	1.51	1.43	0.28	1.24	2.85
United States	261.6	30.0	2.4	0.0	294.0	173.0	121.0	5.95	0.54	1.16	0.06	0.29	1.20

a Spending levels are minimum estimates, based only on amounts that could clearly be accounted for. NA indicates that no data were available even for minimum estimates. Accordingly, actual spending could conceivably be much higher that the totals shown.

b Cooperating nongovernmental organizations include only those that act in concert with the government or on its behalf as an integral component of the government's organizational strategy.

c Gross Domestic Product (GDP) is used instead of Gross National product (GNP) for Canada and Italy.

NOTES:

Exchange rates used : U.S. $1 equals 35 BF (Belgium), 1.36 C$ (Canada), 6.05 FF (France), 1.8 DM (Germany), 1300 L (Italy), 138 yen (Japan), 6.40 SEK (Sweden), 0.59 f (U. K.)

The source document could be interpreted to indicate that for a few entries in this table, 1987 data were not available and data from an earlier year were substituted.

SOURCE: U.S. Department of Commerce, *Export Promotion Activities of Major Competitor* Nations, September 1988, p. 6 (table A) and p. 58 (app. 1).

United States ranked second highest in agricultural export spending per $1,000 of agricultural exports, but lowest in industrial export promotion spending per $1,000 of industrial exports. The United States only spent one-eleventh as much on industrial exports as on agricultural exports, per $1,000 of each type of export. In contrast, France spent 29 times as much on industrial exports, the United Kingdom 5 times, Belgium 1.6 times, and Italy one-fifth as much.

Export Education

Both DOC and SBA provide short, introductory export seminars. For example, many local SBA offices run half-day workshops organized by the Service Corps of Retired Executives (SCORE), a nationwide network of retired executives. Introductory seminars typically give rationales for exporting, explain the steps required, and describe Federal export promotion programs.

Most export education for U.S. firms is undertaken by States and local trade associations, chambers of commerce, world trade center institutes, and other groups. In 1992, all States held export seminars, probably in total close to a thousand; many were cosponsored by DOC or SBA. Some were general seminars; others were on market opportunities in a particular country, a specialized topic such as documentation or freight-forwarding, or current events.[26]

Some European Community and Nordic countries are experimenting with more comprehensive programs that assist firms over an extended time to formulate an export strategy. One example is a pilot program run by the Danish Technology Institute, with six firms each from Denmark, Ireland, and the Netherlands, funded in part by the country governments and the EC Social Fund.[27] Over 18 months, these firms participated in six national seminars and three international seminars on export planning,[28] plus regular progress-and-advice visits by facilitators. Each company produced a 2- to 5-year strategic plan to internationalize its operations; almost all successfully implemented the plan. This program has since expanded to other countries.

Denmark, Norway, and Sweden run export manager-for-hire programs to help small companies develop and implement export strategies.[29] On a cost-shared basis, the governments provide export managers. In Sweden, companies can hire around 20 to 40 percent of an export manager's time for 2 to 4 years. The managers are export professionals with substantial private sector experience. In 1987, the Swedish Trade Council retained 23 such professionals under contract. The export manager develops an export strategy while training company personnel in export techniques. In the first year, the companies pay 49 percent of the manager's cost; the companies pay 75,95, and 100 percent for the second, third, and fourth years respectively, For firms that need less help, the Swedish Trade Council will also cover up to 60 percent of up to 60 hours of export consulting.

General Market Information

Some of the market information governments provide to exporters is collected and disseminated routinely, rather than in response to specific requests from particular firms. Such information includes: trade statistics; studies of foreign markets in particular sectors; descriptions of foreign technology; and data on foreign countries' econo-

26 National Association of State Development Agencies, *NASDA State Export Program Database,* op. cit., footnote 17, p. 22 and table 20.

27 Discussion of this program is based on Nothdurft, op. cit., footnote 3, pp. *19-*1.*

28 Each of these seminars required significant preparation by the companies. The national seminars were on general management, export marketing management, financial controls management, technology and production management, leadership and organization culture, and strategic management and planning. The international seminars discussed export marketing, technology and production, and leadership and organization.

29 'rhis paragraph is based on Nothdurft, op. cit., footnote *3,* pp. *31-32.*

mies, business cycles, regulations, tariffs and other trade barriers, government purchasing, investment climate, aid projects, and trade fairs. It also includes specific trade leads collected by the government's normal monitoring, though such leads are often old. Because general information is much cheaper than specific market research, some companies hope these services by themselves will pinpoint customers. However, this hope is unrealistic; rather, general information just points to markets where firms might look for customers.[30]

France, Germany, Japan, the United Kingdom, and the United States all appear to offer similar services for general market information.[31] U.S. firms may contact DOC desk officers that track information for particular countries. In addition, DOC publishes information for relatively low prices. In the National Trade Data Bank (NTDB), a monthly compact disk service, DOC provides information about foreign markets and Federal services. From September 1989 to November 1992, the NTDB contained 101 Industry Subsector Analyses (ISAs) on the pollution control equipment markets in 38 countries, almost 5 percent of all ISAs in the NTDB.[32] DOC provides two other sources with information similar to that in the NTDB: an Electronic Bulletin Board. which is more timely, and printed journals, which are less timely.[33] All three sources provide both general information and specific leads; however, even the most timely Electronic Bulletin Board probably provides leads only after they are known to firms with an active presence and strategy in the country.

Helping Firms Find Customers

While general market information can be helpful, exporters need quite specific market information and ways to contact potential customers. It is difficult to get data that accurately compares different countries' programs, in part because these programs are organized differently, often described in different terms, and not always precisely described. The data presented in this section, while not definitive, suggest that U.S. programs are often less ambitious than programs in competitor countries.

MARKET RESEARCH SUPPORT

Table 6-6 shows assistance that several countries give for custom research. This can include in-house research; research contracted out; and published reports that fit a firm's special needs. The United States and Germany furnish reports; the United States charges full cost and Germany subsidizes the cost. France, Scandinavia, and the United Kingdom support firms in hiring their own consultants or doing research in-house; the United Kingdom also similarly supports trade associations. In some cases, only smaller businesses are eligible.

The U.S. assistance seems to be much less, on an absolute scale, than that provided by France and the United Kingdom,[34] even though the United States has a much larger economy and export volume, The United States contracts with local firms for about 160 studies per year, passing the full contract price on to the requesting U.S. firm; the United Kingdom subsidizes about 600 consultant studies per year (plus some in-house research and some purchasing of published re-

[30] Ibid., p. 43.

[31] See for example, the country appendices in U.S. Department of Commerce, *Foreign Government Commercial Services: A Comparative Study*, draft, April 1992, issued by the U.S. & Foreign Commercial Service as Strategic and Technical Reviews Working Paper SR 91-15.

[32] Andy Bihun, U.S. Department of Commerce, United States and Foreign Commercial Service, international Market Research Division, facsimile transmittal of computer printout, "Industry Subsector Analyses (ISA) on Pollution Control Equipment, " Nov. 24, 1992.

[33] The Electronic Bulletin Bored costs $35 per year, plus a per-minute charge (after the first 2 hours each year) of $.05 to $.20, depending on time of day.

[34] The sources for table 6-4 do not present comparable data for Germany and Scandinavia countries.

Table 6-6—National Government Assistance for Individualized Market Research

Country	Service
France	France funds up to half the cost of hiring a consultant to carry out detailed research on a market, up to about $30,000 (average cost is about $10,000).[a] Firms apply to their regional government or chamber of commerce and industry. **Only small and medium-sized enterprises (SMEs) are eligible. About 100-150 consultancies per year are approved in the Paris area alone.** **France's export insurance and guarantee agency also offers insurance against unprofitable export research. The insurance covers up to 75 percent of a firm's "fixed costs"[b] to investigate overseas markets which exceed related export profits. Both domestic and overseas costs are covered.**
Germany	**Through local chambers of commerce, the German government's Office of Trade Information provides custom studies at below-cost prices.[c]**
Scandinavian Countries	**The "Export Manager for Hire" schemes run by Denmark, Norway, and Sweden subsidize the hiring of export managers, who conduct research for the firm.**
United Kingdom	**Through a program managed by the Association of British Chambers of Commerce, the British Overseas Trade Board (BOTB) provides to trade associations and to firms with under 200 employees:** • **Free consulting on how to conduct export marketing research.** • **Up to half the cost of hiring a consultant outside the EC, up to a grant of £20,000 (equal to $33,898 in 1990). Trade associations get better terms. Roughly 600 consultancies are approved per year, with an average cost of about $20,000.[d]** • For in-house research on non-EC markets, up to half of travel costs and interpreters' fees, plus a daily allowance for one researcher, up to the same £20,000 limit. • Up to one-third the cost of published market research reports.
United States	**The Department of Commerce provides "Customized Sales Surveys" reporting on overall marketability, key competitors, price of comparable products, customary distribution and promotion practices, trade barriers, possible business partners, and applicable trade events. DOC contracts out these studies and charges firms their full cost, which is $800 to $3,500 per country. DOC provided 151 of these studies in FY 1993, and 171 in FY 1992.**

a The source document (Nothdurft) does not specify whether these numbers are maximum and aVerage costs for the whole study or just the government's share.
b The source (GAO) does not define this term.
c While this table compares national government support, we note that in 11 German states, the state Ministry of Industry, working through the national Association of Chambers of Industry and Commerce (IHK), pays 25 to 30 percent of the cost of custom studies prepared by IHK's affiliated bilateral Chambers of Commerce Abroad.
d It is not clear from the source document (Nothdurft) whether the $20,000 represents the total cost, or just the government's share.

SOURCE: U.S. Congress, General Accounting Office, *Export Promotion: A Comparison of Programs in Five Industrialized Nations*, GGD/92-97 (Gaithersburg, MD: U.S. General Accounting Office, June 22, 1992), p. 29; William E. Nothdurft, *Going Global: How Europe Helps Small Firms Export* (Washington, DC: Brookings Institute, 1992), pp. 43-45; Trade Promotion Coordinating Committee, "Export Programs: A Business Directory of U.S. Government Resources," April 1993; telephone conversations with DOC staff (for U.S. program).

ports), and France subsidizes 100 to 150 consultant studies per year for firms in the Paris area alone. In addition, the costs of the U.S. studies ($800-$3,500) are much less than the average costs of the consultant studies subsidized by France ($10,000) and the United Kingdom ($20,000); thus, the foreign studies are probably more substantial.

The British Overseas Trade Board (BOTB), the United Kingdom's export promotion agency, reports that its consultant study subsidy program has the highest customer satisfaction rate of all

BOTB advice and information services, and claims that virtually all companies using this program have started exporting to their target markets.[35]

TRADE FAIRS

A trade fair is an event at which many vendors exhibit their products or services to potential customers. The U.S. Government and many foreign governments help their firms participate at international trade fairs run by the government and some run by third parties. The Commerce Department runs or sponsors about 80 international trade fairs per year.[36]

While precise comparative data is difficult to obtain, it appears that U.S. firms receive less government support than firms in several other countries for participation in trade fairs, From table 6-7 it appears that foreign firms typically have some of their exhibit-related expenses (e.g., space rental) paid for, while U.S. firms do not. Some argue that this difference in subsidies substantially decreases U.S. firms' participation, compared to foreign counterparts. Some foreign governments started or increased their support to correct what they viewed as inadequate trade fair participation by national fins. In contrast, the U.S. Government's response to low participation rates by U.S. firms was to cut back its trade fair program.

In 1992, State governments sponsored an average of 5.8 trade fairs; 13 State governments provided some type of financial assistance for participating firms.[37]

TRADE MISSIONS

A trade mission is a trip by a group of firms (most often in one industry sector) to one or more foreign countries to meet potential customers and to learn about the nation(s), the market(s), and how to do business there. When U.S. firms go on trade missions, they may also meet U.S. and foreign government officials responsible for trade and investment. Data are not readily available to compare U.S. support for trade missions with that provided by other governments.

Nonagricultural missions run by the Federal Government are usually run by DOC, though other agencies such as USAID, DOE, EPA, and OPIC are sometimes co-sponsors. In fiscal year 1993, DOC ran 44 missions, of which four had environmental themes.[38] DOC and other agencies also can sponsor missions run by non-Federal organizations such as trade associations, State and local governments, and chambers of commerce. In fiscal year 1993, DOC sponsored 41 such missions, of which none had environmental themes.[39] Box 6-B describes an environmental mission in which several Federal agencies cooperated. For most DOC-run missions, participants pay fees of $2,000 to $5,000[40] plus their own travel expenses. Fees are lower for DOC's more modest Matchmaker Delegations, which are for companies that have not yet exported to the target country. SBA at one time provided qualifying companies up to $700 for a Matchmaker trip, which according to one DOC official was a key *incentive* for small business; but this was suspended in March of 1992.[41]

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35 Nothdurft, op. cit., footnote 3, p. 44.

36 Trade Promotion Coordinating Committee, "Export Programs: A Business Directory of U.S. Government Resources," April 1993, p. 26.

37 National Association of State Development Agencies, *NASDA State Export Program Database, Op. Cit.,* footnote 17, pp. 30-31.

38 DOC staff, facsimile communication, OCt. 19, 1993.

39 Ibid.

40 Trade Promotion Coordinating Committee, "Export Programs: A Business Directory of U.S. Government Resources,' op. cit., footnote 36.

41 U.S. Congress, General Accounting Office, *Export Promotion: Problems in the Small Business Administration's Programs,* GGD/92-77 (Gaithersburg, MD: U.S. General Accounting Office, Sept. 2, 1992), p. 11.

Table 6-7-National Government Support for Participation in Trade Fairs

Country	Support
France	Refunds 50-60 percent of the firm's "total cost"[a] of participation in government-sponsored and government-organized international trade fairs if the fair is not profitable for that firm.
Germany	Firms pay for "exhibition space rental and freight transportation"; government (through nongovernment fair organizers) pays "the remaining costs." In practice, this means that the government pays "roughly 30 percent of the cost of participation."[b]
Italy	For government-sponsored foreign trade fairs, pays all "indirect costs, such as publicity and representational events," and pays "direct costs such as construction of displays and space rentals on a cost-sharing basis with the participating firms."[c]
	Industry consortia and overseas chambers of commerce also run trade shows, and contribute support ultimately provided by the government. The so-called R.O.M.E. consortium, for example, pays up to 70 percent of "total expenses."[d]
United Kingdom	Pays up to 50 percent of estimated cost of providing space, stands, utilities, and display aids in selected trade fairs.
European Community	Pays up to 50 percent of the firm's "total cost," including space rental and construction expenses,[e] in EC-sponsored fairs.
United States	For DOC-run fairs, firms must reimburse DOC for all "direct" expenses excluding salaries and overhead. This includes "booth construction, transportation, interpreters' charges, and space rental." For major international trade fairs, the "minimum cost charged by the Department of Commerce. . . may range from $3,000 to *$7,500."*

a It is not clear whether "total cost" is meant to include the firm's own travel costs, or just the government's or other fair organizer's coats initially charged to the firms (e.g., space rental).
b It is not clear whether the figure of 30 percent reflects a consideration of all costs-for example, the firm's personal travel expenses, and the cost of publicity or government staff time.
C It is not clear what the cost-sharing percentages are. It is not clear whether firms' travel expenses are cost-shared.
d It is not clear what "total expenses" includes.
e It is not clear what else "total cost" includes.

SOURCES: U.S. Congress, General Accounting Office, *Export Promotion: A Comparison of Programs in Five Industrialized Nations,* GGD/92-97 (Gaithersburg, MD: U.S. General Accounting Office, June 22, 1992), pp. 28-28, and discussions with GAO staff; some information on the United Kingdom is from documents supplied by the British Embassy in Washington, DC.

OVERSEAS COMMERCIAL REPRESENTATION

A well-funded and staffed overseas commercial service can help companies identify and pursue trade opportunities. The Commerce Department's U.S. & Foreign Commercial Service (US&FCS) has staff posted abroad in U.S. embassies. Compared to its European competitors, Canada, and Japan, the United States has the lowest ratio of foreign posted commercial staff to exports, and by far the lowest ratio of foreign posted commercial staff to GDP (table 6-8).

After the United States, Japan has the next lowest staffing ratios. However, Japan's overseas commercial service strengths vis-à-vis the United States are not all reflected in the table's numbers. Japan's staff appears to be concentrated in the most significant markets. For example, DOC reported that when the Japan External Trade Organization (JETRO) employed 74 commercial officers and 144 total staff in the United States (the latter amounting to a quarter of JETRO's total overseas staff), the US&FCS employed only

Box 6-B-The Mae Moh, Thailand, Power Project

The Mae Moh power project was an attempt by U.S. industry and several U.S. Government agencies to act in concert to sell clean coal technologies to Thailand. The project provides a case study of interagency and government/industry cooperation.

In June 1992, the U.S.-ASEAN Council for Business and Technology[1], with the support of the U.S. Agency for International Development (USAID), the Department of Commerce (DOC), the Department of Energy (DOE), and the Environmental Protection Agency (EPA), organized an eight-firm trade mission to Indonesia and Thailand. The Trade Promotion Coordinating Committee, an interagency group, partly facilitated the organization of the mission, through its Coal Technology Export Group. TPCC also helped gain agency support for the trade mission, kept the agencies briefed on the mission development, and provided a forum where all participants could agree on what message to send the hosts. In-country organization was orchestrated through the U.S. and Foreign Commercial Service (US&FCS) and USAID's ASEAN Regional Office in Bangkok. The U.S.-ASEAN Council helped incorporate industry input and planned the mission from the U.S. side.

Participants identified an opportunity to supply the Electricity Generating Authority of Thailand (EGAT) with U.S. clean coal technologies. EGAT plans to increase its coal (including lignite) generating capacity from 2,100 MW to 11,775 MW by 2006. Desulfurization technologies (retrofit and new installations) were identified as a market opportunity at EGAT's active mine development project at Mae Moh.

After the June trade mission, the U.S.-ASEAN Council wrote a draft mission report that identified market opportunities and mapped out a plan for followup action. This draft was reviewed by representatives from industry and the four participating agencies, and was released in the first week of September.[2] Recommendations included funding for feasibility studies, a reverse trade mission, and a demonstration project at Mae Moh to inform Thai officials about U.S. technology and its potential to meet their needs. Although there was general agreement that such activities should be pursued, the four participating agencies were slow to provide funding. Because EGAT wanted fast action, US. companies considered whether they should go it alone without government assistance. Without the support of the U.S. Government, however, Thai officials were less likely to be certain that they were being offered the most appropriate technologies.

The U.S. Government and industry periodically sent officials to Thailand to maintain interest in the U.S. proposal. The U.S. Trade and Development Agency sent two consultants to conduct a definitional study for a pre-feasibility study. The head of the U.S.-ASEAN Council and an Assistant Secretary of Commerce made a detour from another trade mission to check in with EGAT officials, and AID's Off ice of Energy and infrastructure also sent officials to Thailand. These trips may have helped reassure EGAT officials that the United States took this project seriously.

The project became more urgent after a temperature inversion and power plant emissions created a health emergency in the vicinity of Mae Moh in October 1992. in the meanwhile, US. industry received news that Japan had packaged and submitted a proposal to the Thai Government in October 1992.

1 ASEAN is the Association of South East Asian nations consisting of Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore, and Thailand. The U.S.-ASEAN Council for Business and Technology is a private organization promoting trade and investment between the United States and ASEAN countries.

2 U. S.-ASEAN Council for Business and Technology, inc. "Mission Report; U.S. Coal Technology Mission to Thailand and Indonesia."

(Continued on next page)

Box 6-B–The Mae Moh, Thailand, Power Project-Continued

Thai officials asked EPA to conduct health and environmental assessments. In January 1993, EPA and DOE assessed health and environmental damage from the October emergency and identified U.S. sulfur dioxide control technologies appropriate for the Mae Moh facilities. A reverse trade mission brought Royal Thai Government and EGAT officials to the United States in March 1993. USAID's Bangkok office monitored and communicated progress at Mae Moh.

in the end, a Japanese company won contracts to provide fluegas desulfurization technology to new and existing boilers at Mae Moh.[3] Reportedly, last minute concessional financing from the Japanese government tipped the balance away from the U.S. contenders which had submitted a lower bid than the Japanese and which-according to some Thai officials--offered the better technology. Japanese contacts with EGAT officials were probably a factor as well. A U.S. firm did win a sole source contract to provide computerized process monitoring services for all units at Mae Moh. Another U.S. company is well-positioned to earn a contract to provide air quality monitoring equipment at Mae Moh and other Thai facilities. Both of these American companies believe that this presence in the Thai market will lead to long term business opportunities in Thailand and the region.

The Mae Moh experience provided some lessons. While TPCC coordinated the trade mission, it had problems coordinating follow-up action and funding. And although TPCC served as a useful information clearinghouse among participating agencies, it was not the primary motor for action. The TPCC's Coal Subgroup met only twice over the period of this project. Most of the day-today work was carried out by the U.S.-ASEAN Council, which served as a liaison, persuading industry and the agencies to make commitments and informing agencies of progress and of the activities of other agencies. As a non-governmental body, the Council may have been able to facilitate cooperation, and work through turf issues. It maybe that private multiplier entities will play a key role in packaging disparate Federal export promotion services for environmental companies. The U.S.-ASEAN Council, agency participants, and firms are hopeful that coordinated project-focused export promotion efforts can be improved and employed elsewhere.

Perhaps the major lesson is that money talks. Despite the various actions Federal agencies took in support of the US. company contenders and the apparent ability of the U.S. firms to provide appropriate technology at a good price, foreign government concessional financing determined the outcome for a major portion of the project.

3 Len Jornlin, U.S.-ASEAN Council for Business and Technology, personal Communication, Oct. 14, 1993.

11 commercial officers in Japan.[42] JETRO's commercial officers are not rotated as often as U.S. staff, better allowing them to become experts on specific markets.[43] Because of their nondiplomatic status and their close relationship with industry, JETRO officers maybe more attuned to industry needs.

In addition, table 6-8 includes only JETRO staff; it omits diplomatic staff. ' 'Japan's diplomatic corps regards export promotion as a major

42 U.S. Department of Commerce, *Foreign Government Commercial Services: A Comparative Study,* undated. This report appears to be the final version of the draft cited in footnote 31, though a DOC staff contact could not verify this.

43 Ibid., p. 7.

Table 6-8-Foreign Commercial Service Staffing,[a] 1990

Country	Overseas posts	Commercial officers	Local professional staff[b]	Total staff	Total staff per $100 billion of GDP	Total staff per $1 billion of exports
France	180	100	1,130	1,230	108	5.87
Germany	50[c]	NA[d]	NA	960[e]	67	2.28
Italy	83	170	580	750	72	4.14
Japan[f]	76	300	300	600	18	1.72
United Kingdom	185	523	961	1,484	159	8.05
United States	123	155	460	615	11	1.56

a This table excludes staff for agricultural export promotion. General Accounting Office staff, personal communication, Oct. 25, 1993.
b The United States employs foreign nationals as commercial specialists, who are called "foreign service nationals" (FSNS). For the United States, the number given represents FSNS; for other countries, the number given represents FSN equivalents.
c These posts are all chamber of commerce Offices.
d NA denotes not available.
e Includes 900 commercial staff in overseas chambers of commerce.
f Staffing and posts as of March 1992; GDp and export data for 1991. staffing and posts are those of the Japan External Trade Organization (J ETRO).

NOTE: Exchange rates used: one U.S. dollar equals 5.7 francs (France); 1.7 DM (Germany); 1,254.3 i ire (Italy); 134.7 yen (Japan); 0.59 £ (United Kingdom).

SOURCES: U.S. Congress, General Accounting Office, *Export Promotion: A Comparison of Programs in Five Industrialized Nations,* GGD/92-97 (Gaithersburg, MD: U.S. General Accounting Office, June 22, 1992), p. 25 (based on GAOanalysis of information provided by government of ficials), and discussions with GAO staff. ForJapan posts and staffing: JETRO, "JETRO: Japan External Trade Organization," not dated, p. 17 (reporting data as of March, 1992). For GDP data, and for export data for Japan: International Monetary Fund, *International Financial Statistics*, September *1992* and April 1993.

priority, "[44] though staffing figures are not available. On the other hand, table 6-8, which gives JETRO's total overseas staff, could overstate JETRO's export promotion staffing. The reason is that recently JETRO has expanded its mission from export promotion to include import promotion as well. In response to international pressure on Japan to increase its imports, JETRO staff are expending substantial effort to help U.S. firms sell in Japan's market; JETRO may be doing the same for firms in other countries. JETRO claims that its primary mission is now import promotion. However, this claim is difficult to verify, and such a shift would be surprising in view of Japan's historical philosophy and policies and its continuing drive to compete for world market share. Thus, it seems likely that JETRO's mission is still predominantly to promote exports. Moreover, a core JETRO function is gathering information on foreign firms and markets and reporting that to Japanese firms; and even staff nominally engaged in import promotion are in a good position to continue that function.

Another factor is the overseas export promotion staff's sectoral expertise and focus. In this regard, U.S. agriculture (not included in table 6-8) is well represented; as of September 1993, the U.S. Department of Agriculture's Foreign Agricultural Service had export promotion staff in 79 overseas offices covering 117 countries, which together represented 100 percent of the market for U.S. agricultural exports.[45] In contrast, US&FCS officers are generalists working to promote all types of nonagricultural exports. However, the

44 Trade Promotion Coordinating Committee, *Toward a National Export Strategy,* op. cit., footnote 4, p. 75.

45 Ibid., p. 28.

Export Enhancement Act of 1992 could lead to placement of some environmental specialists. That Act authorizes the Secretary of Commerce to designate a Foreign Commercial Service Officer as an Environmental Export Assistance Officer in any country ''whose companies are important competitors for United States exports of environmental technologies, goods, and services, ' or "that offers promising markets for such exports."[46] That Officer's duties would include ''assess[ing] government assistance provided to producers of environmental technologies, goods, and services in such countries, the effectiveness of such assistance on the competitiveness of United States products, and whether comparable United States assistance exists"; pointing U.S. producers to assistance programs; informing U.S. firms of foreign standards and regulations; helping companies identify market opportunities and potential customers; and helping them obtain necessary business services abroad.[47]

In addition, since the time covered in table 6-8, US-AEP has opened nine business offices in Asian capitals to strengthen commercial representation for U.S. environmental products and services. The USAID-funded Private Investment and Trade Opportunities Organization has staff in the ASEAN region to promote exports and investment, with emphasis on environment, energy, health care, and food industries.

OUTREACH TO POTENTIAL CUSTOMERS

Providing databases to potential customers is one form of outreach. EPA, USAID, and DOE co-sponsor the Environmental and Energy Efficient Technology Transfer Clearinghouse, an on-line computer service of linked databases that provides users with vendor, technical, and regulatory information for pollution control, renewable energy, and energy efficient technologies. Managed by the World Environmental Center (a nonprofit organization), the Clearinghouse as of December 1992 operated in four Mexico City locations, in Vienna at the United Nations Industrial Development Organization, and in Washington at EPA and the Inter-American Development Bank; other locations are planned.[48] EPA makes its Vendor Information System for Innovative Treatment Technologies (VISITT), a database on U.S. technologies to treat contaminated groundwater, soils, sludges, and sediments, available to foreign companies. The most recent database gives has technical descriptions and vendor information for over 230 technologies offered by 140 vendors, although some of these technologies are not yet proven at full commercial scale.[49]

Another outreach activity is the reverse trade mission, in which foreign government and industry officials travel here for presentations by U.S. fins. The U.S. Trade and Development Agency (TDA), discussed in more detail later in this chapter, brings officials from low- and middle-income countries to the United States on such missions. In fiscal year 1992, TDA spent $1.9 million on reverse trade missions to show U.S. technology to developing country private and public sector representatives planning major capital projects.[50]

Other countries may have similar outreach activities; no comparison is attempted here.

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46 The Export Enhancement Act of 1992, op. cit., footnote 7, sec. 204(a), adding 15 U.S.C. 4728(d).

47 Ibid.

48 EPA, ''Global Markets for Environmental Technologies: Defining a More Active Role for EPA Within a Broader U.S. Government Strategy," Report of the EPA Task Force on Technology Cooperation and Export Assistance, December 1992, p. 5.

49 EPA, "WSIIT Vendor Information System for Innovative Treatment Technologies: User Manual (VISITT Version 2.0), ' EPA 542-R-93-O01, No. 2, April 1993.

50 U.S. Trade and Development Agency, 1992 *Annual Report,* Washington, DC, 1993, p. 8.

High-Level Advocacy to Influence Government Procurement

Foreign governments have sometimes been forceful advocates for their national firms when bidding on other countries' government projects. Even heads of states have made personal appeals to procuring governments. While the U.S. government has done some high-level advocacy, it has done much less than many other governments and has not set strategic priorities for advocacy. The Clinton administration plans to greatly increase high level advocacy and to set strategic priorities.[51]

TECHNOLOGY VERIFICATION AND DEMONSTRATION

An important aspect of selling goods and services is to convince potential customers that they will work as claimed. In the environment field, testing by the customer is often not practical, and a technology's failure to perform as advertised could have not only environmental but regulatory consequences. In this context, independent evaluation of the technology by a credible third party can help to lessen a potential customer's doubts. Such an evaluation would report the technology's cost and performance under specified conditions.

In many ways, the U.S. Government is in a good position to foster such independent evaluations. It can provide land test sites; guarantee no legal liability if a test fails; and lend its credibility to independent evaluations by performing them itself or hiring persons to do them under government supervision. In particular, EPA's worldwide technical reputation could make a test done under EPA auspices quite persuasive abroad, as well as useful at home. As is discussed in chapter 5, some American firms contend many foreign governments often endorse technologies of their national fins, giving them a leg up in competing for contracts.

Technology demonstrations performed abroad under U.S. Government auspices may also be a useful tool to familiarize foreign customers with U.S. technical capabilities and their application in foreign conditions. Technology developers get to showcase their capabilities and may gain technical and commercial insights that can help them adapt their products and services for foreign markets. Demonstration projects can also be an avenue for technology cooperation and transfer, and an opportunity for training and technical assistance (discussed below).

The government's role in technology verification and demonstration can be seen either as export promotion (the subject of this chapter) or as a late stage of technology development (the subject of ch. 10). Chapter 10 discusses evaluations under EPA's SITE program. An expanded government role in environmental technology evaluation and verification has been proposed in legislation before the 103d Congress, as discussed under Option 8 in chapter 2.

USE OF FOREIGN AID TO PROMOTE EXPORTS

Development assistance programs can promote exports, including environmental exports, as discussed in detail in OTA's background paper, *Development Assistance, Export Promotion, and Environmental Technology*.[52] The background paper discussed certain structural features of development assistance programs that affect export promotion potential, and compared leading donors' practices. Such features include sectoral emphasis; formal and informal tying; linkages between bilateral and multilateral aid; use of loans with aid components; funding of feasibility studies; and technology cooperation. This section

[51] Trade Promotion Coordinating Committee, *Toward a National Export Strategy*, op. cit., footnote 4, pp. 34-38.

[52] U.S. Congress, Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology*, op. cit., footnote 1.

discusses in detail only feasibility studies and technology cooperation (the latter is also discussed in ch. 10); use of loans with aid components is mentioned in the next section, on financing. Chapter 2 discusses policy issues and options (see Issue Area D: Export Promotion, Development Assistance, and Environmental Firms).

As is discussed in chapter 5, aid can be important to commercial outcomes in specific environmental sectors. The purchaser of environmental infrastructure projects is often a government (e.g., in its role as a utility owner), whose purchasing behavior can be influenced by aid programs. Environment-related capital projects are often quite large, so that financing packages, especially those incorporating an aid component, are often important in making sales. Private-sector environmental sales are largely driven by environmental regulations and their enforcement; a donor's assistance to the government in developing regulations and monitoring compliance can increase private sector demand and may to some degree influence environmental requirements in ways that favor goods and services from the donor country's fins.

As developing countries begin to address their environmental problems, some analysts see the potential to link development assistance and promotion of environmental exports as a potentially important business opportunity. Others see it as a means to transfer needed environmental technology to developing countries, and still others as a potentially dangerous course that could result in transfer of inappropriate technologies that do not meet recipients' developmental or environmental needs. OTA's background paper discussed these tensions between export promotion goals and development and environmental goals in some detail. In brief, the potential for transfer of inappropriate technologies could be reduced through safeguards to keep export promotion efforts consistent with developmental and environmental objectives (see ch. 2).

Japan's aid programs pose the most commercial challenge to U.S. firms. Japan is, with the United States, the largest donor of aid and probably of environmental aid, and it has made a commitment to expand its environmental aid substantially. Japanese aid, though becoming more geographically dispersed, still focuses on East Asia, with its potentially large market for environmental goods and services, and where Japan has a strong commercial presence.[53] Japan's aid includes two types of programs whose export promotion effects can last far beyond the time of the aid, with benefits far exceeding the size of the aid program: funding for feasibility studies, and training programs. Corresponding U.S. programs appear to be smaller, though they could grow.

Feasibility Studies

Large capital projects are usually preceded by preliminary study of the project's context, scope, planned methods of implementation, and likelihood of success. Donors often use aid to fund such feasibility studies-often tying the funding (i.e., requiring the recipient government to hire a donor country firm to do the study). This often makes it more likely that a firm from that donor country will be selected to do the follow-on engineering and construction, even if bidding for the construction phase is open. If the company performing the study bids on the engineering and construction phases, it is likely to have an informational advantage. Even if the firm itself cannot bid on the project, it maybe more familiar with, and thus recommend, technical specifications that can be met by donor country technologies or vendors.[54]

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[53] Ibid., pp. 36,43,23 @OX 2-B). While Japan's aid programs historically were motivated by a desire to promote exports, Japan's government denies that this motivation exists today. However, regardless of motive, Japan's aid is still (albeit somewhat less than before) structured in ways that appear to enhance the aid's export promotion potential. See ibid., pp. 37-38,4146.

[54] Similarly, if the firm doing the feasibility study is selected o@ to manage the construction, it is likely to use its position of setting specifications and advising the recipient country on procurement in a way that steers construction business toward firms from its own country.

Furthermore, the firm performing the study establishes or maintains an in-country presence that can help it make other sales.

The Japanese International Cooperation Agency (JICA) seems to have an annual budget of about $200 million for tied feasibility studies.[55] The corresponding U.S. budget is much smaller. The primary agency involved is the U.S. Trade and Development Agency (TDA, formerly the Trade and Development Program). TDA's mission is ''to assist the U.S. private sector in exporting goods and services for major capital projects in developing and middle-income countries.''[56] TDA's appropriations were $35 million for fiscal year 1992 and $40 million for fiscal year 1993.[57] The fiscal year 1994 appropriation remained at $40 million, although the administration had requested $60 million. TDA estimates that for every dollar of TDA program expenditure, over $25 are returned to the U.S. economy in export income; however, an unknown portion of those exports are themselves financed or otherwise supported by other U.S. Government agencies such as USAID and Eximbank, so the ratio of outlays received to U.S. Government program expenditures would be lower.[58] By sector, TDA's fiscal year 1992 program spending was 33 percent for energy and natural resources and 12 percent for water and environment; transportation and manufacturing were also emphasized.[59]

In fiscal year 1992, TDA spent $39 million on program activities (including some funds transferred from other agencies), of which $25 million went to bilateral grants for feasibility studies (79 studies costing an average of $319,000), and another $2.5 million to similar grants for multilateral development banks to evaluate proposed projects.[61] (Most of the rest was spent on training, discussed below.) To receive feasibility study finding, projects must meet four criteria aimed at maximizing export impact:

- *Development priority.* **Projects** must be development priorities of the host country, and likely to be implemented; the host country must request TDA assistance, and the U.S. embassy must approve.
- *Export potential.* Potential sales of U.S. goods or services must be large relative to the cost of the feasibility study.
- *Open to U.S. firms.* It must be likely that the project will be open to bidding by U.S. fins, and that financing will be available that is not restricted to firms of particular countries.
- *Competition.* It must be likely that U.S. firms will face strong competition from foreign companies with foreign government support.[62]

One study funded in fiscal year 1992 was for a facility to treat industrial and municipal wastewater in the Asuncion and Lake Ypacarai region in Paraguay. TDA reports that the study costs $680,000, and states that the U.S. export potential in mechanical and electrical equipment and engi-

55 U.S. Congress, Office **of Technology Assessment,** *Development Assistance, Export Promotion, and Environmental Technology, op. cit.,* **footnote 1, p.** 43.

56 U.S. Trade and **Development Agency, 1992** *Annual Report,* **Op. Cit.,** footnote 50, p. 5.

57 Ibid., p. 4.

58 See U.S. Congress, Office **of Technology** Assessment, *Development Assistance, Export Promotion, and Environmental Technology, op.* **cit., footnote 1, p.** *88 &* **note 14.**

59 U.S. **Trade and Development Agency, 1992** *Annual Report,* **op. cit.,** footnote 50, **pp.** E1,18.

60 Ibid., p. 22. Program activities accounted **for 92** percent **of** TDA's **expenditures;** the rest was **for** operating expenses.

61 Ibid., pp. C1, 7. The Clinton Administration **Plain** to consolidate USAID feasibility study funds **for** capital **projects in TDA. Trade Promotion Coordinating Committee,** *Toward a National Export Strategy,* **op. cit., footnote** 4, p. 50.

62 U.S. Trade and Development Agency, 1992 *Annual Report,* op. cit., footnote 40, p. 6.

neering and project management services is over $149 million.[63]

Technology Cooperation

"Technology cooperation" means cooperation between or among countries (either government-to-government or with private sector participation) in developing or transferring technology. It includes technology demonstrations, research and development centers, training programs, and technical assistance to nascent institutions such as a government environment agency. Technology cooperation can encourage environmental exports in several ways. For example, exporters may work with potential clients in another country to adopt technologies to local needs, thus making t

ogy cooperation also can provide access for one country's firms to key government and industry decisionmakers in the other country. Where aid is involved, training grants may help to develop the needed technical and managerial skills in the recipient country to make use of the donor country's technology.[64]

Training will be discussed in detail below; technology development and demonstration, in chapter 10. Technical assistance to new institutions will not be discussed in detail, but is a significant factor. Both the United States and other aid donors provide assistance in developing regulations, testing protocols, and compliance measurements. This assistance can increase the recipient country's environmental market. If the recipient country adopts standards and practices similar to those of the donor country, donor country equipment and service vendors could have an advantage (see ch. 5).

TRAINING BY THE UNITED STATES

TDA spent $7.4 million, about a fifth of its fiscal year 1992 budget, on training.[65] Some of this went to sweetening the bids of U.S. firms on capital projects meeting TDA's four criteria (listed above); some familiarized potential customers with U.S. technology, in cases where future projects meeting those criteria seemed likely. TDA also spent over half a million dollars on technical seminars for government and industry officials, on topics such as sewage treatment technology.[66]

The United States Environmental Training Institute (USETI), a nonprofit organization established jointly by the U.S. Government and some U.S. businesses, also supports training for developing country decisionmakers.[67] Under USETI, firms provide training at their own expense, in return for which they can showcase their proven technologies. U.S. Government agencies such as EPA, TDA, and USAID also contribute instructors. U.S. embassies and commercial offices promote the courses. USETI only commenced training in December 1992; it estimates that by the end of 1993 over 450 people will be trained. Its 1993 courses covered subjects such as solid waste management, pollution prevention, efficiency in energy use, and air pollution control; courses were 2 weeks long. For 1994, USETI plans to train about 1,300 persons.

USETI's 1993 budget was $3.4 million, including both cash and the value of in-kind resources (primarily

effort was $2.1 million, of which all but $0.2 million was in-kind. Over 20 firms, trade associations, and other organizations participated, including a technical school in Thailand. The public

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63 Ibid., p. 7.

64 To properly Seine a developing country's needs, a capital development project based on imported technology requires trained local operators; this is true of many environment-related projects. Some projects have not provided for enough training. U.S. Congress, Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology,* op. cit., footnote 1, p. 12.

65 U.S. Trade and Development Agency, *1992 Annual Report,* op. cit., footnote 50, pp. Cl, 8-9 (training and technical assistance categories).

66 Ibid., pp. C1, 8-9 (technical symposia category).

67 This discussion is based on information provided by USETI.

sector contribution (from nine Federal agencies, plus small contributions from the World Bank and the International Finance Corp.) was $1,3 million, primarily in scholarships for travel and living expenses and in training.

US-AEP funds environmental fellowships for professionals from Asia and the Pacific islands to work in business, government, and nongovernmental organizations (NGOs). These fellowships, administered by the Asia Foundation, last 1 to 4 months and cover both technology and policy. During the period 1993 to 1995, 125 fellowships are planned, 35 of them at EPA. Some fellowships, such as those at EPA, might involve no direct U.S. commercial contacts or implications but might nevertheless help another country to write and enforce environmental regulations, thus creating demand for U.S. environmental technologies and services.

TRAINING BY JAPAN

Japan's MITI funds the International Center for Environmental Technology Transfer (ICETT), established in 1990. ICETT's first project involved training nine Mexican engineers on gas emission controls. ICETT plans to train 10,000 engineers from developing nations by 2001.[68] ICETT will work with environmental protection specialists from developing countries, including Eastern Europe.

The Japan International Cooperation Agency (JICA) also runs a training program for foreign officials and has 10 training centers throughout Japan. While none are called environmental training centers, many of the fields officially covered likely have substantial environmental content. Of 7,556 people accepted for training by JICA in 1990, 1,456 were in the area of public works and utilities, 837 in mining and industry, 713 in public health and medicine, and 211 in energy.[69] In 1991, JICA offered training courses in Japan on environmental maters to about 690 participants from developing countries. The training covered water quality monitoring, air pollution monitoring, technologies to reduce CFCs, waste disposal, and conservation of the agricultural environment, among others. JICA has funded construction of three environmental technology centers in Asia with training components: the Thai Environmental Research and Training Center; the Japan-China Friendship Environmental Preservation Center; and the Indonesia Environmental Management Center.[70]

The extent to which Japan's government offers training to sweeten the bids of Japanese firms (as the United States' TDA does) is not known.

FINANCING

Most exporters need at least short-term financing to cover the time between when they ship goods and when the customer pays. Some require longer term financing for customers that demand an extended payment plan. Long term financing is critical for funding large capital projects such as wastewater treatment plants and powerplant environmental controls. Smaller businesses may need ''working capital' loans to pay for production or marketing before export sales are made.

In the United States, private sector export financing (without government help) is inadequate to meet exporters' needs (especially those of small exporters); many competitor countries do better. There are several reasons for this.[71] Export financing tends to be more labor-intensive and to

68 ''Aid Offered t. Clean Environment Abroad; Help for Soviets in the Works at MITI, " *The Nikkei Weekly,* July 27, 1991.

69 JICA, ''JICA, For the Future of the Earth, " not dated, p. 6.

70 As cited in Japan International Cooperation Agency, *JICA Newsletter*, July 1993, and Government Of Japan, *Environment and Development: Japan' s Experience and Achievement,* Japan's National Report to UNCED 1992, December 1991, pp. 25-26.

71 This discussion of private sector export financing is based on James S. Altschul, "The Export Finance Crisis" (Washington DC: Economic Strategy Institute, July 1992), pp. 1-10; TPCC Working Group on Trade Finance, "National Export Initiative Bankers Meetings on Trade Finance, ' not dated (reporting on workshops held with bankers in 1991); and Nothdurft, op. cit., footnote 3, p. 56.

have lower profit margins than other banking activities, making it less attractive for banks. In the United States, the profitability of export financing is often further reduced because of unfavorable tax consequences, and real or perceived unfavorable reserve requirements; further, some U.S. banks' accounting rules make export financing appear less profitable than it is.

The low profitability of export financing has mattered more in recent years because U.S. banks have switched away from relational banking, in which banks considered relationships with clients to be paramount and therefore provided less profitable services within the context of those relationships, to transactional banking, in which each type of transaction is scrutinized and dropped if not sufficiently profitable. (In Europe, relational banking still predominates.)

Because many U.S. banks incurred major losses in the 1980s from unrepaid loans made to developing countries, most U.S. banks have become wary of lending to these nations, and of international lending in general U.S. banks often feel unqualified to judge foreign risks-they generally lack the international experience of European banks. U.S. banks are particularly cautious about medium- and long-term loans for exports to countries outside the industrialized West and Japan, which the banks consider the most risky.

The situation is particularly difficult for small exporters. Smaller banks tend not to handle export financing, and larger banks may find small exports (below about $300,000) not worth their while .72 U.S. banks are rarely willing to make working capital loans for production or marketing. Even when an exporter has an order and is ready to ship, U.S. banks normally will not, without a government loan guarantee, finance simply against foreign receivables; they normally demand that the exporter get a confirmed letter of credit, which is a promise by the customer's local bank to pay once documents conveying title to the goods are delivered, guaranteed **by a U.S. bank that** processes international transactions. (European banks more readily finance against foreign receivables.) The minimum charge for a confined letter of credit is often at least $400,[73] which can take a fair bite out of the profit of a small order. An order of $20,000, for example, might have a profit margin of $2,000 before financing costs. Letters of credit also require meticulous documentation when title to the goods is delivered; inexperienced exporters often need instruction on how to prepare documents, and frequently prepare them incorrectly, which delays payment for the goods.

To some extent foreign banks operating in the United States are filling the demand unmet by U.S. banks. However, their services concentrate on larger firms and larger transactions. Moreover, foreign banks seem interested primarily in providing financing for sales already in hand, rather than working with firms to put together competitive bids.[74] A foreign bank might be particularly reluctant to work with U.S. firms to put together a bid that would compete against one of the bank's clients in its home country.

Not only do U.S. exporters get less export financing help from the private sector than their counterparts in many major competitor countries; at least for nonagricultural exports, U.S. exporters also get less help from the national government. U.S. Government assistance for nonagricultural exports is provided primarily by the Export-Import Bank of the United States (Eximbank), which in fiscal year 1992 assisted $14.0 billion in

72 US-AEP is working with the Bank Association for Foreign Trade to link local banks with commercial banks experienced in international transactions. Lewis Reade, Director-General, US-AEP, presentation at the Clean Air Marketplace Conference, Washington DC, Sept. 9, 1993.

73 James S. Altshcul, op. cit., footnote 71, p. 7.

74 In situations involving Eximbank's assistance, U.S. banks have shown a greater willingness than foreign banks to work in this way with US. firms.

exports.[75] In 1991, perhaps 13 percent of Eximbank's assistance (by volume of exports assisted) has gone directly to small business[76]; if the same proportion held for 1992, about $1.8 billion in small business exports were assisted in that year. As shown below, Eximbank's assistance is limited in several respects: total amounts, criteria for assistance, and ease of administrative access. However, Eximbank has taken measures to improve access, especially for small business, and is likely to finance environmental exports more.

Eximbank's financing programs cover a much smaller share of exports than analogous programs in major competitor countries. One report covering 1989 showed U.S. coverage at about 2 percent of total exports, compared with 32 percent for Japan, 21 percent for France, 20 percent for the United Kingdom, and 4 percent for Germany .77

Eximbank's limited export coverage results in large part from budgetary constraints:

> While Eximbank must consider the budget implications of transactions, regardless of 'need' (i.e., whether Eximbank has the budget resources to commit to a particular transaction), its European and Japanese competitors generally have the budget flexibility to pursue creditworthy transactions which fall within their stated parameters.[78]

Also, Eximbank requires more justification for assistance in particular cases than most major foreign competitor agencies require:

> In general, U.S. economic policy is guided by a ''needs based' principle, and such is the case for Eximbank. Specifically, this policy translates to Eximbank supporting exports facing officially supported competition, or transactions for which the private sector is unwilling or unable to provide financing. Therefore, Eximbank generally must find evidence that one of these conditions exists to provide support for a transaction. In contrast, most of our major competitors view exports as being crucial to their countries' eco-

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75 Eximbank, *Annual Report 1992*, p. 2, This takes into account Eximbank's loans, loan guarantees, and insurance.

76 GAO reported 13 percent. Congress, General Accounting Office, *The U.S. Export-Import Bank: The Bank provides Direct and Indirect Assistance to Small Businesses* (Gaithersburg, MD: U.S. General Accounting Office, Aug. 21, 1992), pp. 2-5, 13, Direct assistance includes only financing provided directly to small businesses; it does not include financing provided to subcontractors working through larger businesses that receive Eximbank financing. GAO did not count some unverified data, and noted problems with some data that it did count. Eximbank, which counted both direct and indirect assistance, reported that it assisted small business exports of $2.1 billion in 1991 out of total exports of $12.1 billion, or 17 percent, Ibid, pp. 2-5; Eximbank, op. cit., footnote 75, pp. 3, 14-15.

77 First Washington Associates, Ltd. (Arlington VA), *Comprehensive Directory of the World's Export Credit Agencies* (October 1991). These figures include exports assisted by loans, loan guarantees, and insurance. The figures omit certain agencies, including the United States' Small Business Administration for which data were unavailable. (SBA assists under $100 million of exports per year-less than 1 percent of what Eximbank covers.) The U.S. figure includes 0.5 percent for Eximbank and 1.5 percent for the Foreign Credit Insurance Agency (FCIA), which issued insurance for Eximbank; FCIA's operations have since been absorbed into Eximbank itself.

A report covering 1987 gave similar figures, and a figure of 12 percent for the Netherlands. Altschul, op. cit., footnote71, p., 11, citing *Trade Finance & Banker International*, January 1990, p. 32-4, and speech by Albert H. Hamilton to the American Bankers Association, May 1989 meeting on small business.

Both of these studies omit financing for agricultural exports by the U.S. Department of Agriculture's Commodity Credit Corp., while the figures for the foreign countries probably include agricultural expert promotion. Thus, the U.S, financing and foreign countries' financing are, strictly speaking, not being compared on the same basis. However, the Commodity Credit Corp. covers only about 1 percent of U.S. exports, so including it would just raise the U.S. figures by 1 percent (see figures for 1991 in First Washington Associates, Ltd. (Arlington VA), *Comprehensive Directory of the World's Export Credit Agencies* (forthcoming in 1993)); this would not change the result that the other countries listed have much higher export coverage (except perhaps for Germany). Also, some of the foreign countries probably offer limited agricultural export financing, so that the figures reported in the study are correct or nearly correct comparisons of nonagricultural export financing. In 1990, as a percentage of total exports, agricultural exports were only 17 percent in France, 5 percent in Germany, 0.4 percent in Japan, 24 percent in the Netherlands, and 7 percent in the United Kingdom. U.S. Department of Agriculture, Economic Research Service, *World Agriculture*, Statistical Bulletin # 815 (September 1990); U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Agriculture 1992* (Washington, DC: USDA, December 1992), pp. 53, 93.

78 Eximbank, *Report to the* U.S. Congress on *Export Credit Competition and the Export-Import Bank of the United States for the Period January 1, 1991 through December 31, 1991* (July 1992), p. 8.

nomic well-being and security. To this end, they provide export credit on more of an "entitlement" basis by broadly defining their target audience and parameters, and allowing automatic access to their programs when the parameters are met.[79]

These differences mean that U.S. companies applying for Eximbank assistance, compared with foreign firms applying to counterpart agencies, must expend more effort in applying and have less certainty of receiving help. U.S. firms, especially small business, could therefore be discouraged from applying.

Other factors have impeded access to Eximbank assistance, though Eximbank is trying to change that.[80] Eximbank now has 6 domestic offices, compared to only one full-service office before 1992; France's export-import bank has 22. Eximbank has no overseas offices; Japan's export-import bank has 16. Companies have consistently complained that Eximbank is slow in processing applications.[81]

While Eximbank traditionally has relied on commercial banks to reach small business, many U.S. banks have discontinued international lending. Eximbank hopes to fill the gap with its City/State Program, by which State and city development and finance agencies can help firms to apply for Eximbank assistance while perhaps adding their own financing to the package. Begun in 1987, this program by early 1992 included 18 States, Puerto Rico, a city, and a port authority. Eximbank's other steps to improve service to small business include creating a high-level small business unit, streamlining approval for most small (under $2.5 million) working capital loan guarantees, increasing marketing efforts, and improving coverages.[82]

The Small Business Administration (SBA) also provides export financing. However, the exports assisted are under $100 million per year[83]; this is tiny, compared to Eximbank, which assists (see above) an estimated $1.8 billion dollars per year of small business exports. The General Accounting Office has also found evidence that export promotion, including export financing, is not a priority at SBA.[84] The Clinton administration has proposed harmonizing and ultimately merging SBA's and Eximbank's working capital programs.[85]

The Export Enhancement Act of 1992 requires Eximbank to encourage "the use of its programs to support the export of goods and services that have beneficial effects on the environment or mitigate potential adverse environmental effects. Eximbank is to report annually on this effort.[86]

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79 Ibid.

80 The information in this and the next paragraph is taken in part from U.S. Congress, General Accounting Office, *Export Finance: The Role of the U.S. Export-Import Bank,* GAP/GGD-93-39 (Gaithersburg, MD: U.S. General Accounting Office, Dee. 23, 1992), pp. 22-29; U.S. Congress, General Accounting Office, *Export Promotion: A Comparison of Programs in Five Industrialized Nations,* op. cit., footnote 20, p. 31; and Eximbank, *Report to the U.S. Congress on Export Credit Competition,* op. cit., footnote 78, pp. 27, 32-35.

81 See, for example, Kenneth D. Brody, letter to Donald W. Riegle, Jr., Chairman, Senate Committee on Banking, Housing and Urban Affairs, and to Henry B. Gonzalez, Chairman, House Committee on Banking, Finance and Urban Affairs, July 30, 1993, reprinted in Eximbank, *Report to the U.S. Congress on Export Credit Competition and the Export-Import Bank of the United States for the Period January 1, 1992 through December 31, 1992* (July 1993). Access to Eximbank programs is also impeded, especially for small business, because, as discussed above, there is no "one-stopshopping" for export services; firms must seek assistance individually from Eximbank and other agencies involved in export promotion.

82 U.S. Congress, General Accounting Office, *Export Finance,* op. cit., footnote 80, p. 24. When it issued this report, GAO found that it was too early to evaluate the success of these efforts.

83 U.S. Congress, General Accounting Office, *Export Promotion: Problems in the Small Business Administration's programs,* op. cit., footnote 41, pp. 8-9.

84 Ibid., pp. 10-12.

85 Trade Promotion Coordinating Committee, *Toward a National Export Strategy,* Op. Cit., footnote 4, p. 47.

86 The Export Enhancement Act of 1992, op. cit., footnote 7, sec. 106.

Pursuant to the statute, the Bank's board has appointed an officer to advise it on ways to use Eximbank programs to support environmental exports.[87]

In 1992, 20 States provided export loans and/or loan guarantees. California had the largest program, assisting $180 million in exports over 1 year; Minnesota assisted $2.6 million in exports. In addition, some States provided export insurance.[88] California also provides seed money to partially cover costs of putting together export deals (e.g., the cost of an investment banker's services) in the energy field, many of which concern energy efficiency or renewable energy. In its fifth year, California's International Energy Fund has provided $250,000 per year in contingent loans, to be repaid (with interest) only if the project generates revenues. The loans are matching funds, and projects are selected by a stiff competition.[89]

Financing with an aid component

Countries sometimes use aid funds to sweeten an export financing package, creating so-called "tied aid credits." The United States has used tied aid credits less aggressively than many competitor countries. Other countries' use of tied aid credits appears to be declining, but is still substantial. Power generation is one sector in the energy/environment realm that attracted substantial tied aid credits; it is possible that tied aid credits will focus more on the environmental sectors in response to changes in international rules. Tied aid credits are discussed in detail in OTA's background paper.[90]

87 Eximbank, *Annual Report 1992*, op. cit., footnote 75, p. 8.

88 National Association of State Development Agencies, *NASDA State Export Program Database (SEPD): 1992*, op. cit., footnote 17, pp. 27-29.

89 Tim Olson, California Energy Commission, personal communication, Oct. 22, 1993.

90 U.S. Congress, Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology*, op. cit., footnote 1, pp. 46-54.

PART III. Users of Environmental Technology: U.S. Manufacturers

Environmental Requirements and U.S. Manufacturing Industry Competitiveness 7

Environmental regulations can produce substantial benefits in the form of improved human health and a healthier ecosystem, with reduced costs in these areas. However, these benefits accrue to society as a whole, while individual firms that bear the higher compliance costs experience higher production costs as a result.[1]

Total U.S. spending (both public and private) on pollution control and abatement (including local solid waste collection costs) rose from approximately $52 billion in 1972 (1990 dollars) to $108 billion in 1990. As a share of gross national product (GNP), these expenditures grew more slowly, from 1.52 percent of GNP in 1972 to 1.95 in 1990. Expenditures could increase to between $133 and $147 billion (1990 dollars) by the year 2000, or between 2.0 and 2.2 percent of GNP.[2]

Relative to total production costs, the cost of pollution control to U.S. manufacturers is small-amounting, by one estimate, to $21 billion or about 1.72 percent of manufacturing value added in 1991. Moreover, the differential in compliance costs borne by U.S. firms compared to foreign fins, especially in advanced industrial nations, is not great. Factors other than environmental regulations, such as market access, management capability, financing, work force skills, labor costs, and technology, play more prominent roles in determining competitive advantage. Also, pollution control costs have not increased significantly

[1] For discussion of the many factors that contribute to a firm or muon's competitiveness see Michael Porter, *The Competitive Advantage of Nations* (New York, NY: The Free Press, 1990); and U.S. Congress, Office of Technology Assessment, *Competing Economies: America, Europe, and the Pacific Rim*, OTA-ITE-498 (Washington, DC: U.S. Government Printing Office, October 1991).

[2] U.S. Environmental Protection Agency, *Environmental Investments: The Cost of A Clean Environment* (Washington, DC: Island Press, 1991).

since the mid-1970s as a share of sales. However, these costs may be more troublesome to U.S. manufacturers now, due to intensifying demands of international competition. In an era when U.S. firms face increasing competition from able and effective competitors from both advanced and developing nations, even relatively small cost differences can affect relative competitive advantage.

Pollution control expenditures by manufacturers in the United States differ significantly by sector. For some industries, particularly process industries (e.g., chemicals, petroleum, pulp and paper, primary metals), pollution control expenditures can be a relatively large share of total capital expenditures and a small but significant share of value added. For example, as a share of value added, the petroleum industry spends over 15 percent on pollution control, primary metals and pulp and paper each spend over 4 percent, and chemicals spends over 3 percent. Most other industries, particularly discrete parts manufacturers and assemblers, spend much less. (It is possible, moreover, that these expenditures on pollution control by manufacturers are underreported, perhaps by as much as 20 to 30 percent. See app. 7-A.)

Expenditures are only part of the picture. As U.S. manufacturers seek to continuously improve production processes and rapidly introduce new products, complex and time-consuming permitting procedures and regulatory inflexibility can present serious obstacles. Many analysts argue that the U.S. regulatory system is more adversarial and rigid than those of most other nations.

While it is difficult to accurately compare pollution abatement and control costs among nations, it appears that compliance costs for U.S. industry are among the highest in the world. Manufacturers in western Germany and perhaps a very few other Northern European countries incur comparable costs; elsewhere in Europe costs are lower. Japanese pollution control costs for manufacturers have been lower than those for the United States since 1977, and that gap has been growing. For example, compared to firms in Japan, in 1990 automobile manufacturers in the United States spent over five times more as a percent of total capital investments and three times more as a percent of sales to control pollution from the production of automobiles. Pollution control and abatement costs in newly industrialized and developing nations are significantly lower than in the United States.

Some of these cost differentials might be due to more efficient regulatory systems. However, the major source of difference appears to stem from variances in regulatory requirements and the intensity of their enforcement (or the degree of compliance). Finally, U.S. firms often receive less government financial and technical help (e.g., tax deductions, loans, and R&D grants) than their counterparts in Japan, Germany, and some other countries.

Several attempts to assess the competitive impacts of environmental regulation on the economy have been conducted since the early 1970s. These studies differ in methodology, assumptions, and conclusions, and, because of the complexity of the research question, offer limited insight. The little research on employment effects suggests that in the medium to long-term, the impact on jobs from pollution and waste control requirements is likely to be minimal. However, it appears that pollution and waste control regulations had a small negative impact on manufacturing productivity, industrial innovation, balance of trade, and the location of industrial investment. While the effects are small, this does not mean that they are insignificant and should not be

[3]Compared to the United States, much of the private sector spending for pollution control in Japan is not by manufacturers, but rather by electric utilities to control nitrogen oxides (NO_x) and sulfur dioxide (SO_2). Moreover, regulations of many pollutants, including volatile organic compounds and hazardous wastes, are much stronger in the United States than in Japan.

[4]Japanese automobile firms maintain higher capital investment rates as a percent of sales than do U.S. automakers,

Figure 7-l—External Determinants of Environmental Compliance Costs

Location (e.g., density of nearby pollution sources and population)	Weak environmental regulations and enforcement	Direct subsidies of environmental compliance costs	More efficient regulatory system (e.g., pollution prevention, Marketable permits)

SOURCE: Office of Technology Assessment, 1993.

addressed+ specially if analysis could point the way to more effective and less burdensome methods of achieving environmental goals. This is particularly true given stricter pollution control requirements which will come into effect in the mid and late 1990s.

This chapter first discusses the costs of complying with U.S. pollution control regulations for manufacturers in the United States. It then discusses costs and regulatory requirements for manufacturers in other nations, including Japan, Germany, and Holland. Finally, it discusses research on the effects of regulation on technology innovation and foreign trade and investment. Appendix A discusses effects of regulation on GDP and productivity.

OVERVIEW

Externally imposed environmental compliance costs are determined in at least four ways (see figure 7-1).

First, geographic location and density of pollution sources can be a factor. Firms located in sparsely populated areas with very low levels of pollution from other sources, may not have to control pollutants as strictly to meet overall ambient standards (unless, of course, requirements are in place to prevent any significant deterioration of existing environmental conditions).

Second, companies may bear few costs if they are located in nations or regions that allow them to pollute heavily, even where there are high pollution loads. Moreover, while few data compare worker health and safety costs in different nations, U.S. firms may carry higher costs in this area compared to those in many competing countries, particularly newly industrialized and developing countries.[5]

In the long term, nations may pay more for these implicit subsidies (e.g., through increased health costs and reduced natural resource productivity). In some cases this penalty maybe so large as to impede economic growth, as the current situation in Eastern Europe and the former Soviet Union illustrates. However, just as other subsidies can create industrial competitive advantages,[6] so can environmental subsidies, whether in the form of lax regulations or direct assistance.

Some argue that strict environmental regulations can lead to increased competitive advantage.[7] Firms in countries with strict regulations on industrial processes might find that aggressive environmental actions, particularly pollution pre-

[5] See Lawrence J. MacDonnell, "Government Mandated Costs: The Regulatory Burden of Environmental, Health and Safety Standards,' *Resources Policy,* March 1989, pp. 75-96.

[6] U.S. Congress, Office of Technology Assessment op. cit., footnote 1.

7 A number of analysts use Michael porter's, article, "America's Green Strategy" *Scientific American*, April 1991, vol. 264, No. 4, p. 168 as evidence of this relationship. Porter's writings on this relationship suggest a more limited view (see box 3-2).

vention, make them more competitive relative to other *domestic* competitors having to comply with the same standards. However, as a group, firms within countries with stringent environmental regulations may often face a competitive disadvantage in a global marketplace where they must compete with firms in *foreign* countries with more lax standards. When waste disposal costs are high and regulatory requirements are stringent, firms can sometimes save money by controlling pollution and reducing wastes. However, these actions are seldom financially justifiable in the absence of waste treatment or pollution control requirements.

The third factor in determining compliance costs is the degree to which nations or regions provide financial or technical assistance to meet pollution control regulations. Although the Organization of Economic Cooperation and Development (OECD) has adopted the polluter pays principle, which states that the polluter should bear the expenses of carrying out measures to protect the environment, the principle is not strictly adhered to in any developed or developing country. However, there is significant variation in the degree to which governments provide both financial and nonfinancial assistance to help industry meet environmental requirements. Relative to some countries, the United States provides little help to its industries to comply with pollution abatement requirements.

Fourth, firms in nations that structure their regulatory systems more efficiently (e.g., fewer delays, more flexibility) while maintaining similar levels of protection, may face lower costs than firms in nations that achieve the same level of protection in less efficient ways. To some extent, market incentives (e.g., taxes and fees, tradable permits) and performance-based standards may produce lower costs (see ch. 9). While no country has used these approaches extensively, a number of other countries' systems do appear more flexible than the United States, which may enable them to achieve more pollution reduction per compliance dollar spent. Another source of environmental efficiency is to reduce pollution through prevention (in-process changes) as opposed to end-of-pipe methods. Countries appear to differ little on the relative extent of in-process changes.

Some analysts have argued that some environmental regulations impose sizable costs on the economy, but deliver quite small benefits.[8] Such analysis is complex and requires a greater understanding of costs and benefits than currently exists. As a result, this report does not examine the issue of whether U.S. environmental regulations are too strong (or too weak). Rather, it discusses the extent to which U.S. regulations affect economic competitiveness. Chapters 8 and 9 examine ways in which pollution control regulations can be modified to minimize their negative effect on industrial competitiveness, while achieving stable or greater levels of environmental protection.

U.S. POLLUTION ABATEMENT AND CONTROL EXPENDITURES

The Bureau of Economic Affairs (BEA) in the Department of Commerce estimates that U.S. pollution abatement and control costs in 1991 were $91.5 billion, or 1.61 percent of GDP.[9] The Environmental Protection Agency (EPA) reports a higher figure of $108 billion in 1990, or 1.95

[8] Some have called for regulations increasingly informed by sounder scientific information, often based on risk assessment techniques to determine relative risks, benefits, and costs. It is beyond the scope of this study to examine the potential for such approaches to lower compliance costs while maintaining current levels of environmental protection.

[9] Gary L. Rutledge and Mary L, Leonard, "Pollution Abatement and Control Expenditures, 1987-91," *Survey of Current Business*, vol. 73, No. 5, May 1993, p. 61. These are net costs, which subtract the savings firms received from recovered energy and materials due to pollution control. In 1991, these amounted to approximately $1.6 billion, Gross pollution abatement and control costs were $93.1 billion.

percent of GDP.[10] Box 7-A discusses the different methods for measuring costs.

Total pollution control and abatement expenditures (constant dollars) declined slightly in the early 1980s, then steadily increased throughout the rest of the 1980s (see figure 7-2). Expenditures increased from $52 billion in 1972 to $108 billion (by EPA calculations) in 1990 (inconstant 1990 dollars) .11 However, as a share of GNP, environmental expenditures have increased less rapidly, from 1.52 percent in 1972 to 1.95 in 1990.[12]

According to BEA, business accounted for slightly over half, or $48 billion, of the $91 billion spent on pollution control and abatement in 1991 (see table 7-l.) Most of the cost to business was for acquisition and operation of pollution control equipment; a smaller share was for fees to publicly owned wastewater treatment works and for costs of pollution control devices on automobiles and trucks purchased by business. Of the business expenditures, approximately $21 billion was incurred by manufacturers: $6.4 billion for electric utilities; $1.6 billion for mining; and the rest by other sectors, including expenditures on waste collection and sewage treatment.

Expenditures by manufacturers are displayed in figure 7-3. The high level of capital expenditures in the mid-1970s reflects initial acquisition of equipment as industry complied with the 1970 Clean Air Act and the 1972 Clean Water Act. The portion of capital expenditures for pollution abatement and control then tapered off for several years. It appears to be increasing again, in part because of the 1987 Clean Water Act amendments and the 1990 Clean Air Act amendments. Operating costs have increased slowly and steadily, as the stock of pollution control equipment

FORD MOTOR CO.

Large *fans and ducts transfer exhaust emissions from automobile paint booth operations to the next stage of the emission control system. The $35 million dollar system reduces solvent emissions.*

has grown. In 1991, capital expenditures to comply with air and water requirements accounted for almost 85 percent of pollution control and abatement capital expenditures; solid waste, including hazardous waste, accounted for the rest. Operating costs were divided almost equally between the media (see figure 7-4).

Pollution Abatement and Control Expenditures by Sector

Pollution control costs for industry can be defined as the direct and intentional outlays by industry for pollution abatement and control. These costs differ significantly by sector. In general, process industries (e.g., chemicals, petroleum) experience higher compliance costs than

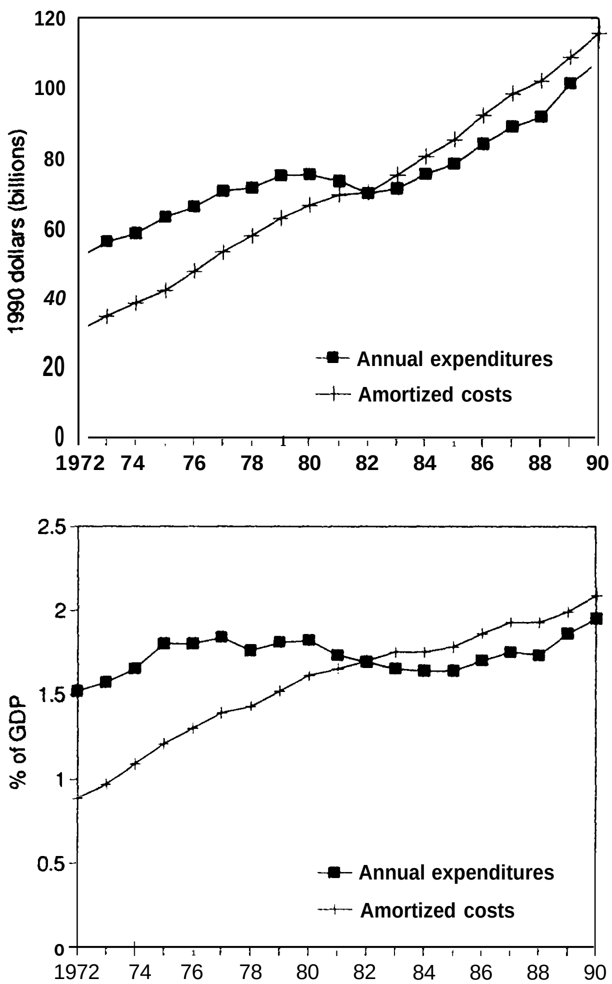
10 However, EPA includes some expenditures that are only tangential to pollution abatement, such as 100 percent Of the $17 billion spent on municipal solid waste collection costs. The EPA figures for 1990 are estimates. Environmental Protection Agency, op. cit., footnote 2.

11 Environmental Protection Agency, Op. Cit., footnote 2.

12 Historic statistics are generally expressed as a share of Gross National Product (GNP) whereas more current statistics are expressed as a share of Gross Domestic Product (GDP), Differences between the two measures are insignificant.

Box 7-A-Government Measures of Pollution Abatement and Control Costs

Figure 7-A1—Differing Measures of Environmental Compliance Costs



SOURCE: Environmental Protection Agency, *EnvironmentalInvestments* (Washington, DC: Island Press, 1991).

There are three main sources of data on U.S. environmental compliance costs:the Environmental Protection Agency (EPA) published a report in 1990 on total pollution abatement and control costs; the Census Bureau publishes an annual report on manufacturers abatement costs; and the Department of Commerce's Bureau of Economic Analysis (BEA) annually publishes data on total costs that rely in part on the Census Bureau data.

BEA and EPA estimates differ significantly. One reason is that the EPA study included all costs ($17 billion) for solid waste management collection. BEA includes only 70 percent of these costs. EPA includes all superfund costs ($4.2 billion). BEA includes a smaller but indeterminant share. Because garbage has been collected for at least 100 years, It makes little sense to include all these *costs* when considering the effect of regulation on economic competitiveness. EPA (but not BEA) also included a share of expenditures for water supply ($4 billion), pesticide and fungicide regulations ($2 billion), and nonpoint source water pollution controls ($0.77 billion).[1] Both include the costs from mobile source pollution control (primarily automobile pollution control devices), but BEA's estimate ($14.6 billion) was almost double the EPA estimates of $7.7 billion.

EPA and BEA account for capital expenditures for environmental protection indifferent ways. BEA counts capital expenditures and operating costs in the year they are made. In contrast, the EPA study converted the data into annualized expenditures (the sum of operating costs for the year in question plus amortized capital costs, which include interest and depreciation associated with accumulated capital investment).

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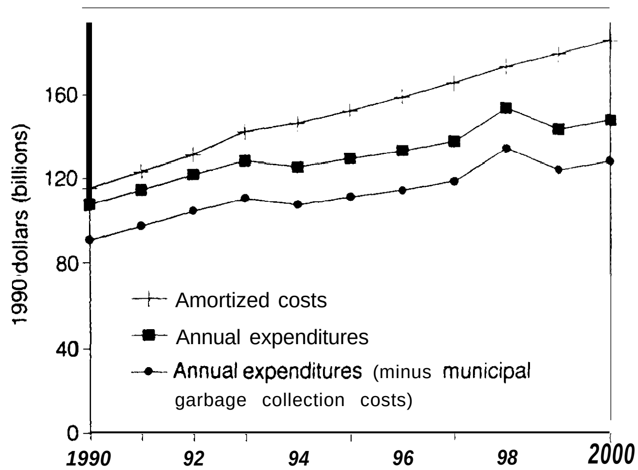
[1] U.S. Environmental Protection Agency, *Environmental Investments: The Cost of A Clean Environment* (Washington, DC: Island Press, 1991).

Box 7-A-Government Measures of Pollution Abatement and Control Costs-Continued

In other words, if a firm spent $20 million in 1975 on capital equipment with a useful life of 20 years, the EPA study would record $1 million for each year from 1975 to 1994, and add in annual interest payments.[2] The EPA study provides both actual and annualized costs, but its annualized numbers have been more widely reported.

While EPA's actual and annualized measures are both valid, the latter measure gives the impression that the environmental regulatory cost burden has risen steadily and significantly (278 percent) since 1972, when, in fact, annual expenditures (operating costs plus capital costs in the year purchased) increased only 77 percent (adjusted for inflation, figure 7-AI).

Figure 7-A2—EPA Environmental Compliance Cost Projections



SOURCE: Environmental Protection Agency, *Environmental Investments* (Washington, DC: Island press, 1991).

Using the annualized method, EPA estimated that the cost of environmental compliance will increase significantly in the 1990s, increasing 61 percent from 1990to$185 billion in 2000, assuming full implementation of all existing and new regulations currently under development or proposed by EPA. However, nonannualized expenditures in 2000 will increaseto$147 billion, and $127 billion if local garbage collection is not included (figure 7-A2).

Since 1973, the Census Bureau has annually reported pollution abatement and control expenditures for manufacturers (SIC 20-39).[3] in 1990, when Census surveyed over 20,000 randomly selected manufacturing establishments, over 90 percent responded to the survey.[4] Appendix 7-1 discusses the validity of this data.

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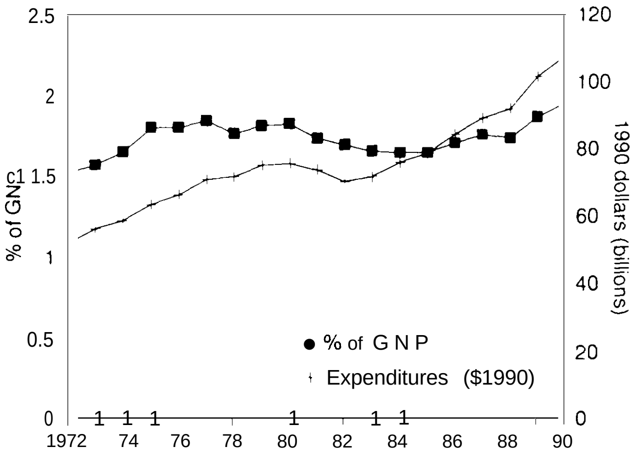
2 This is a particularly important distinction to make in estimating environmental industry revenues, since amortized costs measure depreciation, interest, and operating expenses.

3 U.S. Department of Commerce, Economics and Statistics Administration, Bureau Of the Census, *Pollution Abatement Costs and Expenditures* MA200 (Washington, DC: U.S. Government Printing Office, published annually).

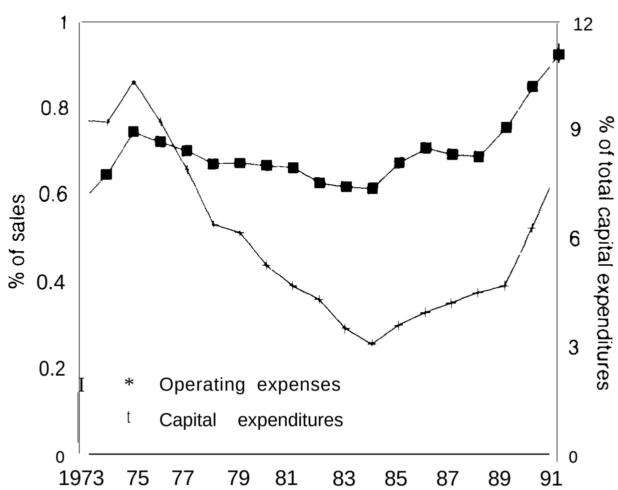
4 There are two mistakes commonly made when interpreting Census data. First, while Census reports total gross operating costs, net costs should be used. To calculate net costs, operating costs recovered (usually through recycling or energy production) are subtracted from gross operating costs. Second, total environmental expenditures are sometimes calculated as the sum of capital expenditures and annual operating costs. However, this overestimates total costs since operating costs already include costs of depreciation of capital equipment. Subtracting depreciation from the total operating costs and capital expenditures provides a more accurate measure of total spending,

Figure 7-2—U.S. Environmental Compliance Costs



SOURCE: Environmental Protection Agency, *Environmental Investments* (Washington, DC: Island Press, 1991).

Figure 7-3-Trends in Pollution Abatement Expenditures for U.S. Manufacturers



SOURCE: U.S. Census Bureau, *Pollution Abatement Costs and Expenditures* (Washington, DC: U.S. Government Printing Office, various years).

the discrete part manufacturers (e.g., electronics, automobiles). In large part, this is because process industries use significant amounts of energy and process large amounts of materials to produce output. This transformation of raw materials into

Table 7-l—Composition of Spending on Pollution Abatement and Control in 1991 ($ millions)

Sector	Amount	Share
Personal consumption	$18,544	20%
Government[b]	24,653	27%
Business	48,259	53°/0
Plant & equipment	42,515	
Motor vehicle emission abatement	5,744	
Net total	$91,456	100%

Estimates of sectoral composition of business plant & equipment operating and capital expenditures

Sector	Amount	Share
Manufacturing	$20,910	49%
Electric utilities	6,385	15%
Mining	1,562	4%
Other business[d]	13,658	32%
Total business	$42,515	100%

a Includes mobile source pollution control, private septic systems and sewer connections linking household plumbing to street sewers, and household payments for sewage treatment.

b Includes government direct expenses, principally for investments and operation of municipal water treatment facilities, as well as costs of regulation and monitoring, and research and development.

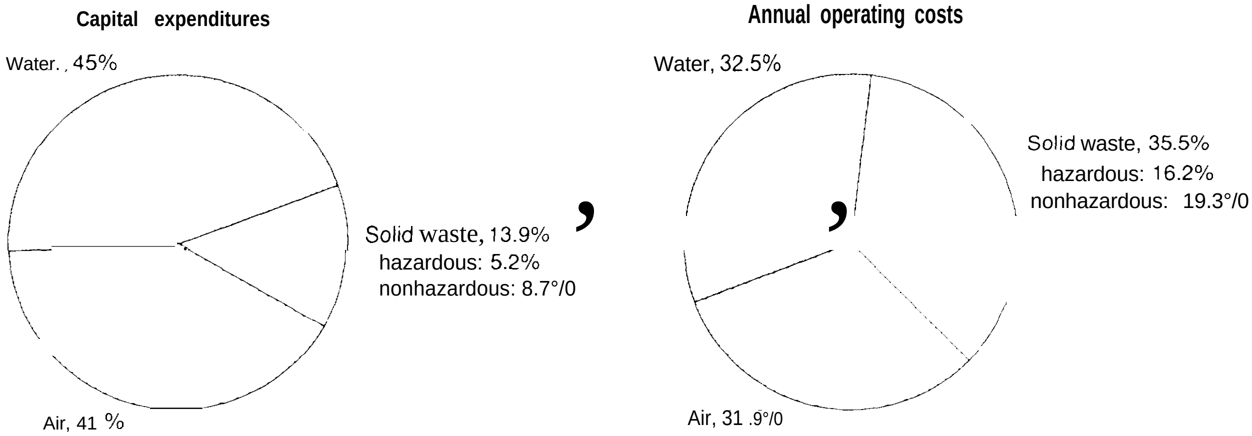
c Includes capital expenditures and annual operating Costs, such as payments to government units for sewage services and waste collection and disposal. Excludes the cost of mobile source (automobile and truck) pollution control equipment.

d Other sectors, such as construction, services, retail trade, etc., while perhaps not bearing large pollution control costs related to stationary source capital equipment, do bear costs through payments for sewage services and solid waste collection and disposal.

SOURCE: Derived by OTA from data provided in Gary Rutledge and Mary Leonard, "Pollution Abatement and Control Expenditures, 1987-91 ," *Survey of Current Business,* May 1993, pp. 55-59; U.S. Bureau of the Census, *Pollution Abatement Costs and Expenditures, 1991, MA200 (91)-1* (Washington, DC: U.S. Government Printing Office, 1993), and other unpublished data provided by Gary Rutledge.

products is often pollution-intensive. Four broad industrial sectors (chemicals, petroleum refining, pulp and paper, and primary metals) that produce slightly over 20 percent of U.S. manufacturing value added account for over 70 percent of all pollution control capital expenditures by manufacturers, approximately 80 percent of all criteria air emissions by manufacturers (particulate, sulfur oxides, nitrogen oxides, volatile organic compounds, and carbon monoxide), nearly 70 percent of Toxic Release Inventory emissions,

Figure 7-4-Manufacturers' Pollution Abatement Costs by Media: 1991



SOURCE: U.S. Census Bureau, *Pollution Abatement Costs and Expenditures, 1991* (Washington, I) : U.S. Government Printing Office, 1993) page 12.

and over 70 percent of manufacturing energy usage[13] (see figure 7-5).

In 1991, 7.9 percent of capital expenditures by manufacturers in the United States went toward pollution control equipment. The share can be higher in particular industries. For example, over one-quarter of new capital expenditures by the petroleum industry were for pollution control, while the chemical industry spent over 13 percent. In contrast, the rubber, machinery, and printing industries spent less than 2 percent of capital expenditures for pollution control. However, significant differences among subsectors are obscured when looking at broad industrial categories. For example, while only 4.6 percent of capital expenditures for the fabricated metals industry as a whole went for pollution control, one subsector—the metal plating and polishing industry—spent over 27 percent.

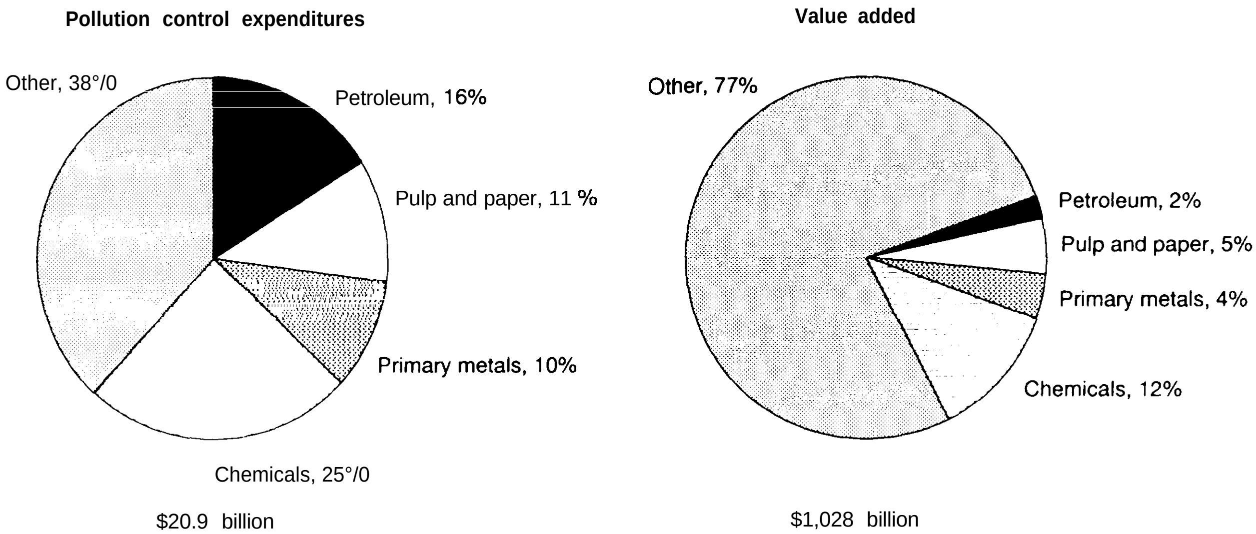
Total compliance costs (capital costs plus operating costs minus depreciation) as a share of sales and value added also differ by industry. The petroleum industry spends the most, about 2.2 percent of sales, while the pulp and paper, chemicals, and primary metals industries all spend over 1.65 percent of sales on pollution abatement and control. Share of value added may be a more accurate measure of environmental regulatory burden, since it measures the level of economic activity performed by the firm, and does not include the cost of materials purchased. Using sales as the denominator understates the true cost of pollution control to a firm, since the pollution control costs embedded in the firms' purchased products are not included in their pollution control costs, but are included in the sales figures.[14]

As a share of value added, the petroleum industry spends over 15 percent on pollution control, the pulp and paper and primary metals spends over 4 percent, and the chemical industry spends over 3 percent. For manufacturing overall,

13 U.S. Census Bureau, *1990 Annual Survey of Manufactures: Value of Product Shipments, M90(AS-2)* (Washington, DC: U.S. Government Printing Office, 1990); U.S. Congress, Office of Technology Assessment, *Industrial Energy Efficiency*, OTA-E-560 (Washington, DC: U.S. Government Printing Office, August 1993); U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, *1991 Toxic Release Inventory, Public Data Release* (Washington, DC: Environmental Protection Agency, May 1993).

14 Without the use of more sophisticated models relying on input/output tables, it is not possible 10 assess total pollution control costs to the firm embedded in its purchases. For example, firms that purchase large amounts of energy (e.g., aluminum or industrial gas producers) pay more for electricity due to environmental controls on electrical utilities.

Figure 7-5--Manufacturers' Pollution Control Expenditures and Value Added, 1991



SOURCE: U. S. Census Bureau, *Pollution Abatement Costs and Expenditures,* 1991 (Washington, C) C: U. . Government Printing Office, 1993); U.S. Census Bureau, 1991 *Annual Survey of Manufactures,* Statistics *for Industry Groups and Industries* (Washington, DC: U.S. Government Printing Office, 1992).

these costs are less--0.80 percent of sales and 1.72 percent of value added in 1991[15] (see table 7-2.) As discussed in appendix 7-A, these figures may underreport actual costs, possibly by as much as 20 to 30 percent.

Even among most high-compliance-cost sectors, pollution control costs are only one of many factors affecting competitive advantage. Not all high-compliance-cost industries are heavily involved in international trade. Among those that are, some industries, such as chemicals and wood pulp, are highly competitive internationally, with significant trade surpluses.[16] Others, such as primary metals, have struggled competitively.[17] Because environment is seldom the primary factor in determining competitive advantage, it is misleading to look at the performance of sectors as a measure of the effect of pollution abatement costs on competitiveness. It is possible, for example, that lower compliance costs in the chemical industry could make it even more competitive. Moreover, when compared to other corporate expenditures these costs are not trivial. For example, while business spent $43 billion on

15 At least one analysis claims that costs are much higher. A report by the National Commission for Employment Policy (*Measuring Employment Effects in the Regulatory Process,* Washington, DC: January 1993), uses Census data to assert that total abatement expenditures account for 3.48 percent of sales. However, this figure appears to significantly overstate the actual cost effect. The authors overestimated Census costs (double counting capital expenditures and depreciation and failing to subtract recovered costs) and used a methodology resulting in inflated costs,

16 The chemical industry's exports in 1991 were $43 billion and the trade surplus was $18.8 billion. U.S. *Chemical Industry Statistical Yearbook, 1992* (Washington, DC: Chemical Manufacturers Association 1992). However, developing nations, which generally have weaker regulations, increased their share of chemical exports faster than developed nations between 1980 and 1991. Earl Anderson, "Developing Nations' Chemical Exports Surge, " *Chemical and Engineering New,* Aug. 2, 1993, pp. 14-15. The United States has enjoyed a trade surplus in pulp since 1987, importing $1.9 billion worth of pulp in 1992 and exporting $3.1 billion. However, the paper industry ran a $2 billion trade deficit in 1992. U.S. Department of Commerce, *U.S. Industrial Outlook, 2993,* (Washington, *DC:* U.S. Government Printing Office).

17 In 1992, the U.S. ran a $s billion trade deficit in steel mill products (U.S. Department of Commerce, International Trade Administration, *U.S. Industrial Outlook, '92* (Washington, DC: U.S. Government Printing Office, 1992), p,142.

Table 7-2—Pollution Abatement Expenditures by U.S. Manufacturing Industries, 1991[a] (millions of dollars)

	Pollution Capital Expenditures			Total Pollution Control Expenditures		
Industry & (SIC Code)*	$	% of Total Capital Exp.	Net Operating costs	$	% of Sales	O/. of Value Added
Petroleum (29)	$1,463	25.7%	$1,982	$3,444	2.25%	15.42%
Primary (33)	$673	11.6%	$1,512	$2,185	1.68%	4.79%
Blast furnace (331)	*$398*	*12.0%*	*$851*	*$1,249*	*2.26%*	*6.49%*
Paper (26)	$1,233	13.8%	$1,139	$2,372	1.87%	4.13%
Pulp Mills (261)	*$169*	*17.2%*	*$130*	*$299*	*5.70%*	*12.39%*
Chemical (28)	$2,066	13.4%	$3,114	$5,180	1.88%	3.54%
Inorg.Chem (281)	*$211*	*15.9%*	*$472*	*$683*	*2.74%*	*4.59%*
Stone (32)	$154	7.2%	$345	$499	0.93%	1.77%
Lumber (24)	$141	11.1%	$232	$373	0.63%	1.67%
Leather (31)	$15	16.2%	$41	$56	0.65%	1.37%
Fabricated (34)	$177	4.6%	$757	$934	0.65%	1.34%
Plating (3471)	*$42*	*27.5%*	*$176*	*$218*	*5.77%*	*8.81%*
Food (20)	$482	5.3%	$1,067	$1,549	0.42%	1.11%
Rubber (30)	$82	2.0%	$385	$466	0.49%	0.98%
Textile (22)	$57	3.3%	$190	$247	0.38%	0.93%
Electric (36)	$234	2.9%	$715	$949	0.49%	0.91%
Transport.	$301	3.0%	$909	$1,210	0.33%	0.80%
Motor Vehicles (371)	*$182*	*2.9%*	*$443*	*$625*	*0.31%*	*0.86%*
Furniture (25)	$24	3.4%	$117	$141	0.38%	0.73%
Machinery (35)	$128	1.9%	$517	$646	0.29%	0.57%
Miscellaneous (39)	$13	1.8%	$66	$79	0.26%	0.48%
Instruments (38)	$104	2.4%	$230	$335	0.27%	0.42%
Printing (27)	$37	0.8%	$166	$203	0.15%	0.21%
Tobacco (21)	$6	1.5%	$38	$44	0.14%	0.18%
Total U.S. manufacturers	$7,390	7.9%	$13,522	$20,912	0.80%	1.72%

a This table lists expenditures and costs reported *by* industry to the U.S. Census Bureau. As discussed in the text, these figures may underreport actual costs, possibly by as much as 20 to 30 percent.

Net operating costs = Total operating costs and payments to governmental units minus casts recovered and equipment depreciation.

Total pollution control expenditures = Total operating costs plus payments to governmental units plus total capital expenditures minus costs recovered and equipment depreciation,

*Pollution abatement and control cost data are only for establishments with 20 employees or more. To ensure comparability, total capital expenditures, value-added, and sales were estimated for establishments of 20 employees or more, using ratios from 1987, the most recent year the Census provides data for, (U.S. Bureau of the Census, 1987 Census *of Manufactures,* MC87-S-1 [Washington, DC: U.S. Government Printing Office, 1991).

SOURCES: U.S. Bureau of the Census, *Pollution Abatement Costs and Expenditures, 1991 MA200 (91)-1* (Washington, DC: U.S. Government Printing Office, 1993); U.S. Bureau of the Census, *1991 Annual Survey of Manufacturers, Statistics for Industry Groups and Industries M91* (AS-1) (Washington, DC: U.S. Government Printing Off Ice, 1993).

Table 7-3-Selected Corporate Costs, 1991 (billions of dollars)

Non-environmental new plant and equipment[a]	$519
Corporate R&D[b]	78
Pollution abatement and control	43
Employee training[c]	43

a U.S. Bureau of the Census, *Statistical Abstract of the U. S., 1992* (Washington, DC: U.S. Government Printing Office, 1992), p. 538. Capital expenditures for environmental control were subtracted from total expenditures on plant and equipment.
b National Science Foundation/Science Resources Studies, *National Patterns of R&D Resources: 1992* (Washington, DC: National Science Foundation, 1993), table b-3.
c This figure includes nonmilitary related training expenditures in government. Jack Gordon, "Training Budgets: Recession Takes A Bite," *Training, October* 1991, p. 37.

plant and equipment for pollution abatement and control in 1991, it spent $43 billion on formal training and $78 billion on R&D[18] (see table 7-3.) To the extent that pollution control expenditures make a claim on the resources of the firm, they could divert funding from these activities.

Future Costs

New and stricter environmental regulations put in place in the 1990s may increase pollution control costs, particularly for some industries. Currently, about one-third of compliance costs (public and private) result from regulations under the Clean Air Act, another third from the Clean Water Act, and the remainder from a variety of laws covering drinkingwater contamination, pesticides and herbicides, chemical production and use, and solid and hazardous waste disposal.[19] Assuming full implementation of all existing and pending regulations and rules, clean air spending (nonannualized) could increase about 85 percent between 1990 and 2000.[20] Compliance costs for water are expected to increase more slowly, by approximately 28 percent. Costs for hazardous waste disposal and cleanup will continue to grow, particularly for Superfund, whose costs are expected to rise from $3.6 billion in 1990 to $9.5 billion in 2000. Federal Government costs, principally for Department of Defense (DOD) and Department of Energy (DOE) cleanup of contaminated sites, are also likely to grow significantly.

EPA projects that with full implementation of present laws, environmental costs will rise 40 percent by 2000, to $147 billion, including local garbage collection ($127 billion excluding garbage collection) .21 As a share of GDP, environmental costs (including garbage collection) would rise from 1.95 percent in 1990 to 2.25 percent in 2000.

Future reductions in pollution may be more expensive if firms must reduce pollution to very low levels. As cheap reductions are exhausted, more expensive methods may be needed. Yet there are reasons why costs may, in fact, be lower than EPA estimates. First, full implementation of all laws—including bringing all cities into attainment with the national ambient air quality standard for ozone and satisfying the nation's municipal wastewater treatment needs to bring about fishable/swimmable water quality-may not occur or may occur more slowly than EPA projects. Assuming 1990 levels of implementation, EPA forecasts costs to increase only to about $133 billion, by 2000, $13.7 billion less than with full implementation.[22] In addition, in estimating costs,

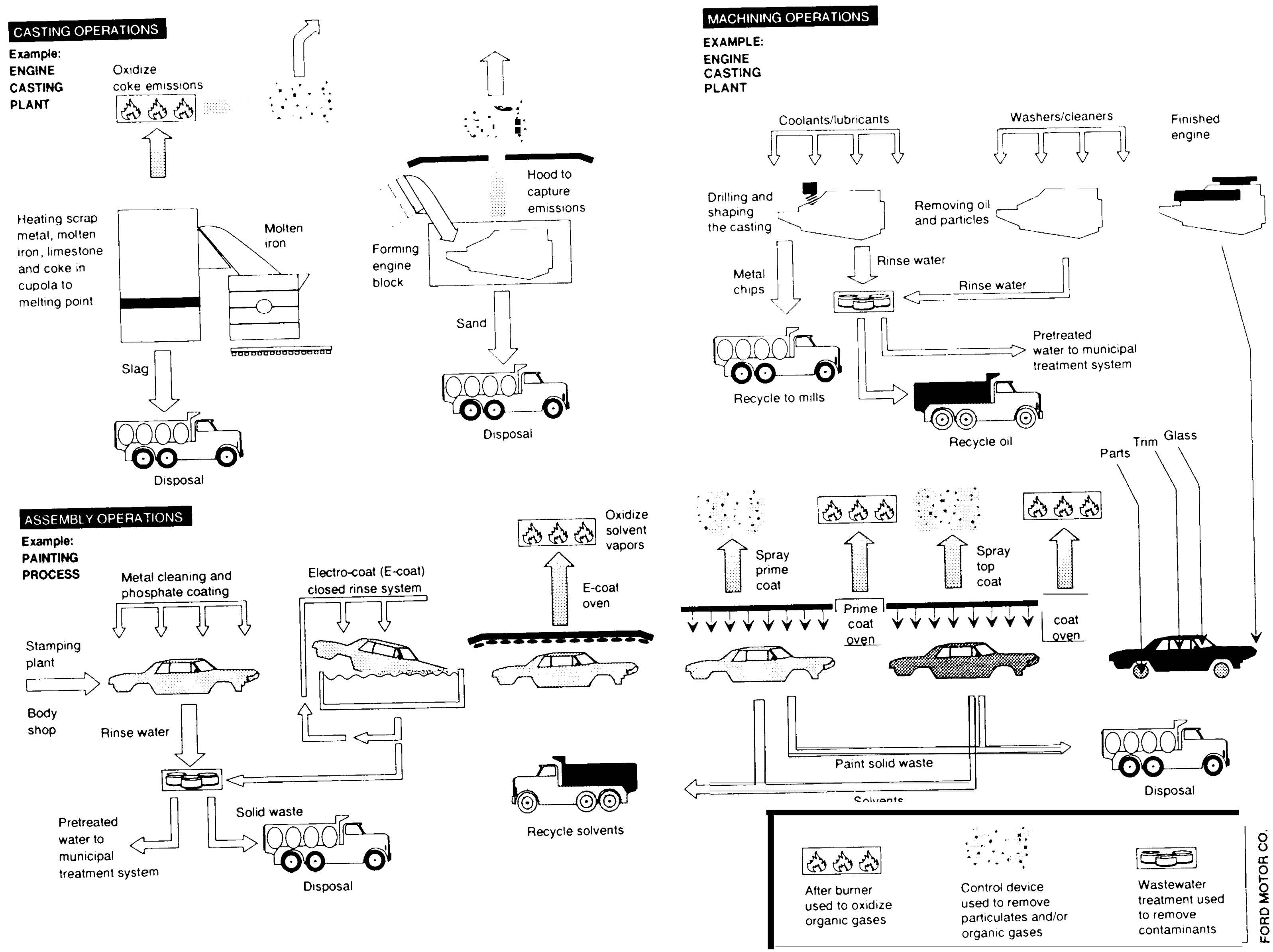
18 U.S. business is widely viewed as placing too little emphasis on training and R&D. U.S. Congress, Office of Technology Assessment, *Worker Training: Competing in the New International Economy,* OTA-ITE-547 (Washington DC: U.S. Government Printing Office, September 1990).

19 Raymond J. Kopp, Paul R, Portney, and Diane E. DeWitt, "International Comparisons Of Environmental Regulation,'' *Environmental Policy and the Cost of Capita/,* Monograph Series on Tax and Environmental Polities and U.S. Capital Costs (Washington, DC: American Council for Capital Formation, Center for Policy Research, 1990).

20 Environmental Protection Agency, *Environmental Investments,* Op. cit., footnote 2.

21 Ibid.

22 Ibid.



While the painting process is the main source of emissions from automobile production, other steps, including casting and machining, also produce pollution and waste. Various prevention, control, treatment, and disposal options are employed to control wastes.

EPA assumed that future compliance will be attained with current technologies. Technological innovations could lower compliance costs as they come on line.[23] For example, in the pulp and paper industry, new in process methods to treat waste cost slightly more than conventional sys-terns, but result in lower operating costs and avoided end-of-pipe costs, with the result that total costs are lower.[24]

Accuracy of the Cost Estimates

The principal source of data on pollution abatement and control costs for manufacturers is from the survey of abatement expenditures by the Bureau of the Census. There are various ways the data could overstate or understate the actual costs.

There are several potential sources of overreporting, although their extent appears to be minor. Anecdotal evidence indicates that respondents may include, as pollution control costs, those costs that were incurred for worker health and safety.[25] In addition, firms may include all the cost of an expenditure when only part of it is attributable to environmental regulation. However, one study suggests that, if anything, firms are likely to underreport expenditures when they do not have full information. Plant managers may classify some investments as environmental in order to get projects approved more easily, particularly when the return on investment (ROI) is low.[26] In addition, firms may lack full knowledge of recovered costs.[27] Finally, while there is no evidence of this, some analysts speculate that some respondents exaggerate costs in order to influence regulation.[28]

The preponderance of evidence suggests that the survey underreports pollution control costs. For example, while Census figures indicate that pollution control costs added 4 cents per pound to the price of copper in 1985,[29] at least four other sources, based on actual examination of copper smelting fins, found that the expenses were much higher, ranging from 7.5 to 15 cents per pound.[30] Some industry association surveys of compliance costs also report slightly higher costs than Census.[31]

Census surveys may underreport for two reasons. First, survey respondents normally do not have complete knowledge of all expenditures,

23 Robert Leone, "Some Complication in the Measurement of Environment Control Impacts: A Case Study of Water pollution Controls," *Socio-Economic Planning Science,* **vol.** 12, No. 3, 1978.

24 Interview with Neil McCubbin, N. McCubbin Consultants, Inc. December 1992.

25 Raymond J. Kopp and Paul R. Portney, "Estimating Environmental Compliance Costs for Industry: Engineering and Economic Approaches," in *Workshop on Effects of Environmental Regulation on Industrial Compliance Costs and Technological Innovation,* National Science Foundation Division of Policy Research and Analysis, (Washington, DC: Sept. 10-11, 1981).

26 Beth Snell and Bob Unsworth, "Evaluation of Uncertainty Associated with Air Pollution Abatement Compliance Cost Estimates—Stationary Sources," (memorandum) Cambridge, MA: Industrial Economics Inc., Oct. 13, 1992.

27 one estimate suggests that this leads to a l-percent overreporting of net costs. (Ibid., P. 5.)

28 Richard Andrews, " Summary," *Workshop on Effects of Environmental Regulation on Industrial Compliance Costs and Technological Innovation* (Washington DC: Nationat Science Foundation, September 1981).

29 Data on pollution control costs from the U.S. Bureau of the Census, *Pollution Abatement Costs and Expenditures, 1985,* MA-200(85)- 1 (Washington DC: U.S. Government Printing Office, 1987),

30 See U.S. Congress, Office of Technology Assessment, *Copper: Technology and Competitiveness,* OTA-E-367 (Washington, DC: U.S. Government Printing Office, September 1988)----10 to 15 cents per pound; National Research Council, Competitiveness of the U.S. Minerals and Metals Industry (Washington, DC: National Academy Press, 1990)--9 to 15 cents per pound; "Counting the Cost of Clean Air,' E&MJ, January 1990—7.5 cents per pound; Duane Chapman, "Environmental Standards and International Trade in Automobiles and Copper: The Case for a Social Tariff," Natural Resources Journal, vol. 31, winter, 1991, pp. 449-461-10 to 15 cents per pound. Total U.S. copper production costs averaged 65 cents per pound.

31 For example, see: *A Survey of Pulp and Paper Industry Environmental Protection Expenditures - 1990* (New York, NY: National Council of the Paper Industry for Air and Stream Improvement, Inc., 1991); *Petroleum Industry Environmental Performance, 1992* (Washington DC: American Petroleum Institute, 1993).

including the costs of environmental controls in retrofits and for environmental operating expenditures, since firms tend not to classify these as discrete categories in their accounting systems.[32] Second, the Census survey does not ask respondents to report interest expense; productivity losses; fees, taxes, and frees; administrative and R&D costs; and training costs.[33]

Without establishment-level studies, assuring the validity of these cost data is difficult. It appears, however, that actual costs may be 20 to 30 percent higher than reported costs. Appendix 7-A discusses possible sources of underreporting and, in some cases, the likely associated costs.

Compliance costs do not provide a complete picture of either total industry level expenditures or effects on GDP.[34] A complete picture would account for the costs of dislocations associated with regulation, including costs resulting from closed plants due to regulation or from reduced output (e.g., laid-off workers) due to higher prices.[35] If a regulated firm goes out of business and the products are made all or in part by firms outside the United States, the costs will be greater than if another U.S. firm increased production to fill demand. Also, if regulated firms cut back production because of regulations, this may be compensated for by increases in production by firms supplying environmental goods and services. Macroeconomic costs may exceed industry compliance costs if impacts of increased prices, reduced productivity, and other factors reduce economic activity[36] (see app. A).

A complete picture would also need to account for the significant benefits of environmental regulations, or, put another way, the costs companies, workers, and society would bear if environmental regulations were not in place. A cleaner environment lowers health care expenditures and improves human health, increases natural resource productivity, and provides valuable amenities (e.g., swimmable rivers). Only now is research being undertaken to accurately quantify these benefits.[37]

PRIVATE SECTOR COMPLIANCE COSTS COMPARED WITH OTHER NATIONS

U.S. pollution abatement costs would have no impact on U.S. economic competitiveness if firms in other countries faced equivalent regulatory costs and burdens. To the extent that they do not, U.S. firms could face a competitive disadvantage. Unfortunately, the literature comparing environmental management is sparse and largely limited to Western Europe, Japan, and North America, making accurate comparisons of environmental regulations across all nations extremely difficult. Few studies compare various countries' approaches to regulation, for the information is either not available or not always comparable.

There are several ways to compare regulatory strictness. First, pollution abatement compliance costs can provide a measure of regulatory burden by delineating the costs borne by fins. However, cost data are available from only a handful of nations, and differences in definitions and rneas-

32 Duane Chapman, "Environment@ Standards and International Trade in Automobiles and Copper: The Case for a Social Tariff,'' Ibid.

33 The Census Bureau does not survey firms with fewer than 20 employees. However, one estimate suggests that small firms account fOr less than 2 percent of the total costs, and about 5 percent of sales. (Beth Snell and Bob Unsworth, op. cit., footnote 26)

34 See U.S. Congress, Congressional Budget Office, "Assessing the Costs of Environmental Legislation'' (staff working paper, May 1988).

35 see Maureen L. Cropper and Wallace E. Oates, "Environmental Economics: A Survey, " *Journal of Economic Literature,* vol. 30, June 1992, pp. 675-740.

36 Sec Michael Hazilla and Raymond J. Kopp, ''The Social Cost of Environmental Quality Regulations: A General Equilibrium Analysis, ' *Journal of Political Economy,* vol. 98, No. 4, 1990, pp. 853-873.

37 Debra S. Knopman and Richard A. Smith, ' '20 Years of the Clean Water Act: Has U.S. Water Quality unproved'?' *Environment,* January/February, 1993. vol. 35, No. 1; Organization for Economic Co-Operation and Development *Environmental Policy Benefits: Monetary Valuation* (Paris: OECD, 1989). The EPA, as mandated by the 1990 Clean Air Act Amendments, Section 812, is conducting a study to quantify the benefits of U.S. air pollution regulations. This study will not be released until lat1994.

urement complicate comparisons. Because countries vary in their shares of highly polluting industries, it is best to compare costs for particular industries.

Second, *emission standards* can indicate differences in regulatory strictness. However, standards are often difficult to compare without exhaustive analysis. First, some standards are measured in hours, others in days; some apply to the overall plant, others to particular sources. Also, different categories of polluters may be regulated to different standards (e.g., new sources v. existing sources). Second, and more importantly, the presence of standards gives little clue to their application in practice—strict laws maybe loosely enforced. Third, air standards for some pollutants (e.g., NO_x, ozone) give no indication of the relative degrees of control placed on different sources, such as large and small stationary sources and mobile sources. Some places with low standards may also have significantly less mobile source emissions, necessitating relatively less control on industry. Finally, many of the comparisons of regulatory strictness emphasize air regulations, particularly of oxides of nitrogen @OX) and sulfur oxides (SO_2). Because this is one major area where U.S. regulations may have lagged behind several other nations in the past, simply focusing on common pollutant air regulations can give a misleading picture of regulatory strictness. It is important to focus on all regulations, including volatile organic compounds (VOCs) and air toxics, water and solid and hazardous wastes.

Third, it is possible to compare *ambient concentrations* of pollutants to ascertain regulatory strictness. However, differences in industrial structure, geography, climate, population concentration, and energy and transportation use may have a greater effect on ambient concentrations than differences in regulatory strictness.

Fourth are comparisons of rules and regulations governing the *regulatory process and form.* This assumes that the process by which regulations are formed and implemented can affect outcomes. For example, the degree of public involvement in regulation-making and in prompting enforcement actions differs markedly by country. The United States has a relatively open process, which can make the process of finalizing regulations lengthy and difficult. However, the openness of the U.S. system does provide an opportunity for many parties to have their voices and viewpoints heard and considered. In addition, permitting systems vary in flexibility.

Pollution Abatement and Control Costs in Selected Countries

Unfortunately, environmental cost data for different nations are limited and of varying quality. A number of OECD nations provide time series data for some years, going back to the 1970s, on total private and public sector environmental expenditures .38 Because these data are reported by individual countries, possibly using different methodologies, they are best seen as providing a general yardstick to compare compliance costs. Data are often not available for industries located in countries with less stringent standards.

A very few countries (including the United States, Germany, Japan, and the Netherlands) provide data for environmental capital expenditures by individual manufacturing sectors (e.g., chemicals, pulp and paper). However, there are differences in definition, which must be adjusted for to make meaningful comparisons. For example, some surveys exclude equipment when it is required by the manufacturing process for technical reasons (e.g., United States, the Netherlands, Denmark, Sweden), while others include it (Germany). Some surveys include the costs of interest

38 Japan provides data on public sector expenditures, but not on total private sector expenditures. It does provide data on pollution control capital expenditures for some industries.

payments on equipment (Canada, Holland), while others exclude it (United States). Some countries (Germany and Japan) include noise abatement expenditures, while the United States does not.

Because investments can fluctuate significantly between years, and because some countries may have imposed stricter regulations sooner, it is more accurate to examine time series of **data.** Some costs are not the result of strict standards in the home country, but rather demands arising in other nations that the country exports to. For example, much of the recent increase in pollution abatement expenditures by the Canadian and Swedish pulp and paper industries may result from consumer pressure from Europe (particularly Germany) for chlorine-free paper, not solely from higher standards.[39] In spite of these limitations, the industry-level cost data can provide a broad picture about the different pollution control burdens placed upon industry in different countries,

Table 7-4—Relative Investments in Pollution Control by Industry[a] (U.S. percentage of investments defined as 100)[b]

Country	1978	1979	1980	1981
United States	**100**	**100**	**100**	**100**
Germany	**76**	**67**	**74**	**89**
The Netherlands	**67**	**72**	**72**	**85**
Denmark	**64**	**41**	**66**	**81**
Sweden				**52**

a The author adjusted the data for each country to be generally comparable. For example, in comparing Dutch and U.S. figures, he did not include Dutch investments in noise control, since U.S. studies did not collect data on these costs for U.S. industry. He did not compare all countries together, but rather compared the Dutch to the other countries individually. In addition, because of differences in definitions, German figures are probably slightly overstated relative to theothernations. As a result, these data should be seen as indicative of the direction and magnitude of differences, but should not be seen as exact measures of differences in spending.

b Investment in pollution control by industry divided by total capital expenditures by industry in the country, normalized to the U.S. value **at 100.**

SOURCE: Based on data in "international Comparison of Industrial Pollution Control Costs, " L. H.E.C. Plooy, Statist&d *Journal of the United Nations, 1985,* pp. 55-68.

OVERVIEW OF DIFFERENCES IN COSTS

There are several different data sources presenting pollution abatement compliance costs for a number of countries, including total private sector compliance costs and costs by particular industry. All point to the conclusion that U.S. private sector pollution control costs are among the highest in the world as a percentage of both GDP and total private sector investments.

A study of five countries, which attempted to control for differences in survey methods discussed above, found that during the period from 1978 to 1981, U.S. industry investments in pollution control were between 10 to ***50*** percent higher than European countries (see table 7-4). For example, in 1980, investments in environment as a percent of total Dutch industry investments were only 70 percent of the U.S. rate, despite its having some of Europe's strictest regulations. Differences between the United States and most other European countries were probably greater.

According to OECD information, U.S. private sector pollution control costs as a share of GNP were nearly twice that of any European country in the 1970s, although in the 1980s the gap narrowed with a few countries[40] (see table 7-5.) For example, as a portion of GNP, German private sector expenditures were approximately 60 percent of those in the United States in the 1970s, but by 1990 the two were about equal. Spending by French and Dutch companies continued to be less. U.S. private sector pollution control expenditures as a percentage of GNP are higher or as high as any other OECD nation that reported private

39 Interview with Neil McCubbin, **N. McCubbin Consultants, Inc., December** 1992.

40 *OECD Environment Monographs, No.* 38, *Pollution Control andAbatement Expenditures in OECD Countries* (Paris: OECD, November 1990); *also OECD Environment Monographs, No. 75, Pollution Control and Abatement Expenditures in OECD* Countries (Paris: OECD, June, 1993).

Table 7-5-Private Sector Pollution Control Expenditures as Percentage of GNP[a]

Country	1972	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
U.S.	0.67	0.74	0.82	0.90	0.90	0.91	0.89	0.94	0.96	0.95	0.89	0.88	0.89	0.89	0.86	0.8	0.8	0.8	0.86
Austria	0.26	0.37	0.39	0.37	0.33	0.44	0.33	0.30	0.39	0.36	0.47	0.50	0.47	0.73	0.74	0.7	0.7		
Finland											0.70	0.62	0.71	0.65	0.60	0.82	0.64		
France										0.32	0.31	0.30	0.29	0.30	0.32	0.3	0.3	0.3	0.33
Germany				0.56	0.53	0.52	0.50	0.49	0.53	0.58	0.63	0.64	0.62	0.74		0.8	0.8	0.79	0.8
Netherlands								0.31	0.34	0.34	0.35	0.26	0.26	0.30	0.33	0.6		0.46	
Norway														0.27					
Sweden			0.22												0.27				
United Kingdom							0.84			0.76				0.62					1.0[b]
Canada																		0.28	
Portugal																		0.1	

a Japan does not provide aggregate data on private sector environmental costs.

b United Kingdom private sector expenditures include expenditures by privately owned water treatment and supply plants, which in most other nations listed are assigned to the public sector.

SOURCES: *OECD Environment Monographs, No. 38, Pollution Control and Abatement Expenditures in OECD Countries* (Paris: OECD, November 1990). For data after 1986, *OECD Environment Monographs, No. 75*, OECD, 1993.

sector data as a whole .41 While these numbers give a sense of the magnitude of differences in costs, they should be interpreted cautiously.

INDIVIDUAL COUNTRIES

Japan—The view is frequently held that Japanese manufacturers spend significant amounts of money on pollution control; in fact they spend significantly less than U.S. manufacturers. In part, this view is fueled by the fact that the Japanese have placed high levels of emphasis on energy conservation and on recycling of industrial and consumer products, logical steps for a nation that imports almost all of its energy and materials and has little space for landfills. Energy conservation has contributed to a reduction in some air pollutants. Moreover, much of the pollution control spending by industry in Japan is by electric utilities. Between 1972 and 1990, Japanese electric utilities spent 2.8 times more on pollution control equipment as a share of capital expenditures than manufacturers did. In 1990, they spent 2,5 times more, while U.S. electric utilities spent 14 percent less than manufacturers.[42] As a result, much of the money spent on pollution control in Japan is spent by utilities rather than manufacturers. This is also consistent with the Japanese stress on controlling common air pollutants.

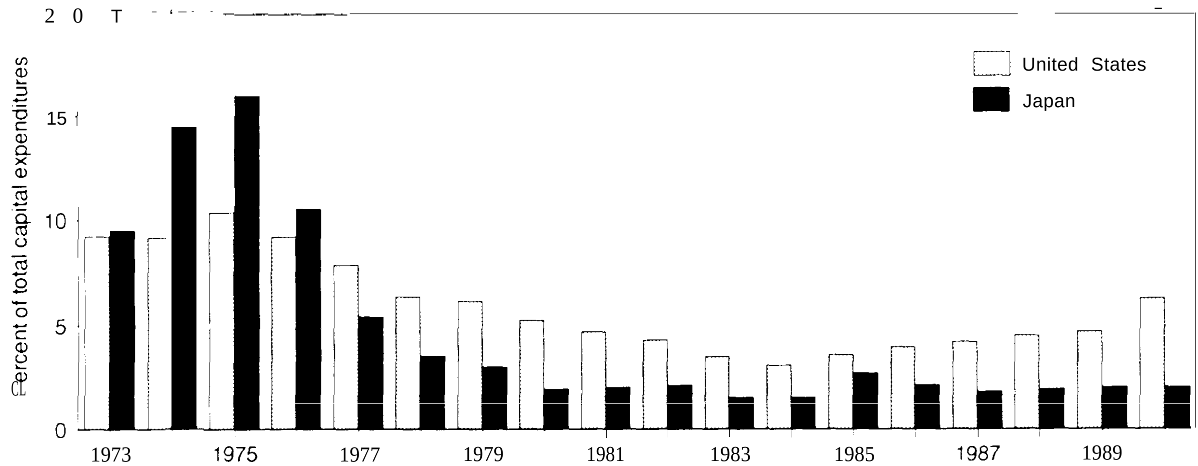
Japanese industry made high levels of investments for pollution control in the early 1970s. However, since 1977, U.S. industry has paid more to control pollution, and that gap is growing (figure 7-6). In 1975, Japanese pollution control investments by manufacturing firms peaked at 16 percent of total investments, while U.S. investments were around 10 percent.[43] However, investments by Japanese firms fell sharply after this initial surge (much of it was to comply with new

41 private sector expenditures excluded mobile source control expenditures, although it appears that the United States pays more per GDP for mobile source control than other countries. Japanese data were limited to a survey of a sampling of industrial firms and are discussed below.

42 Japanese Ministry of International Trade and Industry, *Shuyo-Sangyo no Setsubi-Toshi-Keikaku Heisei 4* (Plants and Equipment Investments of Major Industries, 1992); U.S. Census Bureau, *Pollution Abatement Costs and Expenditures, 1990, MA-200(90)-1* (Washington DC: U.S. Government Printing Office, 1987).

43 This information is derived from a survey by the Japanese Ministry of International Trade and *Industry, Plants and Equipment Investments of Major Industries*. In 1992, the most recent year MITI reported data (for 1990), MITI surveyed the approximately 3,000 Japanese firms with capital stock of over 100 million yen. MITI received 812 usable responses. MITI asked the firms to report capital equipment purchased for environmental protection. Given the possibility that responding firms have higher expenditures than the sample as a whole, it is not likely that the sampling methodology causes underreporting. (Interview with MITI officials, May, 1993.)

Figure 7-6—Pollution Control Capital Expenditures by U.S. and Japanese Manufacturers



SOURCE: U.S. Census Bureau, *Pollution Abatement Costs and Expenditures* (Washington, DC: U.S. Government Printing Office, various years); Japanese Ministry of International Trade and Industry, *Shuyo-Sangyo no Setsubi-Toshi-Keikaku Heisei 4* (Plants and Equipment Investment of Major Industries, various years).

Japanese NO_x and SO_2 regulations) and have averaged around 2 percent of total investments in recent years.[44] In contrast, while U.S. investments never reached this peak, they also did not decline to as low levels and have shown signs of increasing since the late 1980s to over 6.25 percent in 1990 (and 7.9 percent in 1991), while Japanese costs appear stable.[45] Between 1973 and 1990, manufacturers in Japan spent an average of 4.4 percent of investments on pollution abatement, while manufacturers in the United States averaged slightly more, 5.3 percent.[46] Japanese costs are lower than U.S. costs in all media, but particularly in solid and hazardous wastes, where they spend very little[47] (see figure 7-7).

These differences are not caused by different industrial structures, for the trends and differences are consistent across sectors. For example, trends in spending by the chemical industry show a similar pattern (figure 7-8). Similarly, spending for the automobile industry shows consistent differences (see box 7-B). Capital and operating costs associated with the 1990 Clean Air Act Amendments could increase this differential further. Moreover, this differential does not appear to be due to more efficient approaches to pollution

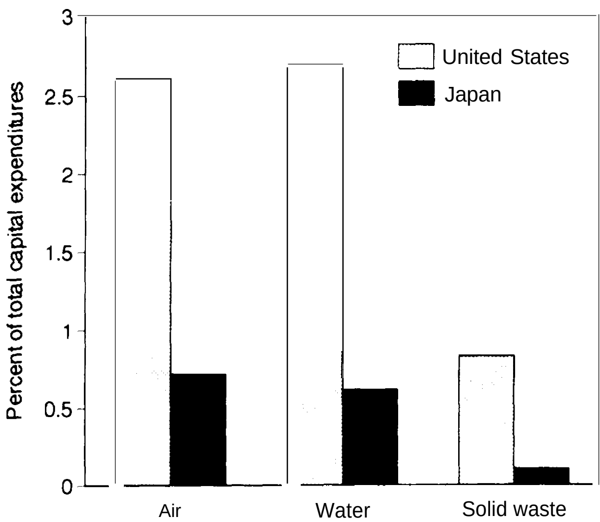
44 Differences in the size of the environmental goods o, services (EGS) markets in the United States and Japan are consistent with these differences in compliance costs, Controlling for differences in size of population the Japanese EGS market is 60 percent of the U.S. EGS market. (Based on OECD data in "The OECD Environment Industry: Situation, Prospects and Government Policies, ' OCDE/GD(92)1 (Paris: OECD, 1992).

45 Japan Ministry of International Trade and Industry, *Plants and Equipment Investments of Major Industries*, various years; and U.S. Bureau of the Census, *Pollution Abatement Costs and Expenditures*, various years, op. cit., footnote 42.

46 Japan, does, however, include noise pollution expenditure, while the United States does not. As a result, Japanese investments in noise abatement were subtracted from total costs. It is not known how much U.S. firms spend on noise pollution, although it may well be less. Even so, these Japanese expenditures arc relatively small, accounting for about 10 percent of total pollution control capital expenditure in 1990.

47 Japan does not have Superfund type provisions for the cleanup of contaminated sites. In addition, while the United States regulates over 425 chemicals under RCRA, Japan has no "hazardous wastes" category per se, although roughly 30 hazardous substances are monitored. Moreover, over 75 percent of Japanese municipal solid waste is incinerated through 1,900 incinerators, with many used to generate electricity or heat. Louise Jacobs and Leigh Harris, *Public-Private Partnerships in Environmental Protection, A Study of Japanese and American Frameworks for Solid Wastes and Air Toxics* (Lexington, KY: The Council of State Governments, 1991).

Figure 7-7—Pollution Control Capital Expenditures by Media by U.S. and Japanese Manufacturers, 1990



SOURCE: U.S. Census Bureau, *Pollution Abatement Costs* and *Expenditures* (Washington, DC: U.S. Government Printing office, various years); Japanese Ministry of International Trade and Industry, *Kogai to Taisaku* (Pollution and Anti-Pollution Measures) vol. 27, No. 15, 1991.

control. Despite progress on industrial energy efficiency, anecdotal evidence suggests that Japanese industry has not emphasized pollution prevention in managing industrial waste.

Germany--In the 1970s, West German manufacturers spent less on capital expenditures for pollution control (as a percent of total capital expenditures) than did American manufacturers. For example, while in 19786.3 percent of U.S. capital expenditures went to pollution control, only 3.6 percent of German manufacturers' capital was spent for this purpose. The gap has narrowed since the mid-1980s, to where spending now appears to be about the same (see figure 7-9). In 1990, as a share of total capital expenditures, pollution control expenditures were lower in West Germany than in the United States in 12 of 17 manufacturing sectors, and were lower for manufacturing as a whole (4.2 percent v. U.S. spending of 6.25 percent, see figure 7-10).[48] However, because German capital expenditure rates as a percent of sales are higher than comparable U.S. rates, pollution control capital investments as a share of sales are slightly higher than in the United States (0.26 percent of sales v. 0.22 percent).

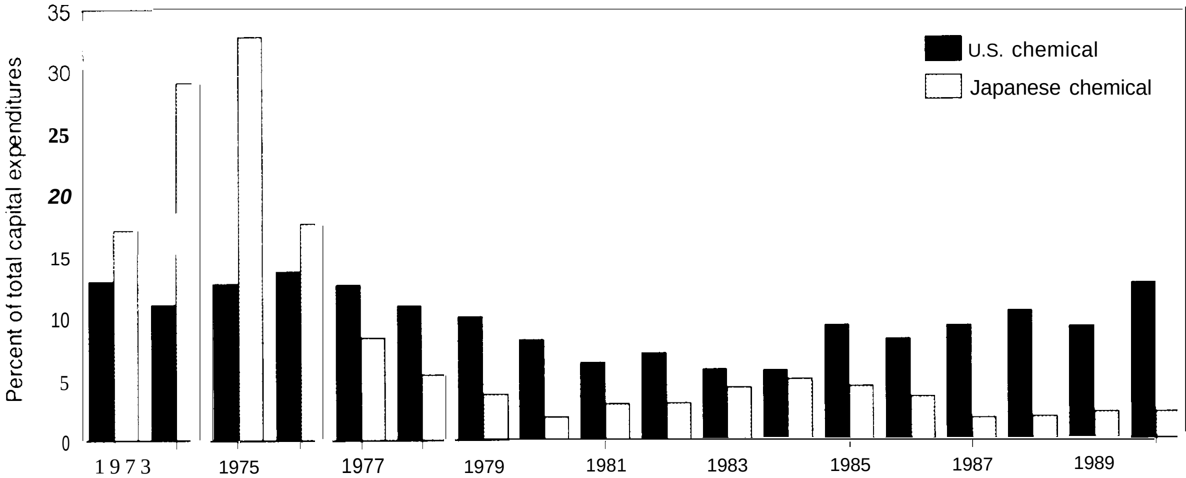
Other European Countries-Germany, Austria, and some of the Scandinavian countries are considered to have the strictest pollution control regulations and enforcement in Europe. But the fact that U.S. and German costs appear equivalent suggests strongly that U.S. costs are higher than for most other nations in Europe. The sector-based data available for the Netherlands and, to a limited extent, for France, support this view. OECD data suggest that industry in countries such as Great Britain and Canada also have lower costs.[49]

Pollution control costs for Dutch industry were much lower than U.S. costs through the mid-1980s. For example, in 1975, when over 10 percent of manufacturing investments in the United States went to pollution control, only 2 percent of Dutch investments did (figure 7-1 1). However, Dutch spending appears to have increased, so that it is now only slightly lower than U.S. spending as a portion of capital expenditures. In 1990, 6.25 percent of manufacturing investments in the United States went to pollution

48 German data include a number of costs not included in the Us, data. Expenditures in noise abatement, land purchases, and capital for environmentally friendly products are included. The data reported here subtract these costs (approximately 19 percent of total costs) from the total German data to make it more comparable to U.S.data.

49 Historically, private sector pollution control expenditures in the United Kingdom have been lowerthan in the United States and Germany. However, in 1989, public water authorities in England and Wales became privately owned companies, As a result, in 1990, U.K. private sector expenditures (1 percent) as a share of GNP were actually slightly higher than in Germany (0.8 percent) and the United States (0.86 percent). However, after reallocating the estimated costs of the formerly public water treatment authorities to the public sector, pollution control expenditures by the private sector in the U.K. amount to approximately 0.75percent of GNP.

Figure 7-8—Trends in Pollution Control Capital Investments by U.S. and Japanese Chemical Firms



SOURCE: U.S. Census Bureau. *Pollution Abatement Costs and Expenditures* (Washington, DC: U.S. Government Printing Office, various years); Japanese Ministry of International Trade and Industry, *Shuyo-Sangyo no Setsubi-Toshi-Keikaku Heisei 4* (Plants and Equipment Investment of Major Industries, various years).

control compared to 5.1 percent in the Netherlands. After adjusting for differences in method, Dutch operating costs (0.57 percent of sales) for pollution control by industry are also lower than U.S. costs (0.72 percent).[50]

According to a recent survey, French manufacturing industry spent approximately 2.9 percent of new capital expenditures on pollution control in 1991 (compared to 7.9 percent in the United States).[51] These differences were consistent across sectors; for example, the share of pollution control investments in chemicals was 6.5 percent in France and 12.9 percent in the United States, and in transportation, including automotive, 0.9 percent in France and 3 percent in the United States, The article also cites European Commission data, indicating that pollution control costs in Italy are significantly lower than in France.[52]

Newly Industrialized and Developing Country Costs–Evidence suggests that pollution control costs in developing and newly industrialized (NICs) are significantly lower than in the United States. For example, environmental compliance costs are estimated at 0.24 percent of GDP in Thailand and 0.38 percent in Indonesia and Korea (1987) compared to 1.63 percent in the United States (1990).[53] Moreover, a greater share of these costs may be for public infrastructure (e.g., sewage treatment plants) than is true in the United States. In addition to having lower environmental

50 Other than the United States, the Netherlands is the only country that provides data on operating as well as capital costs at the industry level. The Dutch survey includes a number of costs not included in the U.S. data, including the costs of interest on capital equipment, R&D expenditures, expenditures on noise and landscaping, and environmental taxes and fees on fuels used or the extra costs of fuels with low sulfur content. To make the data more comparable, these items were subtracted from total Dutch costs. "Statistics on the Costs of Environmental Control by Industry," paper from the Netherlands Central Bureau of Statistics, Department of Manufacturing and Construction, undated.

51 Robert Quivaux and Philippe Sabot, "Antipollution Investments by Industry,' *Industries* (Paris), July-Aug 1993, in Foreign Broadcast Information Service, *JPRS Report: Environmental Issues, JPRS-TEN-93-022,* Sept. 3, 1993, pp. 15-19.

52 Ibid.

53 Dhira Phantumvanit and Theodore Panayotou, "Industrialization and Environmental Quality: Paying the Price,' paper presented at the 1990 TDRI conference, Industrializing Thailand and Its Impact on the Environment Dec. 8-9, 1990.

Box 7-B—Pollution Control and Automobile Production in Competitive Context

Relative to many materials intensive process industries, such as chemicals, the automobile production process is not highly polluting. As a result, the industry faces lower facility compliance costs than some other industries, although imposition of Clean Air Act and other regulatory requirements will raise them.

While automakers face regulatory requirements in a number of areas, including hazardous waste cleanup and disposal and water pollution, the major source of pollution and compliance costs is related to air emissions from the automobile painting process. Paints have traditionally been applied in a liquid form, with organic solvent-based carriers that upon application, evaporate and are emitted into the air. Automakers have three basic control options: changing the coating formulation, improving transfer efficiency, and adding on controls. Modified coatings, including higher solids paints (increasing the paint content relative to the solvent content), water-based coatings containing few organic solvents, and solvent-free powder coatings can reduce emissions of volatile organic compounds (VOCs). However, technical limits and retrofit costs inhibit wider use of water-borne and powder technologies in the near term. Improving transfer efficiency means that more sprayed paint adheres to the car and is not wasted. In the last 20 years, automakers have Improved transfer efficiency substantially-in part to cut paint costs-and additional improvements are sought. Finally, incinerators are used to burn VOCs in oven and paint booth exhausts, supplemented in several installations by carbon adsorption units to concentrate the solvents.

The United States has regulated VOCs from automobile painting since the late 1970s. As a result, most U.S. plants have, at minimum, electro-deposited waterbased primecoats, low VOC coatings (using high solids paints), high efficiency electrostatic spray applicators, and oven exhaust incineration.[1] Because of these requirements, automobile assembly plants (SIC 3711) in the United States spent an estimated $82 million in 1991 on capital equipment to control VOCs, amounting to 63 percent[2] of their $130 million for pollution control capital expenditures, the latter accounting for 6.4 percent of their total capital expenditures. According to estimates by the American Automobile Manufacturers Association, VOC control costs might triple if stricter lowest achievable emission rate (LAER) standards are required at every facility.

Regulations also impose indirect costs. Permitting requirements can reduce operational flexibility needed to accommodate changes in the production process. Moreover, they can potentially delay introduction of new production, particularly when permits are required prior to construction. Because demand for autos fluctuates and models change, operational flexibility and timely regulatory decisions can bean important competitive factor. Finally, regulatory requirements may affect product quality, particularly the paint finish.

Automobile and truck producers in Japan appear to face less stringent and detailed requirements and therefore lower compliance costs and probably greater operational flexibility and product quality advantages. In 1990, U.S. automobile and truck producers, including parts suppliers (SIC 371) spent over five times more on pollution control equipment than Japanese firms as a percent of total capital

1 Energy and Environmental Analysis, inc., "Comparison of U.S. Air Quality Standards and Controls to the Air Pollution Controls in Japan, Germany, Canada, Mexico, and South Korea," draft report prepared for the Office of Policy Analysis and Review, Office of Air and Radiation (Washington, DC: U.S. Environmental Protection Agency, 1992).

2 The majority of this is presumably for paint VOC controls. U.S. Census Bureau, *Pollution Abatement and Control Expenditures,* 7997 (Washington, DC: U.S. Government Printing Office, January 1993).

investments, and three times more as a percent of sales.[3] Moreover, Japanese permitting requirements are generally much simpler, with VOC sources and changes to them not requiring permits or prior government approvals.[4] Finally, it is widely asserted that weaker VOC regulations make it possible for automakers in Japan to achieve very high quality finishes on their premium models (smoother and higher gloss) without facing the environmental control costs U.S. automakers would incur.

If the U.S. motor vehicles industry (SIC 371) spent the same share of investments on controlling pollution from production facilities as the Japanese, they would have spent $247 million less in 1990 in pollution control capital expenditures and $410 million less in operating expenses. Differences in air, water, and waste regulations on the automobile industry (not including costs of regulation on supplier industries, such as steel, glass, rubber) added approximately $50 to the cost of a $15,000 car (sales price of original equipment manufacturer).[5]

While regulatory requirements will likely increase, there are a number of technical changes and regulatory modifications that could minimize the competitive burden. First, new approaches to VOC control may reduce compliance costs relative to end-of-pipe control. The United States Council for Automotive Research (USCAR), an umbrella organization for the big three U.S. automobile manufacturers, has formed along-term low emission paint systems consortium to conduct research and demonstrate VOC reduction alternatives, including electro-coating, powder-based primers, surface coats, and clear-coat paint systems, and waterbased base coats (see ch. 10).

Second, a number of regulatory modifications, including use of facility-wide emissions caps, performance standards, expedited permitting, and emissions trading, could make it easier for the industry to comply with regulatory requirements (see ch. 9). Some specific changes advocated by the auto industry include expanding pre-construction activities which can commence prior to New Source Review permit issuance, determining Best Available Technology/Lowest Achievable Emission Rate requirements at the time the permit application is complete, and prompt development by EPA of Maximum Available Control Technology standards for automobile production paint facilities.

3 Japanese automobile firms maintain higher capital investment rates as a percent of sales than do U.S. automakers. Japan Ministry of International Trade and Industry, *Plants and Equipment Investments of Major Industries, 1992 (Tokyo:* MITI, 1992), pp. 480-493; and U.S. Bureau of the Census, *Pollution Abatement Costs and Expenditures, 1990,* op. cit.

4 Energy and Environmental Analysis, Inc., op. cit.

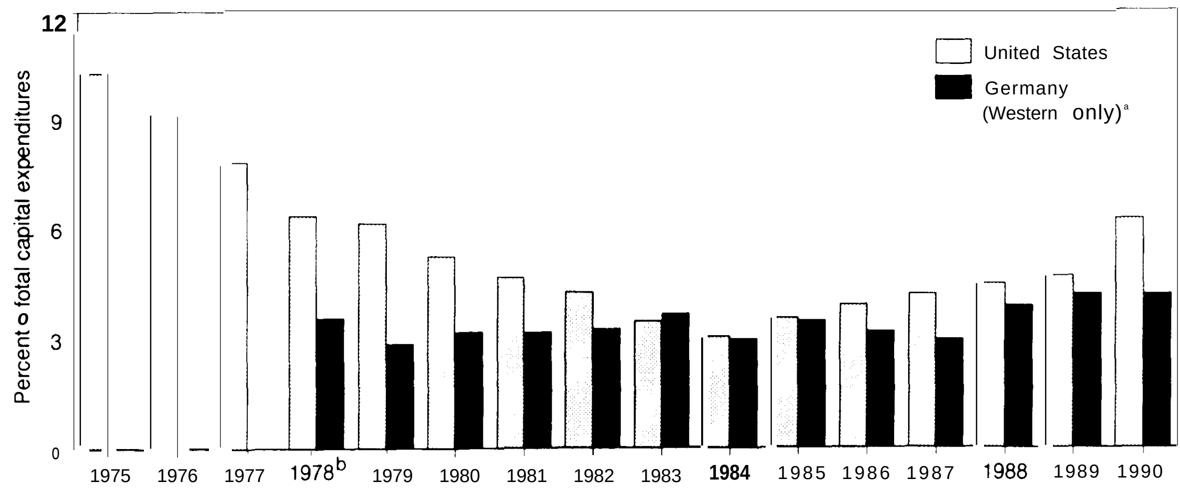
5 This includes pollution control capital and operating expenditures andassumes Japanese industries spend the same ratio of operating costs to pollution control capital rests. OTA calculations based on data from U.S. Census Bureau, *Pollution Abatement and Control Expenditures,* op. cit.; and the Japanese Ministry of International Trade and Industry, *Plants and Equipment /investments of Major Industries,1992,* op. cit.

compliance costs, these nations also have significantly lower labor costs.

While many less-developed countries have minimal regulations, or poor enforcement, some multinational corporations (MNCs) claim to apply their higher home country standards to their investments or plants in less-developed nations. However, little systematic evidence has been presented to evaluate this claim.[54] Moreover, while U.S. maquiladoras firms in Mexico say that

54 One survey of U.S. multinationals suggests that onl, around 20 percent had written policies to meet or exceed U.S. regulations overseas when foreign laws are less stringent, while 40 percent of the respondents said this was very important. Margaret Flaherty and Ann Rappaport, *Multinational Corporations and the Environment: A Survey of Global Practices* (Medford, MA: Tufts University, Center for Environmental Management, 1991).

Figure 7-9—Trends in Pollution Control Capital Expenditures by U.S. and German Manufacturers

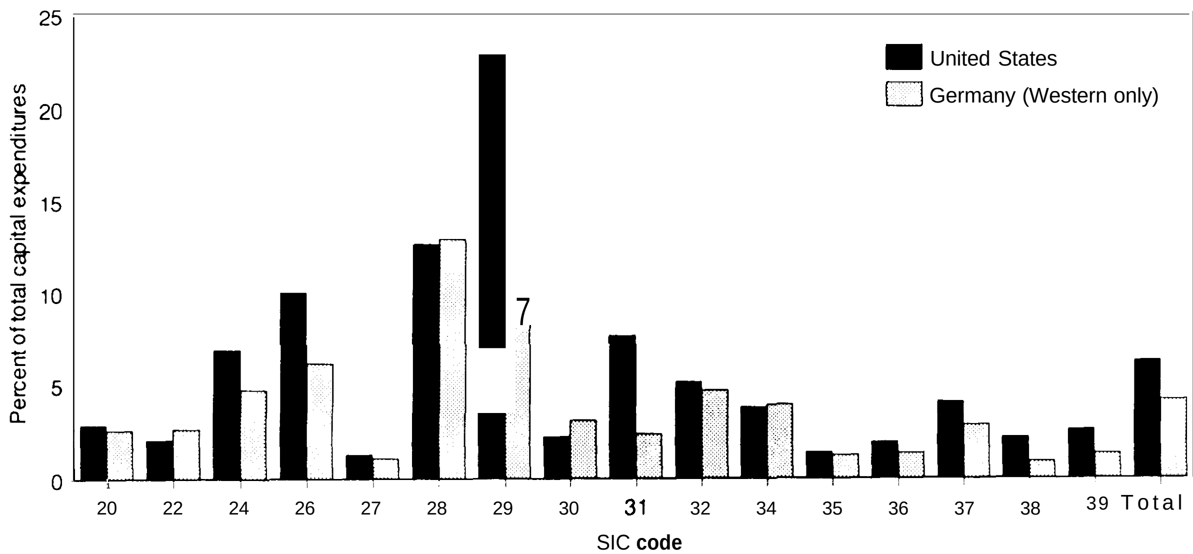


a German data includes costs for noise abatement, land purchases, and capital for environmentally friendly products that are not included in the U.S. data. To make the data comparable, expenditures on these items (approximately 19 percent of total costs) were subtracted from total German costs.

b German cost data not collected prior to 1978.

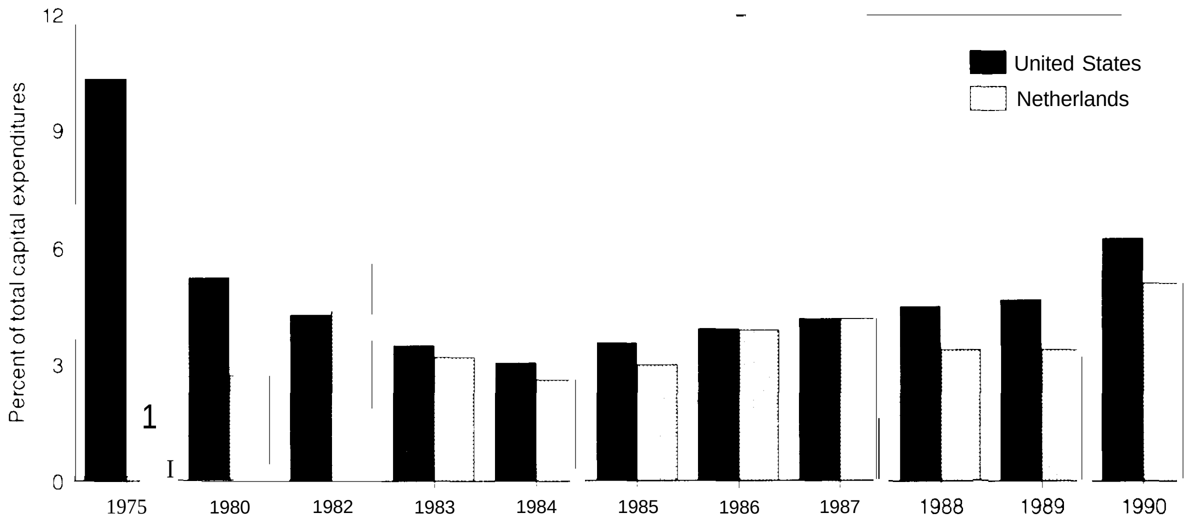
SOURCE: U.S. Census Bureau, *Pollution Abatement Costs and Expenditures* (Washington, DC: U.S. Government Printing Office, various years); Statistisches Bundesamt, *Investitionen fur Umweltschutz im Produzierenden Gewerbe 1990* (Wiesbaden: Metzler Peoschel, 1992).

Figure 7-10—Pollution Control Capital Expenditures by U.S. and German Manufacturing Industries, 1990



SOURCE: U.S. Census Bureau, Pollution *Abatement Costs and Expenditures, 1990* (Washington, DC: US. Government Printing Office, 1992); Statistisches Bundesamt, *Investitionen fur Umweltschutz im Produzierenden Gewerbe 1990* (Wiesbaden: Metzler Peoschel, 1992).

Figure 7-1 l—Trends in Pollution Control Capital Expenditures by U.S. and Dutch Manufacturers



SOURCE: U.S. Census Bureau, *Pollution Abatement Costs and Expenditures* (Washington, DC: U.S. Government Printing Office, various years); "Industrial Investments for the Protection of the Environment, 1990," Government of the Netherlands.

they don't illegally pollute, others dispute this claim and argue that sewage and other runoff from the area is often highly infused with industrial wastes.[55] Even if MNCs abide by home country standards, they may receive a cost advantage for products shipped to countries with higher regulations if their local suppliers are unregulated.

Government Support

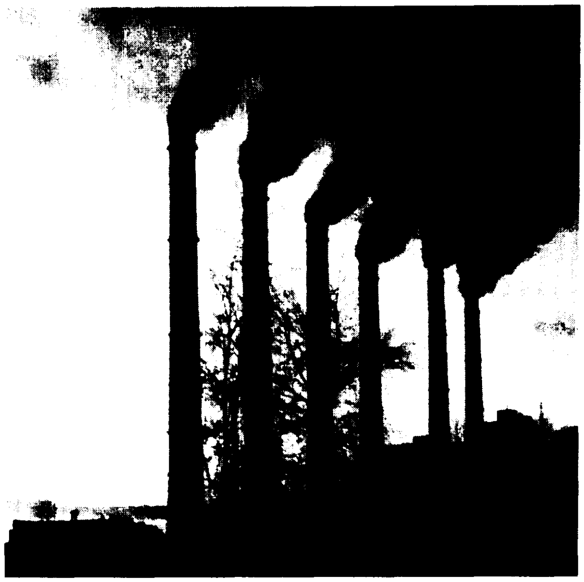
Support for industry to comply with pollution control regulations follows similar patterns for industrial development assistance overall-the United States tends to provide less direct assistance to industry than many of its major industrial competitors, and relies principally on regulatory measures to ensure environmental protection.[56] In contrast, a number of European nations supplement regulation with explicit use of technology and industrial policies to help industry reduce pollution, particularly through support of development and diffusion of innovative environmental technologies.[57]

Several countries provide direct assistance to help firms address pollution control requirements. The Japanese Government contends that private commercial banks are not necessarily willing to finance unprofitable pollution control investments, and that government-sponsored fund-

[55] For example, see **Joseph La Dou, "Deadly Migration: Hazardous Industries' Flight to the Third World,"** *Technology Review,* **vol. 94, No. 5, July 199 i; Sanford Lewis et. al., "Border Trouble: Rivers in Peril. A Report on Water Pollution Due to Industrial Development in Northern Mexico," National** Toxics **Campaign Fund, May 1991; Diane M. Perry, Roberto Sanchez, William H. Glaze, and** Marisa Mazari, "Binational **Management of Hazardous Waste: The** Maquiladora **Industry at the U.S.-Mexico Border,** *Environmental Management,* **vol. 14, No.** 4, **1990, pp. 441** -450; **Sandy** Tolan, **"Hope and Heartbreak,"** *The New York Times Magazine,* **reprinted from Best of Business Quarterly, Winter 1990-9 1; U.S. Congress, General Accounting** Office, **"U.S.-Mexico Trade: Assessment of Mexico's Environmental Controls for New Companies,"** GAO/GGHD-92-1 **13, August, 1992.**

[56] U.S. Congress, Office **of Technology Assessment,** *Competing Economies,* **Op. Cit.,** footnote **1.**

57 Alan C. Williams, "A Study of Hazardous Waste Minimization in Europe: Public and Private Strategies to Reduce Production of Hazardous Waste," *Boston* **College** *Environmental Affairs Law Review,* **V. 14, Winter 1987, pp. 167-255; Kenneth** Geiser, **Kurt Fischer, and Norman** Beecher, "*Foreign Practices in Hazardous Waste Minimization: A Report to the U.S. Environmental Protection Agency* (Medford, **MA: Tufts** University, **Center for Environmental Management, August 1986).**



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Oil Shale Plant in Estonia. Compared to expenditures by industry in the United States for pollution control, firms in most developing countries and Eastern Europe face significantly lower costs.

ing is needed. Between 1975 and 1990, the Japanese Development Bank, the Japan Finance Corporation for Small Business, the Japan Environment Public Corporation, and other institutions provided approximately 35 percent of all funds invested by Japanese industry for pollution control and, in 1992, provided over $2 billion in loans.[58] The loans have interest rates 1 to 2 points lower than commercial loans, interest payments deferred for the first 2 to 3 years, and longer terms.[59] Many Japanese prefectures and larger cities provide direct technical assistance to help firms manage wastes, and most Chambers of Commerce maintain a Pollution Control Office.[60]

European nations are generally less active, but many still provide more financial assistance than the United States. Germany provides interest-subsidized loans for the installation of pollution control equipment.[61] Industry associations manage government grants that pay half the costs of environmental consultants to small and medium-sized enterprises.[62] Germany also provides partial grants for some pollution control investments and R&D. At least 97 distinct programs for environmental assistance to German industry have been identified.[63] Several other European countries, including the Netherlands and Denmark, provide sizable grants for the development of clean technologies (see ch. 10).

Publicly supported pollution control financing programs in the United States are quite small. Prior to 1986, air and water pollution control facilities were eligible for tax exempt Industrial Development Revenue Bonds (IDB's). However, the 1986 Tax Reform Act severely restricted the use of these bonds for pollution control equipment by industry, as these were increasingly considered more of a subsidy to private industry instead of support for public infrastructure. As a result, very few IDBs are issued for industrial pollution control equipment.[64]

The Pollution Control Loan program operated by the U.S. Small Business Administration (SBA) made only four loans totalling $3.7 million in 1991 and 1992. (Some pollution control loans

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58 The *Quality of Environment in Japan*, 1992, Environment Agency, Government of Japan, 1992, p. 133. This included approximately $1 billion through the Small Business Corporation for energy and environmental loans.

59 "Business of Japan Environment Public Corporation,' Environment Administration 1992.

60 Geiser, Fischer, and Beecher, op. cit., footnote 57, p. 54.

61 Organization for Economic C@ Operation and Development, *OECD Environmental Performance* Reviews: Germany (Paris: OECD, 1993).

62 Konrad von Moltke, "American Industry and the Environment: Implications for Trade and Competitiveness, " contractor report prepared for the Office of Technology Assessment, November 1992.

63 Ibid.

64 U.S. Congress, General Accounting Office, The *Effect of the Volume Cap on Investment in Environmental Infrastructure* (Gaithersburg, MD: U.S. General Accounting Office, Oct. 28, 1993).

may be funded under the regular SBA 7A loan guarantee program, but SBA does not report these loans by purpose).

The Federal Government also provides some support to U.S. industry for development of cleaner technologies. For example, DOE's Office of Industrial Technologies funds industry consortia for the development of more energy-efficient and cleaner technologies. These activities are discussed in chapter 10.

A number of other countries have more general tax incentives for pollution control. Accelerated depreciation is the most common tax incentive for pollution control investment.[65] Many countries offer special rates for the depreciation of pollution control equipment that allow at least 80 percent of the cost to be written off after no more than 3 years.[66] The Japan Ministry of Finance establishes a much shorter life span for pollution control equipment than for other fixed assets. Japanese industry can depreciate pollution control equipment in 7 years, and some ''urgently needed' equipment even faster.[67] In addition, Japan allows a special capital cost allowance of 20 percent of the acquisition cost of pollution control equipment for the first year of use. MITI has proposed reducing fixed asset taxes on CFC-free equipment and has allowed new purchases to be depreciated more quickly.

Although no longer in effect, German firms were until recently allowed to take accelerated depreciation of pollution control investments.[68] In 1989, their net value was estimated at more than DM1 billion, or about 13 percent of total private sector environmental capital investments.[69] (In accordance with European Community policy, the net subsidy effect of accelerated depreciation may not exceed 15 percent of the net cost of the environmental portion of the investment.) Taiwan allows air and water pollution control equipment to be depreciated in 2 years, while Mexico allows a first year deduction of 90 percent. While these subsidies may provide an advantage to firms in other countries, they may also stimulate needed environmental investments.

Some countries target abatement incentives for innovative technologies or pollution prevention. In the Netherlands, for example, companies investing in innovative environmental technologies (as selected by the environment ministry) can deduct the full amount of expenditures from taxable income in the first year, instead of the 10-year depreciation period that usually applies. (A broader tax incentive was in effect until 1984, but proved too expensive.)

In the United States, special provisions for writing off investments in pollution control equipment only apply to plants in operation in 1976 or before. As new plants replace old ones, the write-off has declined in importance. Even for facilities in operation in 1976, it takes 5 years for most manufacturers to fully write off the cost of pollution control equipment certified under section 169 of the U.S. tax code. The recovery period is far longer for manufacturing firms that are subject to alternative minimum tax. Finally, while the law includes equipment that prevents the creation of pollutants, in addition to equipment that reduced and controlled pollutants, the amor-

[65] Stephen F. Clarke, "The Tax Treatment of Expenditures on Antipollution Equipment and Facilities in Selected Foreign Countries," in *U.S. Environmental Policy and Economic Growth: How Do We Fare?*, Monograph Series on Tax and Environmental Policies and U.S. Capital Costs (Washington, DC: American Council for Capital Formation, 1992), pp. 53-61.

[66] Ibid.

[67] Bruce Aronson, "Review Essay: Environmental Law in Japan," *Harvard Environmental Law Review*, vol. 7, No. 1, 1983, p. 158.

[68] In 1988, 73 percent of all investments in water, 68 percent in air, and 48 percent in waste management claimed an accelerated depreciation allowance. OECD Technology and Environment program, "Background Paper on Policy Tools and Their Applications in Various Member Countries" (Paris: OECD, June 3, 1991).

[69] Konrad von Moltke, op. cit., p. 61.

tizable cost of the facility must be reduced by the amount of savings generated.[70]

While Federal incentives for investment in pollution control facilities are limited, 38 States offer incentives in the form of sales and property tax exemptions, tax credits, and accelerated depreciation of equipment.[71] However, because State tax rates are much lower than Federal, the effect of these incentives is generally quite small. Many also contain a bias against pollution prevention.

Environmental Standards and Enforcement

While OTA has not made detailed comparisons of regulatory strictness, some broad generalizations can be made. Taking into account all compliance actions demanded of industry, U.S. air, water and waste regulations appear to be among the strictest, but the differences are not large among the leading OECD nations. While differences exist among media, Germany, Austria, Sweden, and some other Northern European countries also impose strict regulations on their firms (see app. 7-B). The differences in regulation between the United States and the middle tier of countries are somewhat larger. A number of developed nations fall into this group, including Australia, Britain, Canada, and France.

Assessing regulatory stringency in Japan is difficult, in part because while Japanese regulations to control several common air pollutants (NO_x, SO_2), have been stricter than U.S. regulations (although they will probably be comparable as the 1990 Clean Air Act Amendments are implemented), in some other areas Japanese regulations are less strict. The Japan Environment Agency, the main regulatory body, is relatively weak in comparison to other Japanese ministries, such as MITI.[72]

Differences between the United States and the lagging OECD nations, Eastern European nations, and NICs is more significant. For example, Greek laws to control pollution are poorly developed and enforcement is lax.[73]

Enforcement of standards in Eastern Europe and the former Soviet Union was very low. Standards and enforcement in the NICs, such as Hong Kong, Korea, and Taiwan, is low, although there are now efforts to strengthen them.[74] (Singapore's environmental regulations are considered on a par with those of several advanced industrial nations.)

Developing countries' standards and enforcement remain low. In 1985 and 1989 the World Health Organization surveyed 116 countries to determine their ability to control key environmental problems, and included such factors as legislation, enforcement, and staffing. They found that while all industrialized countries met most of the requirements needed to control pollution, only 18 percent of the moderately to rapidly industrializing countries and less than 5 percent of the less

70 While the united States does provide less targeted assistance, this does not measure overall levels Of corporate taxation, which are also different between nations. See: Organization for Economic Co-operation and Development, *Taxation in OECD Countries, 1993* (Paris: OECD, 1993).

71 National Association of State Development Agencies, *Directory of Incentives for Business Investment and Development in the United States* (Washington DC: The Urban Institute Press, 1992).

72 Some scholars suggest that the Japanese Environment Agency does not have significant power and cannot afford to offend industry. (Cited in Alan S, Miller and Curds Moore, "Japan and the Global Environment," *Environmental Law and Policy Forum*,, vol. 1, 1992, p. 38; also Bruce E. Aronson, "Review Essay: Environmental Law in Japan," *Harvard Environmental Law Review*, vol 7, No. 1, 1983, p, 145).

73 For example, in May of 1992 Greece passed its first law to control urban airpollution, and much of the focus was on automobiles, nOt industry. The country's first general environmental law was not passed until 1986 and was not begun to be implemented until late 1990. ("Greek Parliament Passes Country's First Air Pollution Law As Conditions Worsen," *International Environmental Reporter*, June 3, 1992, p. 353.)

74 Stacy Mosher, "Hong Kong: Going Green," *Far Eastern Economic Review*, Feb. 27, 1992, p. 17,

developed countries, did so.[75] For example, in Thailand, industrial hazardous wastes are often dumped into rivers and landfills, or stored in drums on site with little or no treatment. Most biodegradable waste is discharged untreated into public water bodies.[76] Many of these countries have highly competitive manufacturing sectors in some areas, boosted not only by low environmental standards and enforcement, but also by low labor costs, and lower standards for worker health and safety.

Standards tell only part of the story. Enforcement and compliance make up the rest. While no country can staff full enforcement, the gap between regulation and enforcement is normally smaller in OECD nations. Developing and newly industrialized nations' standards might be high, but enforcement is often virtually nonexistent.[77] For example, Argentina's new environment secretariat has little power to even inspect polluting plants.[78] Hong Kong has in place environmental legislation, but extremely lax enforcement means that industry is required to spend little and pollution levels remain high.[79] South Korea amended its air pollution law in 1991, but monitoring of discharge by industry is very limited, particularly for pollutants other than SO_2 and particulate.[80] Relying solely on emission standards would lead to an overestimation of the strictness of environmental regulation.

Regulatory Styles

While confirming data are difficult to obtain, many analysts conclude that the U.S. regulatory style is more rigid than those of most other nations.[81] The relationship between regulatory styles and regulatory stringency is complex, in part because many countries with more cooperative styles of regulation appear to place less stringent environmental demands on business. However, it is important to consider standards separately from regulatory styles. When goals and laws are set and commitment to enforcement is evident, cooperative frameworks can make implementation easier and more cost-effective, without necessarily weakening performance. As such, regulatory styles can affect competitiveness.

While increased attention is being paid to more cooperative regulatory processes (e.g., negotiated regulations), the U.S. system is still characterized by adversarial relations between industry and regulators (see figure 7-12). Many U.S. firms spend significant time and effort fighting regulations and delaying implementation, while regulatory agencies often enforce standards in ways that make it harder and more expensive for industry to comply. Short rigid deadlines can lead firms to invest in readily available end-of-pipe approaches rather than pollution prevention. If all facilities face equal strictness, inflexible regulatory demands can raise the costs of regulation beyond those that would follow adjusting control to the

75 Countries that did not meet most of the requirements include some of the most populated nations, including Brazil, India, Mexico, and China, which collectively account for approximately 40 percent of the world's population. Countries meeting most standards contain only 24 percent of the world's population. Morns Schaefer, *Combating Environmental Pollution: National Capabilities for Health Protection* (Geneva: World Health Organization, 1991).

76 Phantumvanit and Panayotou, op. cit., footnote 53.

77 "China: Breathing the Air of Success," *The Economist*, vol. 322, No. 7746, Feb. 15, 1992, p. 40.

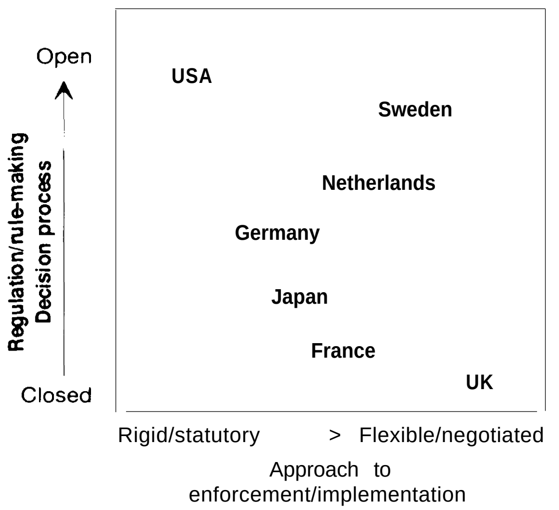
78 "Argentina: Jailing of Executives for Water Pollution Prompts Debate Between Secretariat, Courts," *International Environmental Reporter*, May 20, 1992, p. 308.

79 Emily Lau, "Hong Kong: A License to Pollute," *Far Eastern Economic Review*, May 10, 1990, p. 23,

80 Energy and Environmental Analysis, Inc., *Comparison of U.S. Air Quality Standards and Controls To the Air Pollution Controls in Japan, Germany, Canada, Mexico, and South Korea*, prepared for Office of Policy Analysis and Review, Office of Air and Radiation, U.S. Environmental Protection Agency, February 1992.

81 David Vogel, *National Styles of Regulation: Environmental Regulation in Great Britain a& the United States* (Ithaca, NY: Cornell University Press, 1986).

Figure 7-12-Qualitative Mapping Along Key Environmental Political Variables



SOURCE: Derived from Clinton Andrews, "Policies to Encourage Clean Technology," eds., Clinton Andrews, Frans Berkhaut, Robert Socolow, and Valerie Thomas, *Industrial Ecology and Global Change* (Cambridge, England: Cambridge University Press, Forthcoming, 1 994).

actual technological conditions of the facility. In some cases, technology based standards can freeze environmental control technologies and impede industry's willingness to develop or apply more cost-effective control or prevention approaches.[82] Finally, permitting in the United States is often arduous and time-consuming, requiring extensive studies and documentation.

In many other countries there is a more cooperative relationship between regulators and industry, and relative flexibility in enforcement. This can be helpful if firms need additional time to meet a standard, particularly through pollution prevention. However, public and nongovernmental organization (NGO) involvement is more restricted than in the United States and measures to assure compliance may be weaker in some cases.

Some European countries have established multipartite, collaborative efforts with industry, government, academia, and occasionally NGOs, to formulate and implement pollution control regulations. The Netherlands Environmental Policy Plan formulates objectives to be achieved by 2010. The Environment and Economics Ministries consult with individual branches of industry (e.g., chemicals, printing, metal products) to develop objectives, schedules, and strategies for each sector. In addition, representatives from industry, government, NGOs, and academics consult on specific issues (e.g., waste minimization) to develop strategies and assess technology needs and developments.[83] As part of this, the Environment Ministry, in consultation with industry and academics, identified 30 key waste streams and organized groups of producers and users for each material to develop consensus on methods of waste minimization.

In Germany, which is often characterized as having the most command-and-control-like system in Europe, there is significant bargaining over the terms of regulatory actions between enforcement agencies and their clients.[84] The Canadian Government recently established the National Roundtable on Environment and Economy to bring together government, industry, and NGOs to reach a consensus on problem definition and environmental action needed in Canada.[85]

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82 U.S. Environmental Protection Agency, The National Advisory Council for Environmental Policy and Technology (NACEPT), *Improving TechnofogyDIfisionjorEnvironmenra/Projection*, Technology Innovation and Environment Committee's 1991 Report and Recommendations (Washington DC: Environmental Protection Agency, 1991).

83 See J. Cramer, B. de Laat, and G. Straten, "The Netherlands' NEEP: Can Environmental Goals Be Met Through NEEP Measures, *Pollution Prevention, (European Edition),* vol 2. August 1992, pp. 25-8.

84 Jochen Hucke, "Implementing Environmental Regulations in the Federal Republic of Germany, ' *Policy Studies Journal, vol. 11, No.* 1, September 1982, p. 130; see also Arieh A. Ullmann, "The Implementation of Air Pollution Control In German Industry, " *Policy Studies Journal,* vol. 11, No. 1, September 1982, p. 141.

85 Jean Pasquero, ''Supraorganizational Collaboration: The Canadian Environmental Experiment,'' *Journal of Applied Behavioral Science* vol. *27, No.* 1, March 1991, pp. 38-64.

Firms in other countries often face less arduous permitting requirements, allowing them higher levels of operational flexibility. Danish environmental inspectors have discretion to make exceptions to the regulations, particularly if the present production equipment's lifetime has not permitted sufficient amortization or if the firm needs extra time to deploy the environmental technology.[86] Japan, prefectural governments have 60 days to decide to issue a new permit, after which the firm can legally operate according to its permit request specifications.[87] In Britain, regulators operate with considerable discretion.[88]

In some cases, such flexibility may come at the cost of less vigorous enforcement, however.

Information Disclosure and Public Access

While some European countries are discussing measures similar to the U.S. Toxic Release Inventory (TRI) system, only the United States requires companies to routinely disclose to the public information about their emissions.[89] In Germany, companies are not required to submit confidential information and there is no equivalent to U.S. freedom of information programs for the public at large.[90] The Japanese Government discloses little environmental information about companies to the public.[91] To the extent that competitors can reverse-engineer proprietary processes on the basis of information provided to regulatory agencies, companies operating in the United States may beat a disadvantage relative to those in countries that collect less information or better maintain its confidential nature.[92]

The degree of public participation in the formation of regulations and rules also differs by country. Many U.S. environmental laws explicitly require public participation in formulation of rules and regulations and other administrative actions (see figure 7-12). Several laws also authorize citizen suits against parties (including government agencies) alleged to be in violation of the law. In contrast, some European countries and Japan limit participation rights.[93] For example, Japanese law seldom if ever gives environmental organizations the right to sue the government. The national government has no freedom of information laws, while only a small number of Japan's prefectures and municipalities have them.[94] Japanese Government practices and laws contribute to the weakness of environmental organizations.[95] The environmental movement has faced opposition from industry and government.[96] Even in the EC, NGOs cannot bring suit in the European Court of Justice against countries that violate EC laws.[97]

86 OECD, "Back~ound paper on Policy Tools and their Applications in Various Member Companies,' Op. cit., footnote 67.

87 Ibid.

88 Vogel, op. cit., footnote 81.

89 Under the TRI (mandated in Section313 of the Emergency Planning and Community Right-to-Know Act of 1986), certain manufacturers in the United States must report on an annual basis the amounts of over 300 toxic chemicals that they release to the air, water, or land.

90 SRI International, "Analysis of Impact of U.S. Federal and State Reporting Requirements on Sensitive and Proprietary Company Information,'' prepared for the U.S. Chemical Manufacturers Association, Washington, DC, July 1992.

91 "Intervie with Mr. Saburo Kate: The Subsidization of Johkasu,'' *Water Report* (Tokyo), vol. 1, *No. 3,* 1991, p. 9-10.

92 SRI International, op. cit., footnote 90.

93 von Moltke, op. cit., footnote 6*.

94 Jacobs and Harris, op. cit., footnote 47, p. 14.

95 Jim Griffith, ''The Environmental Movement in Japan,'' *Whole Earth Review,* winter 1990, pp. 90-97.

96 Miller and Moore, op. cit., foomote 72.

97 Hillary French, ''The EC: Environmental Proving Ground,' *World Watch,* vol. 4, No. 6, November/December 1991, pp. 26-33.

U.S. publicly-held companies must also disclose more in securities reporting, particularly potential future significant liabilities. In contrast, such information is very scanty among European firms,[98] and virtually non-existent among Japanese companies.

Future Directions

Regulations on industrial pollution appear to be getting stricter in many countries. In Europe, while EC-wide regulations will increase the regulatory stringency of the countries with the weakest standards, it is unlikely that regulations will be harmonized at the level of the strictest nations. Moreover, when EC directives have been issued, many countries have either not adopted them or been extremely slow to adopt them,[99] particularly in the area of water quality.[100] Inadequate EC enforcement, at least in the near term, will remain a problem.[101] Countries in other regions are also raising standards, but progress is slow. Many of the newly industrialized countries are giving increased attention to the environment, both in setting and enforcing standards.[102] For example, while standards are low in countries such as Hong Kong, Korea, and Taiwan, and enforcement even lower, there is increasing pressure by government and the public to regulate industry more stringently. However, industry resistance makes this a slow process, and enforcement is spotty. Over the long term, however, the likelihood is that enforcement will improve.

EFFECTS OF REGULATION ON INNOVATION, TRADE, AND INDUSTRIAL LOCATION

Since enactment of the major pollution laws in the early 1970s, many have claimed that regulations controlling industrial pollution and economic growth and development are inversely related. More recently, however, a number of analysts have argued that environmental protection and economic growth are compatible and that vigorous environmental protection is necessary to achieve sustainable long-term economic development (see ch. 3.)

The debate has often been characterized by lack of data, poor analysis, and sweeping generalizations of only limited applicability. It is not the purpose of this report to address definitively the question of the relationship between environmental regulations and economic competitiveness. However, this section reviews some studies on the effects of environmental regulation on innovation, trade, and industrial location. Appendix A reviews the literature examining the relationship between environmental regulations and GDP and industrial productivity.

Effects on Innovation

A number of studies attempt to explain the relationship between environmental regulation

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98 For example, see 'UK Study Says Corporate Environmental Reporting Does Not Disclose Enough Concrete Information,'' *Business and the Environment,* September 1992, p. 8.

99 Under EC law, directives falling under Articles 130 R and S, which cover most environmental matters, must be approved unanimously by the Council of Ministers. This may prove difficult if countries with low standards resist the new measures. "Business Can Expect Tougher Measures as a Result of the Maastricht Summit, Report Says, " *International Environmental Reporter,* June 3, 1992.

100 ''The EC and Environmental Policy and Regulations, United States Department of Commerce, International Trade Administration, Oct. 1, 1991.

101 By 1990, the EC had identified 303 cases in which member nations had incorrectly or incompletely implemented EC environmental directives and 60 cases where they had not been implemented at all. Hillary F. French, "The EC: Environmental Proving Ground, " op. cit., footnote 97, p. 26-33.

102 Paul Cullen Beately, "The Benefits of a Global Environmental Compliance Strategy,' *Corporate Management,* vol. 158, No. 3, June 1989, pp. 14-19.

and technological innovation.[103] Depending on its form, regulation can help or hinder the development and application of new technologies that will permit more efficient solutions to environmental problems. Sometimes regulations can discourage use of new environmental technology. Most studies have found that the direct impact of environmental regulation on nonenvironmental technological innovation was negative, although weak. But because competitiveness in advanced industrial nations is based increasingly on innovation, such negative effects could be harmful.

Regulation could hinder innovation in several ways. First, by diverting funds from capital investment in new plant and equipment to pollution control, regulation could retard the diffusion rate for new process innovation and could reduce funds available for commercially oriented R&D. Regulatory requirements are often stricter for new facilities (which usually must install the best available technology) than for older investments; some argue that such regulations discourage new investments.[104] However, it is rare for regulation to be the decisive factor in choosing to develop a new facility.

Second, regulation can delay the introduction of new industrial processes. Delays may stem from lack of agency staff for permit processing, from poorly prepared industry applications, and occasionally from citizen review of new or modified permits. For industries that depend on continuous innovation to maintain competitive advantage, permit delays can be a significant problem. Permitting delays can sometimes impede the introduction of environmentally beneficial technology.[105]

Finally, regulation can increase the risks 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.

However, there can be circumstances where regulation stimulates innovation. Regulations may pressure firms to develop new products or processes, thus adding to the dynamism of the economy (see ch. 5). For example, regulation is credited with encouraging a number of new technologies in automobiles, including some (e.g., computerized engine controls) not directly related to pollution control. In addition, overcoming problems related to regulation may sometimes enhance a fro's problem-solving capacities and contribute to commercial innovation.[106]

The way in which regulations are designed and implemented often affects innovation (see ch. 9). The use of technology-based standards rather than performance standards can dictate particular technological solutions, leading to increased diffusion of an existing technology but retarding the diffusion or development of superior new technologies.[107] The regulatory focus on end-of-pipe

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[103] Roy Rothwell, ' 'Industrial Innovation and Government Environmental Regulation: Some Lessons From the Past, *Technovation*, vol. 12, No. 7, October 1992, pp. 447-458; A. Irwin and P. Vergragt, ''Rethinking the Relationship between Environmental Regulation and Industrial Innovation The Social Negotiation of Technical Change,' *Technology Analysis and Strategic Management,* vol. 1, No. 1, 1989, pp. 57-70; Organization of Economic Cooperation and Development, *Environmental Policy and Technical Change* (Paris: OECD, 1985); Nicholas A. Ashford and George Heaton, "Regulation and Technological Innovation in the Chemical Industry, " Law *and Contemporary Problems,* vol 46, *No,* 3, *1983,* pp. *109-157.*

[104] Robert Crandall, ''Pollution Controls and Productivity Growth in Basic Industries, " *Productivity Measurements in Regulated Industries*, ed. Thomas G. Cowing and Rodney E. Stevenson (New York, NY: Academic Press, 1981).

105 For example, according t. one petroleum industry source, in the course of rebuilding part of a petroleum refinery in Texas, the company sought to also rebuild older inefficient furnaces (making them more energy efficient and less polluting), However, the State indicated it would not be able to issue a permit for the furnace rebuild for at least 9 months to a year. Because the other construction work was to be completed before this, the company choose to not improve the furnaces, since this would have involved shutting down production at a later date.

[106] Roy Rothwell, op. cit., footnote 103.

[107] Wesley A. Magat, "The Effects of Environmental Regulation on Innovation,'' Law *and Contemporary Problems,* vol. 43, winter-spring, 1979, pp. 4-25.

treatment diverts attention away from fundamental process changes. In addition, a rigid regulatory system can make firms unwilling to risk seeking new ways to solve environmental problems, for fear that if the solutions do not fully meet environmental regulations, they will waste time and money, and be penalized for noncompliance. Tight compliance deadlines may also lead firms to choose existing technological solutions rather than develop new, potentially more effective ones.[108] Finally, the current regulatory system gives firms little benefit if they outperform regulatory standards; as a result, they have little incentive to innovate.

Impacts on Trade and Industrial Location

The impact of environmental regulation on trade and overseas investment was discussed in detail in a prior report in this assessment, *Trade and Environment: Conflicts and Opportunities*, and therefore will be only summarized here.[109] Environmental regulation could affect trade negatively if, by raising the costs of U.S. goods relative to producers in nations with lower environmental control costs, U.S. exports fell and imports rose. Some studies find it impossible to isolate the effect of environmental regulation on trade because other variables such as the cost of capital and labor and exchange rate fluctuations overshadow the effects of increased environmental regulation costs.[110] A recent OECD workshop concluded that environmental regulations "have had minimal effects on overall trade balance between OECD and non-OECD countries."[111]

However, other studies claim larger impacts.[112] One study concluded that a l-percent increase in cost due to environmental regulation would have resulted in a net reduction of the U.S. balance of trade of $6.5 billion in 1982.[113] The study concludes that this is a small effect. However, it is worth noting that, if a similar impact had occurred in 1991, the $101 billion U.S. merchandise trade deficit that year would have increased by $8.6 billion. Yet another study found that if a hypothetical pollution tax were imposed on imported Mexican products equal to the difference in environmental control costs borne by counterpart U.S. industries, Mexican exports to the United States would decline 1.2 to 2.6 percent.[114] This would reduce U.S. imports from Mexico by $600 million a year. Moreover, most

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108 Nicholas A. Ashford, "A Unified Technology-Based Strategy for Incorporating Concerns About Risks, Costs, and Equity in Setting National Environmental Priorities,' paper presented at the Conference on Setting National Environmental priorities, Resources for the Future, Nov. 16-17, 1992.

109 See also, Paul Portney, Adam Jaffe, Steven Peterson and Robert Stavins, *Environmental Regulations and the Competitiveness Of U.S. Industry* (Cambridge, MA: Economics Resource Group, 1993).

110 U.S. Department of Commerce, "U.S. Pollution Control Costs and International Trade Effects-1979 Status Report" (mimeo), September 1979, p. 3; also J. Tobey, "The Effects of Domestic Environmental Policies on Patterns of World Trade: An Empirical Test,'' *Kyklos*, vol. 43, No. 2, 1990, pp. 191-209.

111 Organization for Economic C& Operation and Development, "*EnvironmentalP olicies andIndustrial Competitiveness,* "(Paris: OECD, 1993).

112 Organization for Economic Co-operation and Development *Macroconomics Evaluation of Environmental* Programmed, 1978, p. 11, OECD, *Macro-Economic Impact of Environmental Expenditures* (Paris: OECD, 1985); Carl A. Pasurka, "Environmental Control Costs and U.S. Effective Rates of Protection,'' *Public Finance Quarterly*, vol. 13, No. 2, April 1985, pp. 161-182; Joseph P. Kalt, "The Impact of Domestic Environmental Regulatory Policies on U.S. International Competitiveness," A. Michael Spence and Heather A. Hazard (eds.), *International Competitiveness* (Cambridge, MA: Ballinger Publishing Co., 1988); Carl Pasurka and Deborah Vaughn Nestor, "Trade Effects of the 1990 Clean Air Act Amendments,' report prepared by the Economic Analysis and Research Branch, Office of Policy, Planning and Evaluation, U.S. EPA, Mar. 24, 1992.

113 H. David Robison, "Industrial Pollution Abatement: the Impact on Balance of Trade, ' *Canadian Journal of Economics*, vol. 21, No. 1, February 1988,

114 Patrick Low, "Trade Measures and Environmental Quality: Implications for Mexico's Exports, " paper presented at the Symposium on International Trade and the Environment, sponsored by the World Bank, Washington, DC, Nov. 21-22, 1991.

studies rely on data that, as discussed previously, appear to underreport environmental compliance costs. Higher costs would result in greater impacts.

Some studies suggest that sectoral effects are more significant than economy-wide effects.[115] For industries with high compliance costs, such as pulp and paper, copper refining, and steel, the effects on trade can be larger.[116] For example, OTA concluded that the cost to the U.S. copper industry, particularly copper smelting, of environmental regulation "has been large, with substantial negative impacts on competitiveness and capacity."[117] Robinson found that between 1973 and 1982 the United States increased its net imports of goods more from industries with higher environmental control costs than from those in which such costs were lower.[118] Because the products of many highly polluting industries tend to be standardized intermediate goods purchased by other industries (e.g., chemicals, petroleum, minerals) with high price elasticity of demand, small changes in price may cause larger changes in sales.[119]

Some argue that uneven regulation may induce U.S. firms to migrate to countries with lower levels of regulation-the so-called pollution haven effect. There are reasons to suggest that the migratory effect of environmental regulation is likely to be less than the trade effect. Most economy-wide studies suggest a low impact on investment from differing environmental regulation;[120] one study found no significant effects.[121] A study of U.S. maquiladora plants (plants locating in Mexico near the U.S. border through a special Border Industrialization Program) found no relationship between the level of low Mexican regulations and U.S. investment.[122] However, in part, these findings may result from limitations in research methodologies making it difficult to isolate effects of environmental regulations from the effects of a large number of other variables (e.g., labor costs, market access).

On the other hand, anecdotal evidence, case studies, and surveys of businesses suggest that lower environmental regulations do play a role. For example, one study found that 26 percent of maquiladora operators in Mexicali cited Mexico lax environmental enforcement as a major or important reason for their relocation there[123] (see box 7-C).

115 Organization for Economic Co-Operation and Development, *Summary Report of the Workshop on Environmental Policies and Industrial Competitiveness, 28-29 January 1993* (Paris: OECD, 1993).

116 U.S. Department of Commerce, 1979, op. cit., footnote 109, p. 12; Public Research Institute, *The Effects of Effluent Discharge Limitations on Foreign Trade in Selected Industries,* Report to the U.S. National Commission on Water Quality (Arlington, VA: February 1976).

117 U.S. Congress, Office of Technology Assessment, *Copper: Technology and Competitiveness*, OTA-E-367 (Washington, DC: U.S. Government Printing Office, September 1988).

118 H. David Robinson, "Industrial Pollution Abatement: the Impact on Balance of Trade," op. cit., footnote 113.

119 General Agreement on Tariffs and Trade (GATT) Secretariat, "Trade and the Environment," Feb. 12, 1992, p. 20.

120 For example, see Ingo Walter, "Environmentally Induced Industrial Relocation to Developing Countries," Seymour J. Rubin and Thomas R. Graham (eds.), *Environment and Trade* (London: Frances Pinter Ltd., 1982); Hege Merete Knutsen, "International Location of Polluting Industries: Review of the Literature," Department of Human Geography, University of Oslo, Norway, unpublished manuscript, 1991.

121 H. Jeffrey Leonard, *Pollution and the Struggle for the World Product* (New York, NY: Cambridge University Press, 1988).

122 Gene M. Grossman and Alan B. Krueger, "Environmental Impacts of a North American Free Trade Agreement," paper presented at the conference on the U.S.-Mexico Free Trade Agreement sponsored by the Mexican Secretary of Commerce and Industrial Development, Oct. 8, 1991.

123 Thirteen percent of the firms said that weaker environmental legislation was a major factor in selecting Mexico, while another 13 percent said it was an important factor. (Roberto Sanchez, "Health and Environmental Risks of the Maquiladora in Mexicali," *Natural Resources Journal*, vol. 30, winter 1990.) One economic development official for the Mexican state of Sonora suggests, "The red tape and expense of American environmental law is a powerful incentive for some companies to locate in Mexico. I've had a couple of companies come down solely for that reason." (Quoted in Sandy Tolan, "Hope and Heartbreak," op. cit., footnote 55.)

Box 7-C-Regulations and the Furniture Industry in Los Angeles

Environmental regulations in the Los Angeles area are among the strictest in the nation, particularly with regard to air pollution emissions. As a result, regulations have been singled out as a contributor to the relocation of industry out of Southern California. Disentangling the importance of environmental regulations in this industrial migration is difficult, as a host of other factors seem to be operating, including high direct and indirect labor costs, high taxes, land costs, and declining quality of life-including pollution.[1]

The wood furniture industry has been the focus of significant attention because of strict regulations on air emissions. California ranks second in the nation in the production of household furniture; about half of its furniture firms are within the South Coast Air Basin.[2] Claims have been made that furniture manufacturing is being displaced from the Los Angeles economy to Mexico for environmental reasons. The California industry is dominated by a large number of small firms.[3] These firms pay relatively low wages,[4] employ relatively low-skilled workers, have low levels of technology adoption, and have low profit margins. Avery large percentage of the furniture industry workforce is Hispanic. The industry has sought to retain competitive advantage through low costs, while in turn depending on low wage rates. The segments of the industry producingcoated wood furniture is particularly affected by environmental regulations. The environmental impacts of furniture manufacturing are due to t he presence of solvents in wood finishing products. Within this segment, the ability to control solvent emissions varies widely according to the nature of the product being finished. Much of the increase in regulatory pressure on the wood furniture industry came about as a result of local regulations in 1987, which were directed at solvent and coating use for wood furniture producers.

Reported pollution control costs are relatively low for California furniture firms. In 1990, they reported $9.7 million in pollution control expenditures.[5] Even assuming that these costs fall solely on a selected group of SIC codes that use wood finishes, they amounted to only about 0.6 percent of sales and about 1.2 percent of value added. However, air regulations in the furniture industry can reduce productivity and lower product quality. For example, new coatings that comply with South Coast air quality rules often take longer to apply and dry, there are more rejects, and finish quality is poorer.[6] These costs are not reflected in the reported expenditure figures. Increased costs of coatings maybe excluded. (Some savings in coatings are obtained from switching to high-volume, low-pressure spray guns.)

Other factors affect the decisions of these firms to move out of Los Angeles, including salary costs (especially worker's compensation), the rising cost (or value) of land in relation to the value added of the production facilities, and the desire to retain existing advantageous permit conditions when facilities

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1 Barry R. Sedlik and Robert H. Herzstein, *Business Climate In Southern California* (Rosemead, CA: Southern California Edison, November, 1991).

2 Luci Hise, "The Role of Environmental Regulations in Industrial Location: Furniture Manufacturing in Southern California" Masters thesis, Department of Urban Planning, UCLA, 1992, p. 92.

3 Over 70 percent of the establishments in 1989 had less than 50 employees, and 54 percent had less than 20 employees. ibid.

4 Wages range from an average of $5.11 an hour for assemblers with few skills, to $10.97 for maintenance mechanics. Furniture industry wages were 65 percent of regional manufacturing average in 1987, down from 87 percent in 1977. ibid., p. 43.

5 However, because Rule1136 did not get adopted until August 1988, It is possible that compliance costs will increase. These costs are for establishments with greater than 20 employees. Share of sales figures were normalized to reflect this.

6 Luci Hise, op. cit.

must move or expand rather than having to meet new source standards in the region.[7]

In contrast, Mexico had no established standards regulating emissions from paint coatings and solvents in wood furniture manufacturing.[8] In 1991, Mexico employed approximately 255 pollution inspectors, roughly the same number of inspectors for the South Coast Air Quality Management District, which covers four counties in the Los Angeles area.[9]

While the difference between environmental regulation in Los Angeles and Mexico is stark, differences in wages are also large. Mexican furniture industry wage levels are less than 10 percent of Los Angeles wages.[10] Because of the high cost of living, Los Angeles labor costs are also one-third more than in parts of Texas, Colorado, and Oklahoma.[11] Moreover, workers' compensation is nonexistent in Mexico and quite high in California. From 1980 to 1989, workers compensation rates more than doubled for wood furniture manufacturers, from $9.06 to $19.40 per $100 dollars of labor costs.[12] Other worker-related costs are also higher, including health care and retirement benefits, and expenses related to worker safety and health. Southern California utility rates areas much as 50 percent higher than those in other States. Land prices are among the highest in the Nation. The 1990 average price for a single family home in the State was $210,000, more than double the national average.[13]

The U.S. General Accounting Office found that between 11 and 28 wood furniture manufacturers in the Los Angeles area relocated to Mexico between 1988 and 1990, taking with them 960 to 2,547 jobs.[14] About 80 percent of the firms cited stringent air pollution standards as well as lower labor costs as major factors in t heir location decision. In Mexico, these firms faced no air pollution standards fort he application of paint coatings and solvents.[15] But the majority of firms that relocate from Southern California go to other U.S. States, rather than to Mexico.

Clearly, the ability of manufacturing industries to stay in an area with increasing population, rising property values, and associated environmental pressures that drive more stringent environmental standards is heavily dependent on the degree of value added of the activity in question. Low value-added industries that face environmental pressures will have a harder time staying in the area. Differences in labor compensation (wage rates, benefits, workmens' compensation insurance) between furniture workers in Mexico and Los Angeles appear to be driving the relatively small amount of relocation that is occurring. However, strict environmental regulations governing the furniture industry in Los Angeles and their absence in Mexico appear to be exacerbating this situation.[16]

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7 Konrad von Moltke, "American Industry and the Environment: Implications forTrade and Competitiveness," contractor report prepared for the Office of Technology Assessment, November 1992, p, 51.

8 Luci Hise, op. cit.

9 "Can Mexico Clean Up Its Act?" Los Angeles *Times*, November 17, 1991, p. A1.

10 GAO reports that the average wage in wood furniture in Los Angeles was $8.92 an hour, while it was $0.77 for wood furniture workers in the maquiladora program (p. 4).

11 Ibid. In 1991, average hourly earnings of workers in Los Angeles were $11.17 while in San Antonio, TX they were $8.19, In the nonmetro areas of these States, the wage rates are lower. Bureau of Labor Statistics, *Employment and Earnings* (Washington, DC: May 1991).

12 Ann M. Lesperance, "Air Quality Regulations and Their Impact on Industrial Growth in California, Based on Census Data: A Case Study of the South Coast Air Quality Management District Rule 1136 and the Wood Products Coating Industry," Masters thesis, Department of Environmental Health Sciences, University of California, 1991.

13 Richard L. Stern and John H. Taylor, "IS the Golden State Losing It?" *Forbes*, October 29, 1990, p. 87.

14 U.S. Congress, U.S. General Accounting Office, "U.S.-Mexico Trade: Some U.S. Wood Furniture Firms Relocated From Los Angeles Area to Mexico," April 1991.

15 Ibid.

16 Luci Hise, op. cit; Anne Lesperance, Op. cit.

Case studies may find greater impacts because pollution control requirements affect some industries more than others. Industries such as mineral processing, toxic products, and intermediate organic chemicals, which face relatively high compliance cost, are more likely than others to relocate for environmental reasons.[124] For example, one 1988 study found that U.S. operations that moved to Mexico were either relatively labor-intensive, low-polluting light manufacturing operations that moved principally to take advantage of low wages, or producers of hazardous waste such as asbestos.[125] As a result, for the subset of industry that is labor-cost sensitive, is relatively footloose, or is making new investment decisions, and has high environmental compliance costs, weak environmental regulations can add to the cost advantage gained by low labor costs.

However, some analysts maintain that environmental regulations could positively affect trade. One argument is that, if the United States is a net exporter of environmental goods and services (including environmentally preferable technology), then the country receives net economic benefits that should be counted against costs of regulation (see ch. 5). Some also argue that, even if U.S. firms are subject to more stringent regulations now, other countries' regulations will catch up. U.S. firms could then beat an advantage having had more experience in producing goods able to meet strict standards. Most importantly, 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. These nations and their resident firms may then be at a competitive disadvantage.[126] In the meantime, U.S. firms still face higher costs.

INDUSTRIAL LOCATION WITHIN THE UNITED STATES

A number of studies have examined how environmental regulations affect investment and growth among U.S. States. Their finding is that differences in environmental regulation are not a major factor governing industry location within the United States. However, it may affect the location of highly polluting industries and influence the location of industry between adjacent States. For example, one study found no statistically significant effect of State environmental regulations on the location of most branch plts.lzT However, the results regarding the effect on highly polluting industries was less conclusive. A study of the location of motor vehicle branch plants found that while environmental regulations had little effect on location, there was some evidence that firms were deterred at the margin from locating in regions where ground level ozone problems were particularly severe.[128] According to a survey and interviews with managers responsible for 162 new branch plants of large U.S. corporations, traditional location factors, such as labor cost and availability, access to markets and materials, and transportation were the key determinants of location choices between regions.[129] As expected, environmental regulations were more important for more polluting plants than less polluting ones, but even for these plants, other factors carried greater

124 Ibid.

125 Leonard, **op. cit., footnote** 121.

126 Moreover, in doing so they may rely heavily on technology and products developed in nations with **more advanced environmental regulations.**

127 Tim Bartik, "The Effects of Environmental Regulation **on Business** Location **in** the United **States,** *Growth and Change*, summer 1988.

128 Virginia D. McConnell **and Robert M. Schwab, "The Impact of Environmental Regulation on Industry** Location **Decisions: The Motor Vehicle Industry,** *Land Economics, vol. 66, No.* **1, February 1990,** pp.67-81.

129 Howard Stafford, "Environmental Protection and Industrial Location," *Annals of the Association of American Geographers,* vol. *75, No. 2,* 1985, pp. *227-240.*

weight. One of the major concerns with environmental regulations was the uncertainty about when necessary permits would be obtained.

A study using an econometric model found that States with more stringent environmental standards experienced stronger economic growth in the 1980s than States with weaker regulations.[130] One reason for this counter-intuitive finding may be that many States with high concentrations of industry not only have more pollution (and thus a need for stronger regulations), but also have nonregulatory locational advantages (e.g., large markets, a large number of input suppliers, good transportation and other infrastructure, and a profusion of vital services). Compliance costs are likely to be higher in these areas than in less-developed and slower growing places.

CONCLUSION

The U.S. regulatory system for dealing with industrial pollution and wastes was set up at a time when the Nation had relatively few worries about international economic competition and the national economy was more insulated from foreign competitors. In a more closed economy, high regulator-y costs could be passed on to consumers. However, in a more global economy with highly competitive foreign fins, many prices are determined by world markets, and firms are less able to pass on the costs of regulation.

Given the assumption that U.S. regulatory standards will continue to be as strict as they now are, or get even stricter in the next decade, there are several possible options for reducing the competitive disadvantage of differential compliance costs and requirements. For example, the United States can work with other nations to encourage them to raise their standards. It also could work to develop new technologies that would make it cheaper for firms to comply with U.S. requirements. In addition, the United States can modify its environmental regulatory system to make it easier for U.S. industry to comply with regulations, while still meeting environmental goals. The latter issues are the topic of chapters 8 and 9.

130 Stephen M. Meyer, "Environmentalism and Economic Prosperity: Testing the Environmental Impact Hypothesis, ' unpublished paper, MIT Project on Environmental Politics and Policy, Cambridge, MA, Oct. 5, 1992.

APPENDIX 7-A. POSSIBLE SOURCES OF UNDERREPORTING OF POLLUTION ABATEMENT COSTS

The U.S. Bureau of the Census' Pollution Abatement and Control Expenditure (PACE) surveys are the principal source of information on U.S. manufacturing pollution abatement and control compliance costs. However, a number of researchers have suggested that these surveys may underreport the true cost of compliance. It is difficult to accurately quantify the extent of underreporting. Adding the costs of those factors discussed below that are quantifiable increases costs by approximately 50 percent. However, 60 percent of this increase is related to interest costs, which should or should not be used depending on the definition of costs. The value of other factors cannot at this time be quantified. As a result, a reasonable but very rough estimate suggests that these costs may be underestimated by as much as 25 percent. There area number of areas that may be underreported, some of which may be addressed by more comprehensive survey methods.

Underreporting from Omitted Cost Items

PRODUCTIVITY LOSSES

If a firm has to stop production because of environmental problems, costs are incurred. If it has to substitute new materials or processes that are less productive than original ones, productivity could decline. More significantly, if environmental equipment is less productive than other equipment, these costs will not be included. However, most pollution control equipment is added to the end of the production process and is not likely to significantly affect production process rates. Moreover, as discussed in chapter 8, at least some inprocess changes boost productivity as they improve energy and materials efficiency.

PRODUCT QUALITY IMPACT

In some cases, environmental regulations lead firms to make changes in materials or processes that negatively effect product quality. For example, because of stringent U.S. volatile organic compounds (VOCs) regulations, U.S. automakers use ''high-solid' paints that sometimes produce lower gloss finishes. In contrast, Japanese automakers can use 'low-solid" paints that allow for a premium "high gloss' finish, particularly on some of the higher priced models.[1]

POLLUTION CONTROL COSTS EMBEDDED IN OTHER PURCHASES

For many industries, the costs of materials and supplies is higher because of environmental regulations. For example, firms in industries that use large amounts of electricity (e.g., industrial gas producers) pay higher prices for electricity because of the regulations on electric utilities. The PACE survey would identify the utilities' higher costs due to environmental regulations, but not added costs for utility customers from higher electric rates.

INTEREST EXPENSE

The PACE survey does not include interest expense for equipment. Using a real interest rate of 7 percent and a 20-year life for investments,[2] interest expense increases the costs of capital investments by 88 percent. This would add another $6.5 billion to manufacturing compliance costs to the $7.4 billion invested in 1991, raising total compliance costs ($21 billion) 31 percent.

FEES AND TAXES

Census figures do not include fees and taxes, which, while currently small, are likely to be a growing share of environmental costs, particularly as new fees related to the 1990 Clean Air Act

[1] American Automobile Manufacturers Association *The Effect of Air Pollution Control Laws on the International Competitiveness of the U.S. Automobile Manufacturers* (Washington DC: AAMA, Jan. 5, 1993).

[2] U.S. Environmental Protection Agency (EPA) uses a 7-percent interest rate to estimate environmental compliance costs, and assumes a useful life of most pollution control equipment at 20 years. (EPA, *Environmental Investments: The Cost of a Clean Environment,* Washington, DC: Island Press, 1991).)

Amendments take effect. For example, Boeing's fees and taxes for environmental permits in the United States increased from $23,000 in 1985 to $2 million in 1991, while its overall costs for environmental compliance exceed $100 million annually.[3] In addition, taxes on industry to support the Superfund Trust Fund are not reported in the Census data. In 1990, the domestic petroleum industry paid $295 million, the chemical industry paid $273 million, and manufacturers paid approximately $252 million, for a total of $820 million. Leaking underground storage tank trust fund taxes were approximately $30 million in 1990. Together, these two taxes add an additional 4.1 percent to total annual pollution control expenditures.[4]

COSTS OF REGULATORY DELAYS

Environmental regulation can delay new investments, as firms wait to obtain permits. Calculating the impact of these delays on costs is very difficult. However, as competitive pressures on U.S. manufacturing have intensified, the potential impact of regulatory delays becomes more serious. Shorter product life cycles, more rapid product introduction, more customized and niche products, and increased use of flexible manufacturing systems require firms to be able to make more frequent and rapid changes in production. To the extent that the current regulatory system is based on an earlier model of manufacturing, characterized by long runs of standardized products with few changes in operating conditions, it can potentially hinder the ability of manufacturers to make changes needed to respond to changing market demands. As a result, regulatory delays, and slow and inflexible permitting processes can sometimes impede a fro's efforts to remain competitive.

LOSS OF PROPRIETARY INFORMATION

In some industries, particularly process industries, information reported to regulatory agencies that becomes available to the public maybe used by competitors to make inferences about the firm's manufacturing process. For example, since basic synthesis methods have been published for most commodity chemicals, a chemical company's competitive edge is often based on know-how or production techniques that provide small but significant advantages for efficiency, yield, and cost.[5] A recent study by the Chemical Manufacturers Association suggests that the reports required by some State environmental laws, if made available to competitors, combined with readily available information at the Federal level, would give them significant opportunities to ''reverse-engineer' proprietary products and processes.[6] One firm indicated to OTA that they had little faith in environmental agencies' ability to maintain confidentiality of sensitive company documents, and that the company itself used this source of information to gain information about their competitors. In part the problem stems from the fact that there appears to be no uniform definition between agencies and programs of what constitutes proprietary information. Moreover, many State environmental agency staff may lack training or experience in this critical area,

RESEARCH AND DEVELOPMENT COSTS

R&D costs are also not included, but are likely to be small. The National Science Foundation estimates that in 1990, total R&D by the private

[3] In 1990, Boeing paid approximately $2 million for water discharge and air emission fees and permit charges, $2 million for land disposal fees (tipping fees), and $6,5 million to publicly operated sewage treatment plants (POTWs). (Information provided by the Boeing Co.)

[4] U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, "Who Pays for Superfund,'' November, 1990. Also unpublished data from this office.

[5] *Impact of the Chemical Weapons* Convention on *the U.S. Chemical Industry-Background Paper*, OTA-BP-ISC-106 (U.S. Congress, Office of Technology Assessment, Washington, DC: U.S. Government Printing Office, August 1993).

[6] SRI International, *Analysis of Impact of US. Federal and State Reporting Requirements on Sensitive and Proprietary Company Information* (Menlo Park, CA: SRI International, Project 3307, July 1992).

sector for pollution abatement was approximately 2.4 percent of private sector pollution control costs.[7] However, much of this R&D was for automobile mobile source controls, new products (e.g., reformulated gasoline), and the environmental goods and services industry. R&D by firms toward compliance with process regulations appears to be less. For example in the petroleum and pulp and paper industries they represented only 2.2 and 1.0 percent respectively of annual pollution control compliance costs.[8]

PENALTIES AND FINES

In Fiscal Year 1991, EPA assessed a total of $87 million in fines and penalties, not all of it to manufacturing firms.[9] While exact data are not available on State fines and penalties, estimates suggest that they total less than $280 million a year.[10] Assuming that some local air pollution control authorities also levy frees, it appears that no more than $400 million is levied in fines. Including all these penalties would increase pollution control costs by approximately 1.9 percent.

OTHER COSTS

The survey also excludes several other costs, including: land needed for pollution control equipment; noise abatement expenditures; and expenditures for complying with regulations to protect worker health and safety, which can be substantial in particular industries. In addition, the potential negative effect of the Comprehensive Environmental Response, Compensation, and Liability ("Superfund") on business access and cost of credit is unknown.[11]

Underreporting From Lack of Full Knowledge of Costs

ENVIRONMENTAL COSTS EMBEDDED IN NEW CAPITAL EQUIPMENT

Companies sometimes do not report the environmental costs embedded in new generations of production equipment. For example, in reviewing reported project expenditures for a segment of the U.S. pulp and paper industry, OTA found that the share of new equipment costs that were environmental were not reported as such. If these expenditures are included, environmental capital costs as a share of total capital costs increase from approximately 12 percent to between 15 and 16 percent.[12] Assuming similar shares for all capital investments, total pollution control costs would increase 10 percent.

ADMINISTRATIVE COSTS

PACE does not directly ask for costs related to environmental regulatory compliance, environmental auditing, recordkeeping, training, and legal services to comply with regulations, particularly at the corporate level, as opposed to the plant or facility. However, while these costs are not insubstantial, relative to overall operating and capital costs they are small. For example, in the pulp and paper industry, corporate environmental administrative costs were only 3.5 percent of

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[7] Unpublished data, National Science Foundation,

[8] American Petroleum Institute, *Petroleum Industry Environmental Performance, 1992* (Washington, DC: API, 1992); National Council of the Paper Industry for Air and Stream Improvement Inc., *A Survey of Pulp and Paper Industry Environmental Protection Expenditures - 1991 (New York, NY:* NCASI, 1992).

[9] Interview with Rick Duffy, Environmental Protection Agency, December 1992.

[10] EPA does publish data on fines levied by states under RCRA. In FY91 these totaled $148.6 million. RCRA fines appear to Constitute at least half of all fines, with fines for air and water accounting for the other half.

[11] There is some evidence that banks are less likely to make loans to businesses with ground contamination on site. U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation "A Preliminary Report on the Indirect Effects of the Superfund Program" (Washington, DC: U.S. EPA, May 20, 1992.

[12] Neil McCubbin, "Environment and Competitiveness in the Pulp and Paper Industry," contractor report prepared for the Office of Technology Assessment, January 1993.

operating costs.[13] However, administrative and legal fees in the Resource Conservation Recovery Act (RCRA) and Superfund proceedings can be larger.[14] These costs can be larger as a percent of sales in small and medium-sized firms.

MANAGEMENT AND ENGINEERING STAFF TIME

Companies may not know or accurately report the managerial and technical time devoted to environmental issues. These issues, particularly related to hazardous waste, occupy a significant portion of time for some top executives—time that might otherwise be spent on matters more central to the corporation's function.[15] In addition, in many firms, a number of department heads, technicians, and engineers devote some share of their time to environmental compliance, which may not be reported.

ENVIRONMENTAL TRAINING

Training for environmental compliance, which can sometimes be a significant share of corporate training expenses, is often not known or reported.

OTHER COSTS

Other items, such as asbestos removal, transformer replacement to eliminate PCBs, and underground storage tank replacement, may also not be reported as environmental expenditures.[16] In addition, some operating costs, such as energy use by abatement equipment, may not be separately recorded.

13 NCASI, *A Survey Of Pulp and Paper Industry Environmental Protection Expenditures -1990, Op.* cit., footnote 8.

14 For example, Portney estimates that costs of litigation and other noncleanup related expenses could exceed 20 percent of total Superfund cleanup costs. Paul Portney, ' 'The Economics of Hazardous Waste Regulation" U.S. *Waste Management Policies: Impacts on Economic Growth and Investment Strategies,* Monograph Series on Tax and Environmental Policies and U.S. Capital Costs (Washington, DC: American Council for Capital Formation, Center for Policy Research, 1992).

15 John H. Sheridan, "Environmental Issues Sap Executive Time, " *Industry Week,* Mar. 16, 1992.

16 One report to EPA suggests a small degree of underreporting of capital investments due to inadequate information and a likely effect of underreporting of operation and maintenance costs. However, the size of this underreporting is not known. Firms also appear to underreport estimates of recovered costs, which would offset to some degree the underreporting of operation and maintenance costs. Beth Snell and Bob Unsworth, "Evaluation of Uncertainty Associated With Air Pollution Abatement Compliance Cost Estimates-Stationary Sources" (memorandum) (Cambridge, MA: Industrial Economics Inc., Oct. 13, 1992).

APPENDIX 7-B. NATIONAL DIFFERENCES IN POLLUTION CONTROL STANDARDS AFFECTING MANUFACTURING INDUSTRIES

It is very difficult to develop accurate cross-national comparisons of environmental regulations and approaches. With only a few exceptions (e.g., some air pollution standards), relatively little information is available.

Air Pollution

The most widely available data on *ambient* standards concern air quality, particularly for sulfur dioxide (SO_2), total suspended particulate matter (TSP), and nitrogen oxides (NO_x).[1] International comparisons of ambient air standards suggest that U.S. standards are very high, although nonattainment remains a major problem. Countries such as Germany and Japan may have higher standards for some pollutants. German standards were especially high, largely in response to concerns with acid rain. In Japan, local standards are often stricter than national rules,[2] although it is unclear the degree to which industry complies with more stringent local standards.[3] Comparisons of *emission* standards show similar patterns. Again, U.S. standards are among the strongest, although Japanese and German regulations of SO_2 and NO_x are stricter. However, countries regulations vary by categories of sources and fuels. For example, in the United States, older sources in most cases have not been required to meet the same performance standards as new facilities, although recent changes will require more retrofitting by utilities. Germany and Japan have required more retrofits. However, while the U.S. Clean Air Act regulates 189 toxic pollutants and 6 criteria pollutants, Japan's Air Pollution Control Law designates only 10 regulated pollutants.[4]

U.S. standards for some emissions, such as total suspended particulate (TSP) and volatile organic compounds (VOCs,) appear to be the highest in the world. When fully implemented, the 1990 Clean Air Act amendments on air toxins will probably be the most demanding. Notably, Japanese regulations of VOCs and hazardous air pollutants are much weaker than those in the United States, and the guidelines are not generally followed.[5] For example, in the organic chemical industry, the Japanese regulate only a few selected organics as toxics. VOC emissions from Japanese automobile painting are subject to minimal regulations, allowing the use of "low-solid' paints that enable a higher gloss finish than from paints with higher solids.[6] In contrast, in response to U.S. VOC regulations, automakers here use higher-solid paints, making it more difficult to achieve high gloss finishes. German controls on automobile painting more closely approximate those of the United States, while

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[1] Raymond J. Kopp, Paul R. Portney, and Diane E. DeWitt, *International Comparisons of Environmental Regulation* (Washington DC: Resources for the Future, September 1990); *Clean Air Around the World: The Law and Practice of Air Pollution Control in 14 Countries in 5* Continents (Brighton, England: International Union of Air Pollution Prevention Associations, 1988); also, Gregory C. Pratt, "Air Toxics Regulation in Four European Countries and the United States," *International Environmental Affairs*, vol. 4, No. 2, spring 1992, pp. 79-100.

[2] Energy and Environmental Analysis, Inc., *Comparison of U.S. Air Quality Standards and Controls to the Air Pollution Controls in Japan, Germany, Canada, Mexico, and South* Korea, prepared for Office of Policy Analysis and Review, Office of Air and Radiation, U.S. Environmental Protection Agency, February 1992 (draft).

[3] Louise Jacobs and Leigh Harris, *Public-Private Partnerships in Environmental Protection: A Study of Japanese and American Frameworks for* So/id *Wastes* and Air *Toxics* (Lexington, KY: The Council of State Governments, 1991).

[4] Energy and Environmental Analysis, op. cit., footnote 2.

[5] Energy and Environmental Analysis, Inc., op. cit., footnote 2, p. 1-11. See also "Interview With Dr. Yasumoto Magara: Amendment of Drinking Water Quality Standards," *Water Report (Tokyo),* vol. 1, No. *4, 1991.*

[6] *in* part, this maybe because as a strategy to control ground level ozone, the Japanese control NOx more heavily than VOCs. Energy and Environmental Analysis, Inc., ibid,

Canadian controls are weaker.[7] Most developing nations, including Korea and Mexico, have no set standards for VOCs, including automobile painting operations. In Mexico, furniture firms face no air pollution standards for the application of paint coatings and solvents.[8]

Water Pollution

In part because standards are often set by subnational governments, it is more difficult to obtain data and compare water regulations between nations. In spite of this, there is some evidence that many other nations regulate water pollution less stringently than the United States. For example, Japanese regulations to protect ground water were established only in 1990.[9] While the Japanese Government has moved to reduce air pollution, it has taken much less action to reduce water pollution and contamination of drinking water.[10] Japan lags behind other industrialized countries in setting chemical standards in drinking water, and currently regulates only 26 contaminants for water quality.[11] Water controls in other countries are also weaker.[12] For example, Canada is only now requiring that all pulp and paper mills install secondary treatment, while virtually all U.S. mills installed secondary water treatment after the mid-1970s.[13]

Hazardous Waste

U.S. laws regulating hazardous wastes are very strong compared to most countries. While many European countries have laws similar to the Resource Conservation and Recovery Act (RCRA), none is as restrictive and comprehensive.[14] For example, while the United States lists approximately 500 wastes as hazardous, the United Kingdom designate 31, the French control approximately 100, and the Germans restrict 348.[15] One estimate suggests that only 20 percent of Italian toxic waste is disposed of properly, with the rest either stockpiled, dumped illegally, or exported.[16] Of the six distinct classifications of waste established by OECD member countries, only the United States regulates waste in all six.[17] However, EC waste laws appear to be getting

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[7] Ibid.

[8] U.S. Congress, U.S. General Accounting Office, "U.S.-Mexico Trade: Some U.S. Wood Furniture Firms Relocated From Los Angeles Area to Mexico' (Washington, DC: U.S. Government Printing Office, April 1991); also Ibid.

[9] Louise Jacobs and Leigh Harris, *Public Private Partnerships in Environmental Protection: A Study of Japanese and Amen"can Frameworks for Solid Wastes and Air Toxics*, op. cit.

[10] Curtis Moore and Alan Miller, "Japan and the Global Environment," *Environmental Law and Policy Forum, vol.* 1, 1992, p. 38; Bruce E. Aronson, "Review Essay: Environmental Law in Japan," *The Harvard Environmental Law Review*, vol. *7, No.* 1, 1983, pp. 135-171; and Shigeki Masunaga, "Water Pollution Control in Japan," *Water Report* (Tokyo), vol. *2, No. 3, 1992.* Japan did take early action to reduce mercury and some other toxic heavy metal levels in water, due to mercury poisoning around several industrial facilities.

[11] "Interview with Dr. Yasumoto Magara: Amendment of Drinking Water Quality Standards,' *Water Report* (Tokyo), vol. 1, No. *4, 1991. In* contrast, the United States regulates 83 contaminants.

[12] One survey of U.S.-owned chemical facilities in Europe found significantly larger discharges of some toxic chemicals to water than in the United States, According to the study, discharges of three chemicals —benzene, MEK, and xylene-from individual chemical plants in Europe exceed the total discharge to water for the same chemicals from all 26,000 facilities that report to the U.S. Toxic Release Inventory. David Sarokin, '‘Toxic Releases from Multinational Corporations: Does the Public Have a Right to Know?' (Washington, DC: The Public Data Project and Friends of the Earth, July 1992).

[13] Discussion with official from the National Council on Air and Stream Improvement, New York, NY, December 1992.

[14] K_{opp}, Portney, and DeWitt, *International Comparisons of Environmental Regulation*, op. cit., footnote 1.

[15] Kopp, Portney, and DeWitt, Ibid., p. 28.

[16] John Glover, "Italian Industry Aims to Get Greener, But on its Own Terms," *Chemical Week*, Feb. 6, 1991.

[17] Source: OECD, *Transfrontier Movements of Hazardous Waste* (Paris: 1985); and Resources for The Future, *International Comparisons of Environmental Regulations.* (Cited in Steel *industry Annual Report,* U.S. International Trade Commission, September 1991, p. 3-30.)

stricter.[18] Japanese ambient standards for dioxin ingestion is 5,000 picograms per day for adults, as compared to the U.S. standard of 50 per day.[19] Few other nations have the regulatory provisions (including mandatory planning in some States and information disclosure) the United States has to encourage waste minimization.

The difference between U.S. hazardous waste laws and those in developing countries is even greater. Few developing nations have significant laws regulating hazardous wastes, For example, maquiladora plants in Mexico generate unknown but evidently large amounts of hazardous wastes, and compliance with Mexican waste laws appears to be low.[20]

U.S. law governing abandoned waste sites is by far the strongest in the world. No other nation has a Superfund law that imposes strict, joint and several, and retroactive liability on industry. While the EC is considering legislation to regulate contaminated sites, it is likely to only address future and not past liability. Industries in Japan are not subject to similar laws.

* * *

The discussion above is a selective discussion of national-level environmental standards affecting manufacturing; subnational standards (which in some cases exceed national requirements) are not considered. A number of areas are not covered. It does not, for example, include differences in requirements pertaining to global environmental issues (such as phase out of substances that deplete the stratospheric ozone layer). Nor does it include post consumer responsibility for product disposal. For example, Germany is starting to make manufacturers responsible for the ultimate disposal of the products they sell. Initially focused on packaging, the requirements may eventually apply to a wide variety of products, including automobiles, computers, and other equipment. Different countries' environmental requirements affecting land use, resource management, wildlife, endangered species, could have differential effects on manufacturers, but are not covered here.

As legislative and administrative bodies periodically revise and amend prior laws and regulations, relative rankings among countries change. Some U.S. environmental laws, including the Clean Water Act and the RCRA, are up for reauthorization. The Japanese Diet is considering changes in Japan's basic environmental law. Administering agencies also vary in the commitment made to implement standards and requirements in a timely fashion, and in the resources available for enforcement.

18 "Europe Making Progress with Environmental Regs" *Pollution Engineering,* Sept.1, 1992.

19 Moreover, the 2,000 incinerators in Japan, the main source of waste treatment &e@ are not monitored for dioxin output. Landfills are scarce in Japan and, as a result, the Japanese are constructing landfills in ocean bays and inlets, using the newly created land as industrial sites. Louise Jacobs and Leigh Harris, *Public Private Partnerships in Environmental Protection: A Study of Japanese and American Frameworks for Solid Wastes and Air Toxics* (Lexington, KY: The Council of State Governments, 1991).

20 By law, these firms are supposed t. ship hazardous wastes back to the U. S., but this provision is notwell enforced. U.S. Congress, Office of Technology Assessment, *U.S. Mexico Trade: Pulling Together or Pulling Apart?,* ITE-545 (Washington, DC: U.S. Government Printing Office, October 1992); See also U.S. Congress, Government Accounting Office, *U.S.-Mexico Trade: Assessment of Mexico's Environmental Controls for New Companies,* GAO/GGD-92-113 (Washington DC: August, 1992).

Pollution Prevention, Cleaner Technology, and Compliance 8

Historically, environmental compliance efforts in the United States have focused principality on treatment of pollution once it has been released (end-of-pipe approach) rather than on prevention or recycling, two approaches that in many cases offer a lower cost means of attaining compliance. End-of-pipe methods often result in increased costs with no appreciable benefits to the firm in the form of enhanced materials or energy efficiency. In contrast, pollution prevention and recycling investments often not only lower energy and material usage but also reduce end-of-pipe treatment costs, resulting in decreased disposal expenditures, possible reduced paperwork, and lower liability and insurance costs, Greater emphasis on prevention and recycling can thus lower environmental compliance costs for U.S. manufacturers.

Congress, in the Pollution Prevention Act of 1990, established a hierarchy of preferred options, from elimination or reduction at the source (including in-process recycling), to out-of-process recycling (on-site and off-site), pollution control, waste treatment, and, finally, land disposal.[1] This chapter discusses pollution prevention and cleaner technology from the standpoint of the manufacturing firms that must comply with environmental regulations, building in part on prior OTA work[2] and on contract

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[1] **F. Henry Habicht II, Deputy Administrator, U.S. Environmental Protection Agency, Memorandum "EPA Definition of 'Pollution Prevention, ' " May 28, 1992.**

[2] **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).**

research undertaken for this assessment.[3] Special emphasis is given to three industrial sectors facing high compliance costs and significant environmental challenges--chemicals, pulp and paper, and metal finishing. The chapter also discusses barriers to pollution prevention, and Federal and State government assistance to manufacturers in the United States to meet environmental requirements, particularly pollution prevention.

MAJOR FINDINGS

Pollution Prevention and Recycling

- Compared to conventional treatment alone, pollution prevention and recycling investments are usually more cost-effective, often resulting in reduced energy and material usage and lower end-of-pipe treatment costs. Pollution prevention can produce significant environmental benefits as well, including reduced cross-media transfers and reduced environmental impacts from avoided energy and materials usage.
- However, while increased reliance on pollution prevention and recycling offers a means to reduce the conflict between environmental protection and industrial competitiveness, it does not eliminate it. While many pollution prevention and recycling options yield net positive rates of return equaling nonenvironmental investments, many others do not, and often cost money. However, in most cases the expense is lower than alternative end-of-pipe approaches.
- While source reduction is normally preferred on environmental grounds, and usually yields the lowest cost option for reducing pollution, there are cases where recycling is preferred on economic grounds. Depending on the material, the size of the facility, and the industry, recycling can be a more economical way of reducing waste than source reduction. Moreover, recycling can be the preferred option if it is less intrusive to the production operations.
- Emphasis on pollution prevention can also lead to beneficial organizational and technological changes. It can speed technical change within an industry, leading to increased investment in new plant and equipment. Moreover, integrating pollution prevention into industrial operations can lead firms to pay closer attention to the efficiency of their production processes and is consistent with new management approaches, including total quality management.
- A variety of evidence suggests that, while industry has increased its pollution prevention and recycling efforts, particularly since the late 1980s, significant pollution prevention opportunities still exist, especially those related to process modifications. A number of organizational and capital accounting factors within firms and aspects of the regulatory system retard greater progress.

Pollution Prevention Technology Development and Diffusion

- As the simpler steps for pollution prevention become widely adopted, a significant source of environmental improvement will lie in new manufacturing process technologies that are cleaner, and often more productive. Many of these approaches to waste reduction are still underused and are just now being explored.
- In spite of the importance of clean process technologies, little Federal environmental R&D support goes to this area.[4] Moreover, no federally supported institution has taken a broader policy role with regard to clean technology development, although some agencies are interested in doing so.

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[3] Information on three industries was provided to OTA by outside contractor reports: Neil McCubbin Consultants, Inc., "Environment and Competitiveness in the Pulp and Paper Industry" David Allen, "Clean Chemical Manufacturing Technologies: Current Practices and Long Term Potential"; F.A. Steward, Inc., "Environment and Competitiveness in the Metal Finishing Industry."

[4] One exception is the Department of Energy's Clean Coal Technology Program, funded at $415 million in fiscal year 1992 (see ch. 10).

- While new technologies are necessary for fundamental gains in pollution prevention, widespread diffusion of existing off-the-shelf technologies will go a long way to reduce pollution. While many in industry want to reduce pollution, a significant share do not know how to move beyond the simplest measures; some, particularly small businesses, may not even be aware of pollution prevention options.
- Technical assistance efforts can help these firms implement pollution prevention and recycling measures. Yet existing programs are very small and many do not adequately meet manufacturers' needs. Most importantly, by considering pollution prevention separately from other manufacturing needs, such as productivity and quality improvements, most programs fail to develop the vital synergies and working relationships with manufacturers that are essential to drive both pollution prevention and increased manufacturing competitiveness.

Financial Incentives

- Government financial support to industry for the cost of environmental compliance can lessen the competitive impact of environmental regulations. A number of other countries provide more financial incentives (tax incentives, loans, grants) to help companies comply with domestic environmental requirements than does the United States.

THE RATE OF ADOPTION OF POLLUTION PREVENTION AND RECYCLING

Because of the dearth of careful studies, it is difficult to document the extent of adoption. However, while industry has increased its pollution prevention and recycling efforts, particularly since the late 1980s, the evidence suggests that significant pollution prevention opportunities remain, particularly those related to process modifications.[5]

Some industries have made more progress than others. For example, such methods have been extensively exploited in many major chemical manufacturing operations.[6] A study of pollution prevention projects in 21 chemical plants found that, while a few projects date back a decade or more, the majority were launched after 1985.[7] The study argues that significant opportunities for pollution prevention are still possible, even at plants that have been implementing pollution prevention for many years. For example, Hoechst Celanese has committed to reducing Toxic Release Inventory (TRI) emissions 70 percent from 1988 to 1996, and expects that over three-quarters of these reductions will come from pollution prevention, with one-half of the total coming from source reduction.[8]

In the metal finishing industry, pollution prevention housekeeping practices have been known for over 20 years, but many firms have not adopted them, as older facilities tend to perpetuate old operating habits. Only a small fraction of metal finishers, principally the larger facilities, appear to have taken advantage of some of the

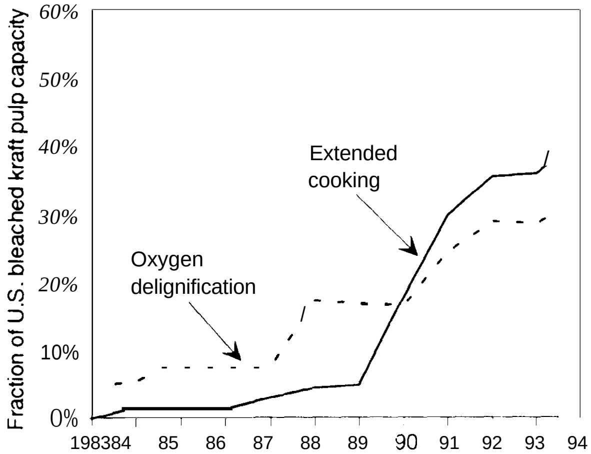
[5] There arc many similarities between energy conservation and pollution prevention. Each is driven by external costs, both are applied at the margin, neither is done in isolation, and both are part of other productivity improvements in labor, equipment, and materials. When U.S. firms first began to focus on energy conservation they focused first on the "low-hanging fruit' and then moved to more expensive changes based on new technologies and processes. However, many companies continue to find new, relatively easy energy-saving opportunities. It is possible that pollution prevention will follow this same path. (See U.S. Congress, Office of Technology Assessment, *Industrial Energy Efficiency, OTA-E-560* (Washington, DC: U.S. Government Printing Office, August 1993.)

[6] Allen, op. cit

[7] Mark H. Dorfman, Warren R. Muir, and Catherine G. Miller, *Environmental Dividends: Cutting More Chemical Wastes* (New York, NY: Inform, 1992), p. 14.

[8] Discussion with James Connor, Environmental Division, Hoechst Celanese, Apr. 20, 1993. (Under Section 313 of the Emergency Planning and Community Right To Know Act, certain manufacturers must report releases or transfers of over 3(?0 toxic chemicals.)

Figure 8-l—Adoption of Selected Cleaner Technologies in U.S. Kraft Pulp Mills



SOURCE: N. McCubbin Consultants Inc., 1993.

promising opportunities, such as use of advanced concentrate and return technologies (e.g., reverse osmosis, evaporation, ion exchange) for the return of excess solution (dragout) to plating baths. Of the installations that could achieve a 3-year payback, one estimate is that less than half have installed the equipment.[9]

In pulp and paper, there has been a slow increase in the share of pollution prevention technology adopted. In 1984, 25 percent of water pollution control investments were for in-process measures, increasing to 30 percent in 1989 and 56 percent in 1991.[10] Much of this increase has been driven by the need to reduce organo-chlorines in waste water. One way to do this is through extended cooking in bleached kraft pulp production. Use of this technique has increased significantly since 1989; currently over one-third of all pulp is made with this process. In contrast, the adoption of oxygen delignification systems has been slower, with about 27 percent of bleached kraft production now using it[11] (see figure 8-l),

Overall, the share of environmental investments in in-process pollution control appears to be similar in Europe and the United States (table 8-l). Contrary to conventional wisdom, the Japanese do not appear to have made significant effort in industrial waste-related pollution prevention. However, because of high energy prices and aggressive government policies, Japanese industry has made significant strides in adopting energy-efficient technologies, which provide both direct and indirect environmental benefits.

POLLUTION PREVENTION, AND RECYCLING AND ECONOMIC PERFORMANCE

Cost Savings From Pollution Prevention and Recycling

There is disagreement on exactly how economical pollution prevention is. Some claim that pollution indicates wasteful and inefficient practices and that, therefore, firms generally save money by engaging in pollution prevention. In fact, there are numerous widely publicized industrial case studies of very successful pollution

Table 8-l—Estimates of In-Process Changes as a Share of Pollution Control Investments

Belgium*	20%
France"	13%
Germany[a]*	18%
Netherlands	20%
United States**	25%

a One study suggests that pollution prevention investments in Germany between 1975 and 1985 ranged from 16 to 24 percent (Christian Leipert and Ucfo E. Simonis, "Environmental Damage-Environmental Expenditure. Statistical Evidence on the Federal Republic of German," paper by Wissensehaftszentrum Berlin Fur Sozialforschung gGmbh, Berlin.).

SOURCES: •Commission of the European Communities, *Panorama of EC* Industry 1990 (Luxembourg: Office of Official Publications of the European Communities, 1990), p. 134.
•* U.S. Bureau of the Census, *Pollution Abatement Costs and Expenditures, 1990* (MA200), *1992.*

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[9] **Steward, op. cit.**

[10] U.S. **Bureau of** the Census, *Pollution Abatement Costs and Expenditures* **(Washington DC: Government** Printing Office, various years).

[11] **McCubbin, op. Cit.**

Table 8-2—Case Examples of Pollution Prevention Savings

Industry	Savings or payback period	Option	Source of savings
Ice cream	4 months	Housekeeping	Material savings
Trailers	4 months	Paint reuse, use of water-based cleaner	Avoided paint purchases, lower disposal costs
Valves	1.4 years	Aqueous parts cleaning	Avoided solvent purchase, lower disposal costs
Chemicals	3 years	Evaporation equipment for ammonium sulphate	Avoided EOP, sales of recovered chemicals
Tobacco products	6 months	Solvent recycling	Avoided solvent purchase, lower disposal rests
Nylon fabrics	5.5 years	Dye substitution, process changes	Reduced wastewater treatment charges
Furniture	1 year	Solvent recycling	Avoided disposal costs
Furniture	2 years	More efficient paint spraying	Paint savings, avoided disposal costs
Furniture	$70,000	Painter training	Reduced paint use
Printing	Immediate	Water-based inks	Lower ink costs, avoided disposal costs

SOURCES: Information provided by the Center for Industrial Services, The University of Tennessee; the North Carolina Department of Environment, Health and Natural Resources, Pollution Prevention Program; *Case Summaries of Waste Reduction by Industries in the Southeast* (Raleigh, NC: Waste Reduction Resource Center for the Southeast, July 1989); Karf S. Tsuji, Energy and Environmental Analysis Group, Los Alamos National Laboratory, “Waste Reduction in the U.S. Manufacturing Sector, A Survey of Recent Trends,” unpublished paper, November 1991.

prevention projects, some with payback times of well under a year.[12] But some in industry view these highly successful projects as relatively rare, and there are elements of truth in both sides of the argument.

However, pollution prevention projects do not need to generate a positive rate of return to be successful. Because most pollution prevention solutions are cheaper than treating or disposing of wastes, a greater emphasis on prevention can reduce environmental compliance costs, regardless of whether pollution prevention is profitable even in the absence of regulatory requirements.

The few studies on the economics of pollution prevention suggest that while there are cases where prevention yields net positive rates of return equaling nonenvironmental investments, more yield either positive, but low, returns, or negative returns.[13] In controlling pollution, firms normally have a range of options with a range of economic paybacks. In a few cases the paybacks are large enough to justify action solely on the economic merits[14] (see table 8-2.) One study found that, where payback information was reported, companies were able to recoup their investments rapidly, in 6 months or less, for

[12] For example, see “Case Summaries of Waste Reduction by Industries in the Southeast,'' Waste Reduction Resource Center for the Southeast, Raleigh, NC, July 1989; Karl S. Tsuji, “Waste Reduction in the U.S. Manufacturing Sector, A Survey of Recent Trends,” Los Alamos National Laboratory, November 1991; Dorfman et. al, op. cit.;“Leaders in Hazardous Waste Reduction, 1989 & 1990, ” Pollution Prevention Program, North Carolina Department of Environment, Health and Natural Resources; *Pollution Prevention* Case *Studies Compendium*, U.S. EPA, Office of Research and Development, April 1992.

[13] As discussed below, firms do not always adequately account for all benefits (and costs) from pollution prevention, including reduced long-term environmental liability.

[14] For example, see Cleaner Production Programme, *Cleaner Production Worldwide* (Paris: United Nations Environment Programme, 1993).

two-thirds of their investments.[15] However, since companies are more likely to implement pollution prevention projects with larger rates of return, such findings may be skewed and not represent the entire universe of projects.

In other cases, while paybacks maybe positive, they are not high enough to be justified on solely commercial grounds. Finally, in many cases the returns are negative, but often represent savings over alternative end-of-pipe approaches. Companies would normally not invest in these projects without some kind of regulatory pressure.

For example, 3M's gross savings of $516 million from 1975 to 1992 in the United States through its Pollution Prevention Pays (3P) program is often cited as evidence of potential savings from pollution prevention.[16] However, 3M has also spent over $220 million on pollution prevention capital investments, and an additional, unspecified, amount on labor to design and implement these measures. Moreover, not all the projects had net positive rates of return.[17]

Approximately half of the projects in Dow Chemical's Waste Reduction Always Pays program (WRAP) cost more to implement than they save.[18] The chemical company Hoechst Celanese analyzed over 200 projects in its Waste and Release Reduction Program, focusing on SARA 313 releases. The company found that about 20 percent of the projects had a positive net present value; the majority showed small but negative net present value; and 20 percent had large negative net present values. As expected, end-of-pipe treatment projects often yielded the worst returns, with source reduction and recycling showing the best returns.[19]

Finally, pollution prevention does not eliminate the need for end-of-pipe treatment: these firms still expend significant amounts on environmental compliance. While 3M saved $47 million from its 3P program in 1992, it also spent over $200 million on environmental compliance.[20] The chemical company Monsanto has spent $100 million to reduce toxic air emissions through end-of-pipe and prevention measures, and only some of the projects were economically positive.[21]

Economics of pollution prevention differ by industry. In the pulp and paper industry, prevention is cheaper than end-of-pipe treatment, because far less pulpmaking chemicals are used. For example, if a new pulp bleaching plant is installed in a greenfield mill or in rebuilding an existing facility, the net capital cost of oxygen delignification systems generally will be close to zero. The system eliminates the need for a chlorine-based bleach stage and reduces chlorine dioxide consumption. In cases of a retrofit, the capital costs typically range from $10 to $20 million, depending on the site. However, operating costs will be reduced by around $10 per metric ton of pulp, equivalent to about $1.5 to $4 million a year at typical production rates. In addition, oxygen delignification generally reduces biological oxygen demand (BOD) emissions by about 25 percent, lowering water treatment costs by a small

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15 Dorfman et. al., Op. cit.

16 It is difficult to determine actual savings, Actual savings may be lower since 3M calculates projected Savings at the time Of project initiation and not after implementation. On the other hand, because savings are only estimated for the first year ioperation, actual savings may be greater.

17 Interview with 3M official, January 1993.

18 "Attacking Wastes and Saving Money. . .Some of the Time," *Industry Week*, Feb. 17, 1992. Full cost analysis may not be done for all projects, resulting in underestimation of savings,

19 Discussion with Hoechst Celanese official, Apr. 20, 1993.

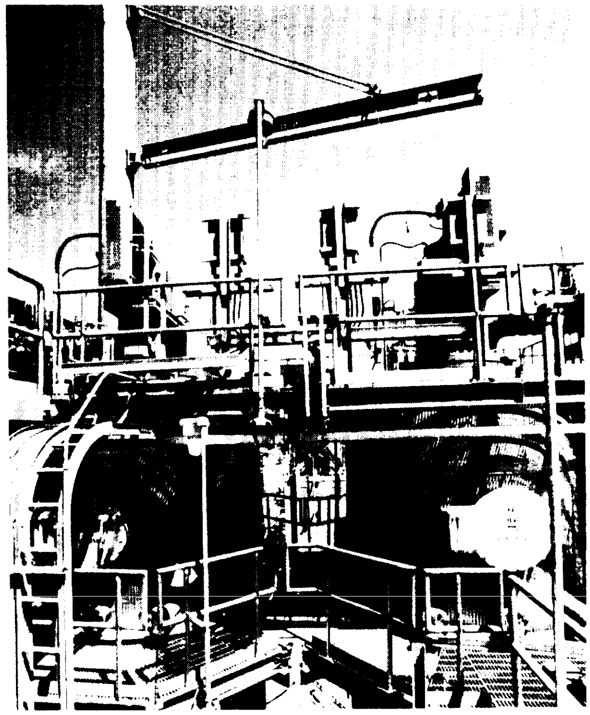
20 Data provided by 3M.

21 Marc Reisch, "Monsanto's Environmental Progress Comes at High Cost," *Chemical and Engineering News*, Dec. 14, 1992, p. 16.

Table 8-3—Capital and Operating Costs for Selected Pollution Prevention Measures in the Wood Pulp Industry

Process option	Capital cost ($ million)	Annual savings ($ million)
Base case example mill	0.0	0.0
Maximum substitution with EOP & existing ClO_2 capacity	2.8	0.5
Extended cooking (if batch digesters exist)	45.6	3.4
Extended cooking (if older continuous digesters exist)	32.6	2.8
Extended cooking (if suitable continuous digester exists)	4.6	3.7
Oxygen delignification	27.5	3.3
100% substitution without EOP	15.9	(7.1)
50% substitution without EOP	5.0	(1.9)
10OO/. substitution with EOP	13.6	(3.2)
Extended cooking with EOP	47.0	3.3
Oxygen delignification with 100% substitution	34.7	2.0
Extended cooking with oxygen delignification	71.6	6.0
Extended cooking with 100% substitution	54.5	0.1
Extended cooking with OD and 10OO/. substitution	75.2	4.6
Extended cooking with OD & EOP	73.0	4.4

Values in parentheses are negative. Savings in parentheses represent costs.
OD=oxygen delignification.
EOP=caustic extraction reinforced with oxygen and hydrogen peroxide bleaching.
Substitution-substitution of chlorine with chlorine dioxide.
SOURCE: Neil McCubbin, *Proceedings,* International Symposium on Pollution Prevention in the Manufacture of Pulp and Paper Opportunities & Barriers, Washington, DC, Aug. 18-20, 1992.


AHLSTROM RECOVERY, INC.

Oxygen reactors, part of an oxygen delignification system in a pulp mill.

amount.[22] If this negates the need to upgrade the treatment system for mill expansion or to comply with regulatory changes, capital savings of several million dollars can occur. Finally, oxygen delignification frees up chlorine dioxide generating capacity, allowing the excess capacity to be substituted for formerly purchased chlorine bleach (table 8-3).

In metal finishing operations, some facilities saved significant amounts of money using pollution prevention technologies. However, many of these firms are plating with more valuable metals (e.g., gold, silver) where metal recovery makes more economic sense. Advanced recovery systems are sometimes more expensive than traditional end-of-pipe treatment, although recovered metals and chemicals and avoided sludge disposal costs do provide savings. Such systems appear to be more economical in the larger metal finishing facilities and for more valuable stable baths and in many cases can provide reasonable payback times (less than 3 years).

22 Similarly, in the electric utility industry, investing in heat rate improvements can reduce scrubber and waste disposal expenses, more than offsetting the costs. Robert C. Carr, "Integrated Environmental Control in the Electric Utility Industry," *Journal of the Air Pollution Control Association,* vol. 36, No. 5, May 1986, pp. 652-657.

Future increases in sludge disposal costs or in costs of input metals and chemicals would make these operations more cost-effective. For example, Freon 113 is becoming more expensive due to the tax aimed at reducing use of ozone-depleting substances. As a result, some pollution prevention solutions that had once been too expensive are now cost-effective.[23]

Organizational and Technological Change and Pollution Prevention

A focus on pollution prevention can sometimes lead to beneficial organizational and technological changes. A driving force for new productive investments is often technological obsolescence. Improved environmental performance of production technology often goes hand in hand with increased productive performance. As a result, a focus on pollution prevention can speed technical change within an industry, leading to increased investment in new plant and equipment.

In some industries, process technologies are relatively mature, with only slow rates of evolutionary change. However, increased concern with reducing pollutants, particularly at the source, can lead to reexamination of long-used technologies and practices and may induce more rapid rates of technical change.[24] For example, pulp and paper technology evolved relatively slowly between the 1940s and 1970s. Increased concern with environmental performance has led to renewed interest in the production process, with a number of major new process innovations being developed within the last decade, and further developments likely to occur in the 1990s. The innovations can involve improvements in productivity or efficiency.

In the drive to become more competitive, many U.S. manufacturers are organizing technology and production processes in new ways (e.g., computer-integrated manufacturing, just-in-time (JIT) delivery, and lean production) and rethinking their management systems (total quality management or TQM).[25] Pollution prevention is consistent with these approaches.[26] For example, the environmental waste reduction program of the textile firm Milliken grew out of its TQM program, which received the Malcolm Baldridge Quality Award in 1989. Similarly, as some firms have moved to JIT delivery systems, they have been able to eliminate decreasing and other cleaning steps. Moreover, there is some evidence that an increased focus on pollution prevention can encourage production workers to present ideas for improvement to process engineering managers .27

There are a number of similarities between pollution prevention and TQM/manufacturing modernization[28] (see table 8-4.) In both, firms examine their production process in great detail

23 For example, *managers* at the GE compressor plant in Columbia, Tennessee replaced their freon degreaser with a $600,000 aqueous washing unit, Without the increase in cost of 113 freon to $84 per gallon (from $45 recently) the new unit would not be cost-effective under the company's cost accounting system.

24 previous OTA work has found that "a new focus on pollution prevention offers an opportunity to reappraise and modernize plant process technology." *Serious Reduction of Hazardous Waste,* p. 30.

25 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); and U.S. Congress, Office of Technology Assessment, *Worker Training: Competing in the New International Economy,* OTA-ITE-457 (Washington, DC: U.S. Government Printing Office, September 1990).

26 In a study of pollution prevention in a large multinational firm, the units that had strong TQM programs in place undertook more wide-ranging and effective pollution prevention efforts than divisions with less commitment to TQM. (Ann Rappaport, *Development and Transfer of Pollution Prevention Technology Within a Multinational Corporation,* Dissertation Department of Civil Engineering, Tufts University, May 1992.)

27 Andrew King, ' 'Cooperatively arning Between Pollution Control and process Engineering Departments in the Printed Circuit Fabrication Industry, " paper presented at The IEEE International Symposium on Electronics and the Environment May 10-12, 1993, Arlington, VA .

28 For example, see Alvin Alm, "Pollution Prevention and TQM,'' *Environmental Science and Technology, vol. 26, No. 3, 1992;* also Gene Blake, "TQM and Strategic Environmental Management,'' *Total Quality Environmental Management,* spring 1992.

Table 8-4-Organizational Aspects of Pollution Prevention and Total Quality Management

Factor	TQM and pollution prevention
Central focus	Focus on continuous improvement of the production process (goal of zero defects and zero emissions)
Source of improvement	Quality and pollution prevention built into the production process
Desired results	Increased efficiency and reduced waste (scrap and pollution)
Measurement process	Benchmarking progress
Internal coordination	Cross-departmental cooperation/coordination
Decision process	Workers at all levels (including shop-floor) involved in decision making
Accounting system	Activity-based and full-cost accounting

SOURCE: Office of Technology Assessment, 1993.

and focus on continually improving the process to improve quality and productivity and reduce scrap and pollution. Both practices incorporate new cost accounting and measurement to assign all costs to particular products or production processes. Benchmarking progress is encouraged in both.[29] In TQM, firms strive for zero defects, while in the best pollution prevention efforts, firms strive for zero discharges.

The process of decisionmaking is also similar. Both practices aim to involve all parts of company, rather than just the quality or environmental departments. For example, in pollution prevention, representatives from purchasing, marketing, R&D, production, and design are all encouraged to work together to find ways to prevent pollution. Similarly, both stress the importance of workforce involvement and the key role of shop-floor workers in improving quality and preventing pollution. Many programs report that their best suggestions to prevent pollution come from the shop floor employees.[30] Both pollution prevention and manufacturing modernization efforts succeed best when shop-floor employees are involved.

In summary, when firms focus on pollution prevention it facilitates the better focus on the broader task of continuous productivity improvement.[31] Preventing pollution through source reduction requires managers to improve materials, energy, and resource efficiency.

POLLUTION PREVENTION OPTIONS

Strategies for reducing waste generation in manufacturing include: good housekeeping, maintenance, and operating practices; product reformulation and raw material substitution; relatively simple process modifications employing currently available technologies; and, perhaps most importantly, more fundamental process modifications, many requiring technological innovation.[32]

29 Ann C. Smith, "Continuous Improvement Through Environmental Auditing," *Total Quality Environmental Management*, winter 1991/92.

30 Similar results have been found with regard to energy conservation. (See *Employee Participation in Energy Conservation: The U.S. and Japan Experience.* University of Michigan, Institute of Labor and Industrial Relations, 1983).

31 There are a number of components of ISO 9000 (the International Standards Organization standard for quality management) that are consistent with pollution prevention. For example, both stress the importance of working with suppliers.

32 R.L. Berglund and C.T. Lawson, "Preventing Pollution in the CPI,' *Chemical Engineering,* September 1991, pp. 120-27; also Harry Freeman et. al. "Industrial Pollution Prevention: A Critical Review" *Journal of Air and Waste Management Association,* vol. 42, No. 1, May, 1992, pp. 618-656.

Good Housekeeping and Innovative Management Approaches

Perhaps the simplest and easiest-to-implement pollution prevention strategy is to adopt good housekeeping, maintenance, and operating practices. Frequently characterized as low-hanging fruit, many different industries have used such methods in varying degrees to cut waste economically.

General improvements in manufacturing efficiency can reduce pollution. For example, statistical process control programs, a TQM element, take some variance out of processes that generate waste. Other improvements include, for example, metal finishing opportunities such as operating at lower concentrations in the bath, better racking or barrel designs, draining over the tank, reduced water usage, and use of simple drag-out stations to catch and return drag-out solution.[33] Such good conservation and process control measures can reduce drag-out by 50 to 60 percent and extend the life of stable baths.

Innovative management approaches to waste minimization include working with customers and suppliers to redefine product needs so that less-toxic chemicals or less-polluting processes are required, renting of chemicals where the supplier takes them back after use, and improved operations management procedures like better inventory control.[34] Similarly, better attention to preventative maintenance to eliminate spills, leaks, and the like, can reduce emissions. Often employee training programs have objectives (e.g., reducing scrap and waste) that bring pollution prevention benefits.

Product Reformulation and Raw Material Substitution

Coating and cleaning operations are a principal area for raw material change. A significant amount of effort has gone into replacing chlorinated solvents with other, often aqueous-based, solvents. In painting, alternatives to volatile organic compound (VOC)-based paints include water-based paints, which can obviate the need for end-of-pipe VOC controls. For example, the Saturn automobile plant uses a water-based base coat that gives off no VOCs. In metal finishing, research is underway to find alloy coating materials that would be acceptable substitutes for cadmium and chromium.[35] On a broader basis, the shift from metal parts to plastic parts in a number of products has reduced the amount of metal finishing required. Substitutes, however, do not always provide identical performance or qualities of the materials they replace.

Process Modifications Using Existing Technologies

While many pollution prevention opportunities represent relatively unique modifications not generalizable between facilities (e.g., fine-tuning process computer control systems to lower waste),[36] many process modifications involve relatively generic process changes. For example, ultrasonic cleaning can greatly reduce solvent usage .37 More efficient paint transfer operations can reduce VOC emissions and paint sludge. In metal finishing, relatively standard technologies, such as improved drag-out tanks and ion exchange, can be employed economically, especially in the larger

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33 Many of these measures focus on ensuring that as much of the metal finish is applied to the part as possible, and as little as possible is lost as parts are taken out of the plating bath.

34 Personal conversation, Jack Eisenhauer, Energetic, Columbia, MD, June, 1993.

35 Department of Energy, LOS Alamos National Laboratory, *Electroplating Waste Minimization,* paper presented at the Office of Industrial Technologies Industrial Waste Reduction Program Review, Washington DC, May 21, 1992,

36 For example, a Sara Lee plant reprogrammed its process control computers to reduce water use 65 percent, and in SO doing avoided installation of a $5 million pretreatment system. (Discussion with Roy Carawan, North Carolina State University, Department of Agriculture, March, 1993.)

37 John A Vaccari, "Ultrasonic Cleaning With Aqueous Detergents, " *American Machinist,* April 1993, pp. 41-42.

operations.[38] More efficient process controls can reduce variations in industrial processes, leading to reduced emissions.

Fundamental Process Modifications, Requiring New Technologies

Strategies involving more fundamental process technology modifications, many requiring technological innovation, can be employed. Many of these approaches to waste reduction are still underused and are just now being explored. However, as simpler steps for pollution prevention become widely adopted, a significant source of environmental improvement will lie in new generations of manufacturing process technologies that are cleaner, and often more productive, than older generations. In addition, many of the innovative clean technologies in the process industries to date have focused on individual processes, whereas process industries are a complex web of interconnected processes. Making each individual process as clean as possible may not be as effective as finding the collection of processes that could make an entire industry cleaner.

Process modifications are usually industry-specific+ specially in industries that process raw materials into intermediate materials (e.g., chemicals, oil, rubber, pulp and paper, steel) .39 For example, new methods of pulp delignification to reduce chlorine bleaching are specific to the pulp and paper industry. Similarly, developments in catalysis to produce higher chemical yields are specific to the chemical industry (see box 8-A). A number of new technologies are possible candidates to replace electroplating, including mechanical plating, physical vapor deposition, and thermal spray processes.

Water soluble flux for soldering electronic circuit boards developed by an aircraft company allows reduced use of CFC-based solvent cleaners.

Other applications may, with some modifications, be used by a number of industries, particularly fabrication and assembly industries (e.g., electronics, transportation equipment, fabricated metals). These include near-net shape metal forming,[40] laser metal cutting, alternative coating procedures (ion implantation, powder coating), better separation and filtration devices, leak-proof pumps, alternative cleaning (e.g., supercritical cleaning, no-clean soldering), and design tools, such as process simulators.[41]

Some fundamental changes in technology may reduce the need for processes that are highly polluting. For example, in the steel industry, the shift away from hot rolled ingots to automated continuous casting, followed by cold working and

[38] Ishwar K. Puri, "The Metal Finishing and Allied Industries-Issues for Pollution Prevention" (unpublished manuscript, University of Illinois, Chicago, 1993).

[39] American Petroleum Institute, *Waste Minimization in the Petroleum Industry: A Compendium of Practices* (Washington, DC: API, 1991).

[40] Noel Greis, *Waste, Energy and Raw Material Reduction Potential of Near Net Shape Metal Forming Processes* (Worcester, MA: Kinefac Corp., Nov. 15, 1991).

[41] Jack Eisenhauer and Shawna McQueen, *Environmental Considerations in Process Design and Simulation*, A Jointly Sponsored Workshop by the U.S. Environmental Protection Agency, U.S. Department of Energy, and the Center for Waste Reduction Technology, Dec. 8-9, 1992.

Box 8-A—Pollution Prevention in the Chemical Industry[1]

The U.S. chemical industry generates over $250 billion in annual sales and runs a trade surplus of $19 billion. However, the industry also generates large amounts of pollution and is the dominant source of hazardous waste in the United States. As a consequence, the chemical industry spent $4.8 billion in 1990 to control pollution and will spend increasing amounts throughout the 1990s to comply with new, tougher environmental standards.

Over 80 percent of air and water pollution abatement capital expenditures went to end-of-pipe treatment equipment. There are, however, significant opportunities to control much of the pollution through pollution prevention in all major unit operations of chemical processing, and in so doing to potentially lower compliance costs.

Storage Vessels-Methods for reducing tank bottom wastes, fugitive emissions from tanks, and residuals in shipping containers are abundant and relatively simple. Mechanical mixing or emulsifying agents can help solubilize tank bottoms and reuse the wastes. Fugitive emissions from tanks can be reduced with a number of fairly simple technologies, including floating roofs, insulated walls, and tanks that can withstand high pressures, but many of these technologies are expensive and the amount of material saved will not always cover the capital costs. Such actions as proper location of drainage valves and dedication of storage containers to specific uses can reduce emissions from shipping containers.

Piping and Valves-The most significant environmental problem associated with valves, pumps, compressors and other pipe fittings are fugitive emissions. Leak Detection and Repair (LDAR) programs can significantly cut fugitive emissions. While such programs are expensive, they can yield significant savings in material. For example, in a study of pollution prevention options at Amoco's Yorktown Virginia refinery, a quarterly leak detection program was projected to yield a 19 percent annual rate of return due to savings from reduced material loss.[2]

Reactors-Reactors are a key element in any chemical manufacturing process and are particularly important in waste generation. There are several levels of analysis to be considered in improving reactor designs, including selectivity, contamination, and vessel design. However, a particularly promising area for reactor improvements involves catalysis. For example, anew selective catalyst increased the yield of linear polypropylene (product) relative to nonlinear polypropylene (a waste), and hence reduced waste polypropylene by 90 percent. Similarly, a catalyst system developed for use in making acetaldehyde cuts chloro-organics formed by over one-hundred-fold. Controlling attrition and limiting deactivation of catalysts can also decrease wastes. Finally, integration of both reaction and distillation in a single vessel (e.g., catalytic distillation) can offer opportunities to cut waste and possibly reduce capital and operating costs. However, the development and new catalysts and reactor designs to lower wastes is still in its infancy and new reactor designs are generally only economically feasible with new plants or major retrofits.

Heat Exchangers-Heat exchangers can be a source of waste when high temperatures cause fluids to form sludges. Steam-based cleaning produces significant quantities of wastewater. Alternatives include sand blasting with dry ice or recyclable sand. In addition, use of adiabatic expanders to mix high and low pressure steam to achieve optimal heat transfer temperatures is a relatively low-cost method of minimizing waste.

Separation Equipment--Since separation units are designed to further purify products and isolate contaminants, they are by nature waste-generating, although sometimes unreacted feedstocks or

1 This box is based principally on a contractor report to OTA written by David Allen, Professor of Chemical Engineering, UCLA.

2 *Amoco-U.S. EPA pollution Prevention Project, Yorktown, Virginia. Project Summary,* June 1992, p. 3.22.

byproducts may be reused or used elsewhere. It is difficult to generalize about separation, while in some cases waste can be reduced economically, while in others it is quite expensive.

Flowsheet restructuring-Much of the focus on pollution prevention in the chemical industry has been on individual unit operations. Another set of methods for waste reduction involves completely reconfiguring the entire process flowsheet within a facility. Such dramatic process modifications are done only rarely, but they do offer significant pollution prevention potential.

Byproduct reuse-Some of the waste products from chemical processes may have other uses. For example, Arco's Los Angeles refinery sells its spent alumina catalysts to Allied Chemical and its spent silica catalysts to cement makers. These were previously characterized as hazardous wastes and disposed of in a landfill at high costs.[3] Solvent recovery also can allow solvents to be reused within the process.

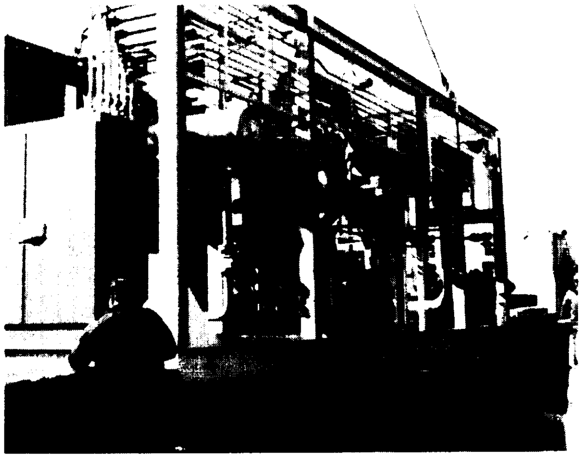
Industry-wide analysis--Selection of particular processes to make individual chemicals is quite complex and will have different energy requirements and rates of waste generation. Moreover, the selection will influence rates of waste generation in the rest of the chemical industry. For example, if methanol is produced via carbon monoxide, it maybe possible to generate carbon monoxide through partial oxidation of a material that is currently wasted. On the other hand, to convert carbon monoxide into methanol requires hydrogen, which is an energy-intensive material. There have been few system-wide analysis of the energy and environmental impacts of chemical processing to inform such choices.

Table 8A-1—Reducing Wastes From Unit Operations in Chemical Processes

	Examples of Process Modifications for Waste Reduction		
	Changes in operating practices	Currently feasible process modifications	Process modifications requiring technology development
Storage vessels	Use of mixers to reduce sludge formation	floating roof tanks, high pressure tanks, insulated tanks	Process specific changes to eliminate need for storage, particularity intermediates
Pipes and valves	Leak detection and repair programs for fugitive emissions	Leakless components	Process designs requiring the minimum number of valves and other components
Heat exchangers	Use of anti-foulants; innovative cleaning devices for heat exchanger tubes	Staged heat exchangers and use of adiabatic expanders to reduce heat exchanger temperatures	Heat exchanger networks to lower total process energy demand
Reactors	Higher selectivity through better mixing of reactants, elimination of hot and cold spots	Catalyst modifications to enhance selectivity or to prevent catalyst deactivation and attrition recycle reactors for catalyst recycling	Changes in process chemistry; integration of reactors and separate units
Separators	Reduce wastes from reboilers	Improvements in separation efficiencies	New separation devices, efficient for very dilute species

SOURCE: David Allen, "Clean Chemical Manufacturing Technologies: Current Practices and Long Term Potential ;" contractor report prepared for the Office of Technology Assessment, May 1993.

3 Robert A. Frosch and Nicholas E. Gallapoulos, "Strategies for Manufacturing," *Scientific American*, September 1989, p. 144-152.



U.S. DEPARTMENT OF ENERGY

Brayton cycle heat pumps allow recovery of solvents and energy from industrial processes. DOE's Office of Industrial Technology supports development of this technology.

atmospheric annealing, significantly reduces both the quantity of scale left on the steel's surface, and the amount of acid needed for pickling. Over the long term, it is quite possible that technology will allow metal goods to be manufactured in such a way that the surface does not require separate finishing, eliminating much metal finishing and the pollutants it generates. If technically and economically feasible, direct steel making will eliminate the highly polluting coke process.

Some technological changes are unlikely to occur in the near future, but hold significant promise. For example, the design and operation of bleached kraft pulp mills without any aqueous effluent, except clean cooling water, is a realistic goal.[42] However, little research is being done on this. Other possibilities may emerge in the longer term, such as developing plastics with built-in catalysts allowing them to be broken down into their constituent chemical components and recycled.

External Recycling

In the last two decades, businesses have made greater efforts to deal with wastes. However, these efforts have been highly atomistic, with little interfirm or interindustry coordination in the area of materials and waste management, and with little consideration of wastes and products at the ends of their useful lives as potentially useful inputs to some other industrial process.[43]

The term 'industrial ecology' refers in part, to the better use of waste and materials among firms.[44] Increasing the rate of recycle and reuse is normally more economical than treatment, and, even pollution prevention in some cases. Moreover, with regard to materials use, exchange of waste products among firms may prove more efficient than source reduction. optimizing an individual plant with respect to waste reduction may be less efficient than optimizing the industrial system with respect to that material.[45]

Similarly, it may sometimes be cheaper to treat pollutants centrally than to install treatment or waste reduction technologies in the individual plants (see box 8-B) For example, when publicly operated treatment works (POTWs) have excess capacity, it maybe cheaper to have them treat and dispose of some industrial wastes than have the individual firms pre-treat their wastes.

There are several sources of savings from recycling. First, firms generating these materials no longer have to pay for their treatment or disposal. Second, and perhaps more important, use of processed materials can generate less

42 McCubbin, op. cit.

43 Robert A. Frosch, "Industrial Ecology: A Philosophical Introduction," *Proceedings of the National Academy of Science*, February 1992, p. 800.

44 C. Kumar N. Patel, "Industrial Ecology," *Proceedings of the National Academy of Science,* February 1992; also Matthew Weinberg, Gregory Eyring, Joe Raguso, and David Jensen, "Industrial Ecology: the Role of Government' *Greening Industrial Ecosystems* (Washington DC: National Academy of Engineering Press, forthcoming, 1993).

45 The Department of Energy Waste Utilization and Conversion Program focuses on these kinds of material reuses issues. (Office Of Industrial Technologies, *Waste Utilization and Conversion: Program Plan,* Washington, DC: U.S. Department of Energy, Apr. 16, 1993).

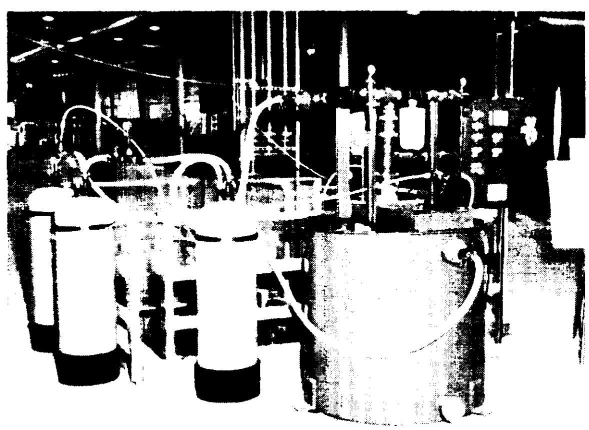
Box 8-B–External Recycling in the Metal Finishing Industry

Many wastes from metal finishing processes are too small, too low in value, or require treatment/recovery technologies too complex to be feasibly processed on-site by the generator. However, because of economies of scale, there are good opportunities to process many of these wastes at an off-site centralized plant that services numerous generators. Such a facility can extract metal and other chemicals from the wastestreams and purify them to commercial standards to produce articles of commerce. The economics of such an operation are only minimally dependent on the value of the recovered metal or chemical. Rather, the primary factor making such a central processing plant economically feasible is the cost to t he waste generator (monetary and on-going liability) for the disposal of waste.

Currently, there are two types of external recycling in the metal finishing industry. Some metal-bearing sludges (e.g., copper, nickel) are sent to smelters, who refine them along with other metal inputs. In a centralized facility, metal finishers segregate their waste and ship it to a facility where it is recycled and treated. in the mid-1980s, when new effluent standards were being promulgated for the metal finishing industry, several communities explored establishing centralized facilities before their metal finishing firms invested in expensive in-house treatment. However, a number of problems, perhaps most importantly an unwillingness by EPA and state regulators to support these projects in many cities,[1] has meant that only one such facility has been developed in the United States, in Minneapolis.[2] In contrast, there area number of such facilities in Japan and Europe.

While operating costs appear to be the same or slightly higher for firms that manage wastes internally versus those that use a centralized facility, the latter are able to avoid large capital expenditures for environmental equipment and instead use the capital for expanding or modernizing production equipment. In addition, they can rely on the centralized facility to professionally manage their wastes. This is especially critical for smaller shops that do not have (and cannot afford) the operation/regulatory expertise to effectively operate in-plant systems.

The economics of a centralized facility are such that it depends on fees for a significant share of revenues. Recovered chemicals and metals (e.g., copper, copper oxide, nickel carbonate) are generally a small share (1 O to 20 percent) of revenues. Recovery at such facilities is in many ways, analogous to recycling elements of municipal garbage. The feasibility of the effort depends in part on the marketability and price of the product produced. Some low value streams, such as those made of commingled metals, will not be economically recyclable, even on a very large scale, until sludge disposal rates increase significantly.



U.S. FILTER RECOVERY SERVICES, INC.

A waste recovery and treatment company places these ion exchange canisters in industries to remove waterborne hazardous wastes for further processing and recovery at its centralized facility.

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1 Stephen Basler, *Central Treatment and Recovery Facilities for the Metal Finishing Industry: A Five City Comparison,* (Chicago: Center for Neighborhood Technology, June 1989).

2 The facility is a division of U.S. Filter Corporation, Inc., and is known as U.S. Filter Recovery Systems, Inc.

pollution and requires less pollution abatement spending than the production of virgin materials. For example, pollutants generated from secondary fiber pulping using recycled paper are quite low compared to conventional bleached kraft pulp production.[46] Third, in some cases wastes of one process can be used as inputs to another. For example, Dupont found a market in the pharmaceuticals and coating industry for hexamethyleneimine, a by-product of nylon manufacturing. The market is now so strong that in 1989, Dupont had to find a way to manufacture what had formerly been a waste. Dow Chemical recovers excess hydrochloric acid, which it either reuses or sells on the open market, making a profit of $20 million annually.[47] While these examples are not the norm, it is possible to design processes that accept the wastes from other processes as inputs and produce their wastes as inputs to other processes.

Even though there are many environmental and economic advantages to both in-plant and external recycling, the regulatory framework often gives little credit to recycling. Some advocates of source reduction argue that by providing firms with the option of external recycling, they will reduce their efforts at source reduction. It is not clear the extent to which this may be true. While source reduction should be the first option examined, there do appear to be cases where external recycling is in fact cheaper.

Some types of pollution cannot yet be prevented and must be treated or disposed of. Some prevention solutions may be relatively risky or unstable under different operating conditions. And some end-of-pipe (EOP) controls allow manufacturers more flexibility in production. As a result, there is always likely to be a need for EOP treatment and disposal of pollutants and wastes. Because of this, and because current EOP technologies are often expensive, advances in EOP technologies are still necessary, particularly for those that lower cost and improve performance (see ch. 10).

FACTORS LIMITING THE ADOPTION OF POLLUTION PREVENTION

To adopt pollution prevention options, firms must first find opportunities, identify solutions, and then authorize and implement them.[48] Because there can be impediments at each of these stages, there are a number of reasons why U.S. manufacturing firms have not made greater strides in pollution prevention[49] (see table 8-5). Not all firms will face the same impediments, which can differ by industry, firm size, and management practices.

Finding Opportunities

Pollution prevention is strongly influenced by the regulatory system. Regulation creates incentives by imposing a cost on polluting, which firms can possibly reduce through pollution prevention. Some regulations, such as the Toxic Release Inventory reporting requirements, focus public attention on emissions and provide an incentive for reduction, particularly the relatively easy-to-

46 Waste paper plants typically produce BOD in the range of 5-10 kg. per metric ton and no organochlorines, and use few chemicals as compared to typical bleached kraft mill, which produces 20 to 50 kg of BOD per metric ton and some organochlorines. (McCubbin, op. cit.)

47 Frosch and Gallapoulos, Op. cit.

48 Peter Cebon, ''Organizational Behavior as a Key Element in Waste Management Decision Making,*The Environmental Challenges of the 1990s* (Washington, DC: Environmental Protection Agency, 1990).

49 Many of the reasons are similar to those found for not implementing cost-efficient energy conservation measures in industry. See, for example, James R. Ross, "Energy Conservation in Sewn Products Plants," paper presented at the 1979 American Institute of Industrial Engineers annual conference; also Peter Cebon "High Performance Industrial Energy Conservation: A Case Study' Kurt Fischer and Johan Schot (eds.) *The Greening of Industry* (Washington DC: Island Press, 1993).

50 The recent changes in TRI reporting, where emissions are reported even if they are treated, will most likely push pollution prevention even more.

Table 8-5-Barriers to Pollution Prevention

Barrier	Decision process affected: Identify opportunities	Identify solutions	Implement solutions
Informational			
Lack of knowledge of wastes	x	—	—
Bias toward end-of-pipe (EOP)	x	—	—
Lack of knowledge of alternatives	—	x	—
Equipment vendors focused on EOP	—	x	—
Environmental managers focused on EOP	—	x	—
Organizational			
Environmental managers may not fully understand production processes	x	—	—
Individuals may not be rewarded for pollution prevention	x	x	—
Worker involvement may be limited	x	x	—
Buyer process specifications may hinder pollution prevention	—	—	x
Technological			
Appropriate technologies may not be available	—	x	—
Existing solutions may negatively affect process or product	—	x	—
Regulatory			
Firms have hands full with compliance	x	x	—
Regulatory definitions of waste limit efforts	—	—	x
Regulatory enforcement patterns may raise risks of trying innovative solutions	—	—	x
Regulations may require EOP solutions or mandate certain sources be controlled	—	—	x
Regulations provide few incentives for going below the standard	—	—	x
Accounting			
Firms may not measure solutions' costs/benefits	—	—	x
Firms may incorrectly measure costs/benefits	—	—	x
Financial practices			
Existing discretionary funds may go to EOP regulatory projects	—	—	x
Firms may not invest in all profitable projects	—	—	x
Corporate hurdle rates may be too high	—	—	x
Plant investment may not be fully amortized	—	—	x
Some industries may grow slowly with low investment rates	—	—	x

SOURCE: Office of Technology Assessment, 1993.

reduce emissions.[50] Similarly, Superfund liability provisions encourage firms to reduce, rather than treat, emissions.[51] However, incentives may not be directed at the most appropriate people or departments within a firm.[52]

Moreover, while the regulatory system as a whole provides an incentive for pollution prevention, certain aspects of the current system dampen this incentive, and in some cases provide a disincentive. An important barrier to pollution prevention is the single-media, command-and-control focus of the regulatory system.[53] The single-media statutory directives, rules, and reward systems for EPA personnel reinforce pollu-

51 However, it is important to note that pollution prevention options inspired by these provisions may not always be the most economically rational.

52 OTA, *Serious Reduction of Hazardous Waste,* op. cit., p. 5.

53 National Commission on the Environment, Choosing a *Sustainable Future* (Washington, DC: Island Press, 1993).

tion control efforts, and provide only token incentives for actively pursuing pollution prevention.[54] While EPA top management has promoted pollution prevention, translating this initiative into action by middle managers has proven more difficult. Moreover, EPA funding is geared toward end-of-pipe, not prevention, programs. Firms are often too busy responding to single-media or end-of-pipe regulatory requirements to devote much attention to prevention.

Many firms are unaware of pollution prevention opportunities or their relative merits over end-of-pipe solutions.[55] Small and medium-sized firms seldom analyze their wastes streams to identify prevention opportunities. Moreover, many firms lack the time and inclination to make their way through the complex regulatory maze in order to identify what is and isn't allowed.

Finding Solutions

In contrast to end-of-pipe treatment, which can be applied without specific operational knowledge of the production process, pollution prevention requires those with intimate understanding of the production process—line workers, managers, and engineers-to contribute their knowledge. However, responsibility for finding pollution prevention solutions may not rest with those most capable of doing so.[56] The tendency of organizations to allocate responsibility for pollution prevention to a few agents in the organization is a common source of many barriers. For example, most plant managers are rewarded for getting product out the door, not for reducing waste. As a result, they may oppose prevention solutions for fear they will divert resources from production projects. Production supervisors may fear that pollution prevention will negatively affect product quality or create interruptions. Engineers may see prevention as diverting them from more interesting and valued work. Production line workers may not be rewarded for initiating prevention solutions, and management may ignore solutions generated. Moreover, buyer specifications may require the use of certain processes, making shifts to pollution prevention difficult.[57] Most environmental managers have been trained in end-of-pipe practices and thus may overlook opportunities for prevention.

Organizational structures can also impede pollution prevention. Environmental management is often the responsibility of a separate department that is physically and strategically peripheral to the production organization. Cross-departmental communication may then be impeded by the physical isolation of the environmental personnel, or by their low status and authority .58

Even when all levels of the organization are involved, many firms, particularly small and medium-sized firms and relatively autonomous branch plants of large corporations, may either lack the knowledge of technical alternatives or not possess the engineering expertise needed to redesign processes. For example, a survey of Wisconsin hazardous waste generators found that insufficient information about how to reduce waste successfully was a significant barrier to

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54 The National Advisory Council for Environmental Policy and Technology, *Transforming Environmental permitting and Compliance Policies to Promote Pollution Prevention* (Washington DC: U.S. Environmental Protection Agency, Office of the Administrator, February 1993), p. 25.

55 For example, see *Industry Survey 92: Barriers to Pollution Prevention* (Baton Rouge, LA: Louisiana Department Of Environmental Quality, 1992); also "Response to Questions for Top Hazardous Waste Generators and TRI Releasers" (Austin: Texas Water Commission, Task Force 21, Nov. 5, 1991).

56 For example, see Manik Roy, "Pollution Prevention, Organizational Culture, and Social Learning," *Environment/ Law*, vol. 22, No. 149.

57 For example, both military specifications from DoD, as well as specifications from large corporate buyers or sellers, can be inflexible.

58 Andrew King, " Cooperative Learning Between Pollution Control and Process Engineering Departments in tbe Printed Circuit Fabrication Industry, " op. cit.

further waste reduction.[59] Moreover, firms may doubt that pollution prevention opportunities or technologies exist.

To overcome this, some fins, particularly small and medium-sized ones, tend to rely on vendors or consultants for information about pollution prevention. Anecdotal evidence suggests that these may steer companies away from prevention in favor of more generic end-of-pipe equipment. This may in part be due to the fact that most environmental consulting, focuses on end-of-pipe treatment, while most environmental equipment vendors sell end-of-pipe equipment.[60]

Finally, many firms overlook sources of savings such as energy reduction and pollution prevention, reorientation of materials flow, reduced inventory, and improved quality, in favor of either increased output or direct cost reductions related to production.[61] This may be because they believe that their core production process is already efficient. While top level management might understand the importance of profit maximization, operating managers often emphasize output maximization, making it hard for them to give priority to pollution prevention investments when other matters occupy most of their attention. Investments in these cost-saving activities are often seen as tying up capital that could be used for other things, including expanding output. Moreover, because pollution prevention projects offer high levels of risk and low rewards for decisionmakers (if they succeed the process continues as usual, but if they fail the managers can get in trouble), managers will often not make the change.

As discussed in chapter 9, regulations require strict compliance with a standard and seldom provide firms with innovation waivers or tradable pollution allowances for implementing pollution prevention solutions that almost attain the standard. Moreover, because pollution prevention solutions, particularly those based on more complicated process redesign, can take a long time to develop, and because regulations often give firms short lead times to meet regulatory requirements, firms often invest in end-of-pipe.

Finally, some prevention solutions may be relatively risky, particularly with new projects. In addition, some end-of-pipe controls allow manufacturers more flexibility in production. For example, the Saturn automobile plant installed a state-of-the-art carbon adsorption unit, which gives them the ability to use many types of coatings on the car, including those with higher VOC content.

Authorizing and Implementing Solutions

Once managers identify and design pollution prevention solutions, firms must still authorize their implementation and provide resources. Top management commitment is important in implementing pollution prevention.[62] One reason why the chemical industry has more aggressively adopted pollution prevention practices is that top management has made it a priority. Likewise, studies have shown that when educated and provided with organization position and effective technology, environmental managers can be pow-

59 *Reducing Hazardous Waste In Wisconsin, Report V: Barriers and Incentives to Hazardous Waste Reduction* (Madison: Bureau of Research, Wisconsin Department of Natural Resources, August 1992).

60 "WC Firms Position For Prevention, " *Environmental Business Journal,* vol. 6, No. 8, August 1993.

61 OTA, *Industrial Energy Efficiency,* op. cit. Also, B. William Riall, "Nontraditional Equipment Justification Methods and Their Applicability to the Apparel Industry," prepared for The U.S. Defense Logistics Agency, November, 1988.

62 "Preventing Pollution: Focus on Organization and Management, " Technology, Business and Environment Program, MIT, September, 1991; also Robert Bringer and David Benforado, "Pollution Prevention as Corporate Policy: A Look at the 3M Experience, " 1989, pp. 117-126.

erful advocates for pollution prevention.[63] Notwithstanding, there are still a number of impediments to implementing solutions.

REGULATORY BARRIERS

The characteristics of the current regulatory system may encourage companies to control pollution from specific sources (e.g., boilers) with end-of-pipe reference technology. As a result, firms may have little incentive to reduce pollution from other sources that might be less stringently regulated or to use pollution prevention to reduce releases below the regulatory standard. Moreover, because end-of-pipe controls are often the defacto standard, firms choose the path of least resistance and install these, rather than pursue prevention. While permit writers normally understand generic control technologies, they often do not adequately understand industrial processes and pollution prevention techniques.[64]

CAPITAL ACCOUNTING

Economic theory holds that managers of an enterprise will attempt to optimize production to maximize profits.[65] Wastes, as one of several cost factors, should be treated in a fashion in which marginal investments are made in pollution prevention until the point where marginal returns on investments in other areas are higher. However, others argue that in practice, projects yielding competitive paybacks are routinely ignored. There are several reasons postulated for this.

First, a large proportion of firms do not conduct discounted cash flow analysis on all investment projects, particularly for pollution prevention investments often seen as mandatory environmental projects that historically cost the firm money.[66] Another barrier is that many firms use simple payback measures, even though the former count against pollution prevention projects that normally have longer term benefits.[67]

Second, conventional discounted cash flow methods can underestimate the benefits of pollution prevention projects. These benefits can include reduced waste disposal costs, regulatory compliance costs, insurance and liability costs, and improved public image. One problem in demonstrating the cost advantage of pollution prevention investments is the inability of some fins' accounting practices to allocate end-of-pipe costs to specific product lines or processes. Moreover, firms can underestimate labor savings from pollution prevention.

There have been several efforts made to develop better accounting practices to credit for the full cost of pollution. Referred to as Total Cost Accounting (TCA), such methods attempt to include all costs including direct capital and operating costs, indirect or hidden costs (e.g.,

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63 Andrew King, "Innovation From Differentiation: Environmental Departments and Innovation in the Printed *Circuit* Industry, " in *International Product Development Management Conference on New Approaches to Development and Engineering (Brussels,* Belgium: EIASM, 1992).

64 Regulations from other agencies can hinder pollution prevention. For example, pharmaceutical firms must receive regulatory approval from the Food and Drug Administration to change their processes.

65 Adam B. Jaffe and Robert N. Stavins, ' 'The Energy Paradox and the Diffusion of Conservation Technology,' (draft), Harvard University, unpublished manuscript, Feb. 12, 1993.

66 For example, 'Amoco's project evaluation approach has usually viewed environmental projects in the limited context of meeting specific regulatory requirements within a freed timeframe. ' *Amoco-U.S. EPA Pollution Prevention Project, Yorktown, Virginia. Project Summary* (jointly published by Amoco Corp., Chicago, IL, and U.S. Environmental Protection Agency, Washington, DC: June 1992). See also Allen L. White, Monica Becker, and James Goldstein, *Alternative Approaches to the Financial Evaluation of Industrial Pollution Prevention Investments,* prepared for the New Jersey Department of Environmental Protection, Division of Science and Research, November 1991, p. 20.

67 Ross feud that for small energy conservation projects financial analysis is usually relatively simple and is supplemented by informal adjustments. The result is that for many firms only the most profitable small projects are undertaken. Marc Ross, "Energy-Conservation Investment Practices of Large Manufacturers,'' in *The Energy Industries in Transition, 1985-2000, Part 2,* edited by John P. Weyant and Dorothy B. Sheffield, Washington, DC: The International Association of Energy Economists, 1984.

compliance costs, insurance, on-site waste management, operation of pollution control equipment), future liability (penalties and fines and payments due to personal injury and property damage), and less tangible benefits (e.g., revenue from enhanced company image).[68] Some costs are difficult if not impossible to quantify, such as improved company image or reduced liability. However, excluding them completely from cost analysis unfairly disadvantages pollution prevention projects.

Case studies applying TCA suggest that in some cases, TCA analysis can improve the internal rate of return of pollution prevention projects to make them competitive with alternative investments. In addition, as an accounting method that leads firms to more accurately measure and assign costs and savings, TCA is consistent with other improved accounting methods, such as activity-based accounting[69] and full-cost accounting,[70] that have been advocated for helping firms make more rational decisions regarding investments generally.[71] However, preparing a TCA analysis can involve considerable effort, limiting its use to larger firms implementing projects with considerable costs and savings.

INVESTMENT PRACTICES

Even if firms accurately measure costs and benefits of pollution prevention investments, capital accounting practices and capital availability may limit the adoption of even profitable pollution prevention projects. Many small and medium-sized firms find it difficult to get financing for pollution prevention projects, in part because banks may not understand the projects and view them as not generating a cash flow. Many larger firms prefer to fund small capital projects (like pollution prevention) from retained earnings, in part to preserve credit ratings. Moreover, large firms often adopt capital rationing systems where divisions and plants are given limited amounts of capital for small projects, regardless of how many profitable projects they have.[72]

Even without capital rationing, small projects are commonly subject to more stringent hurdle rates. The result of both practices is that much less discretionary spending is undertaken than would be justified by conventional analysis. In such circumstances, waste reduction projects (characterized by a high number of small-scale investments) with rates of return higher than the corporate cost of capital may not be funded if other projects have even higher rates of return. Moreover, because waste reduction projects are optional and are often proposed by low-status environmental managers, they are more likely to lose out.[73]

This lack of assertiveness in investing in positive pollution prevention projects may be part of a larger pattern of lack of investment in a wider range of productivity-enhancing technologies. The problems in funding profitable pollution prevention (and energy conservation) projects may be symptomatic of deeper problems in U.S.

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68 White, Becker, and Goldstein, op. cit.; the Northeast Waste Management Officials' Association in conjunction with the Massachusetts Office of Technical Assistance have also developed a manual for TCA, *Costing and Financial Analysis of Pollution Prevention Projects.*

69 Robin Cooper, "Implementing an Activity-Based Cost System,' *Cost Management,* spring 1990, pp. 33-42.

70 Full cost accounting assigns all costs to specific processes or product lines. TCA is concerned with both this more accurate allocation of costs as well as the expansion of cost items beyond traditional concerns. (White, Becker, Goldstein, op. cit.)

71 For example, many argue that conventional accounting methods do a poor job of accurately measuring the savings from implementation of flexible automated production equipment. See R.H. Hayes and R. Jakumar, "Manufacturing Crisis: New Technologies, Obsolete Organizations,' *HarvardBusiness Review,* September-October 1988; also B. William Riall, op. cit.; also Robert A Howell and Stephen Soucy, *Factory 2000+ Management Accounting's Changing Role* (Montvale, NJ: National Association of Accountants, 1988).

72 Marc Ross, "Capital Budgeting Practices of Twelve Large Manufacturers, " *Financial Management,* winter 1986.

73 John Erhenfeld, "Technology and The Environment: A Map or a Mobius Strip, " paper presented at the World Resources Institute Symposium, "Toward 2000: Environment Technology, and the New Century, " Annapolis, MD, June 13-15, 1990.

business financing that lead U.S. firms to underinvest in the assets and capabilities required for competitiveness (e.g., projects with moderate-term paybacks in energy, technology, training, and productivity).[74]

SOCIAL BENEFITS

When firms do invest in pollution prevention, there is evidence that expected corporate rates of return eliminate some of projects that would be justified from a societal perspective because of the external costs of pollution. Ross estimates that if firms applied a longer time horizon to investments (a lower capital recovery rate of 16 percent, instead of the current rate of 33 percent) that energy conservation measures would result in consumption of approximately 20 percent less energy.[75] Similar pollution prevention projects also appear to be overlooked.[76] If this is true, the optimal investment practices of companies will not maximize societal welfare. High hurdle rates are often a hedge against high risk, yet pollution prevention investments often have low risks, possibly deserving lower hurdle rates.

INVESTMENT CYCLES

Finally, some firms and industries do not invest heavily. Some managers are more cautious, focused principally on survival; others aggressively seek out innovation and new investment. Some industries with mature markets and equipment and low profits (e.g., metal finishing) invest less in new facilities, so adding on new environmental equipment is harder. In addition, the recession has further diminished new investments in pollution prevention equipment.

One reason for slow implementation, particularly in the more capital-intensive process industries, is that many firms have large investments in fixed capital. Firms may wait until the capital equipment nears the end of its useful life (sometimes as long as 40 years) before investing in newer, cleaner processes. Moreover, in many industries most firms have invested in pollution control facilities. For example, virtually every metal finishing firm in the United States has a functioning wastewater discharge system.[77] In the absence of new regulations, equipment replacement, or addition of new production facilities, it often makes little sense for firms to invest in new pollution control equipment.

POLLUTION PREVENTION TECHNOLOGY DEVELOPMENT

Considerable gains in pollution prevention are possible through wider deployment of existing technology. Greater gains are possible through development of new technologies. These environmentally preferable process technologies exist or could be developed in all manufacturing sectors, and hence may be critical to U.S. manufacturing competitiveness in an environmentally constrained world.[78]

Only a small share of environmental R&D is for pollution prevention technology development. Of the estimated 1.7 billion dollars the Federal Government spent in 1992 on environmental technology R&D, less than 4 percent ($70

[74] Council on Competitiveness and Harvard Business School, *Capital Choices: Changing the Way America Invests in Industry* (Washington DC: Council on Competitiveness, June 1992).

[75] For most government projects, OMB requires a real discount rate of 10 percent, while EPA requires a real discount rate of 5 percent for evaluating projects under its jurisdiction. Steven R. Booth, Linda K. Trocki, and Laura Bowling (Los Alamos National Laboratory), "A Standard Methodology for Cost Effectiveness of New Environmental Technologies," paper presented at the Hazardous Materials Management Conference and Exhibition Atlanta, Georgia, Oct. 2-4, 1991.

[76] For example, in the Amoco oil refinery at Yorktown, Virginia, 2 of 11 pollution prevention projects had rates of return greater than 10 percent. (Amoco/U.S. EPA, op. cit.)

[77] F.A. Steward, op. cit.

[78] George Heaton, Robert Repetto, and Rodney Sobin, *Transforming Technology: An Agenda for Environmentally Sustainable Growth in the 21st Century* (Washington, DC: World Resources Institute, April 1991).

million) went to pollution prevention R&D. Academic research patterns are similar. A survey of 38 academic research organizations in the United States involved in hazardous waste management found that only 28 of 529 projects could be described as pollution prevention.[79] Moreover, little of the pollution prevention research focuses on the fundamental changes in manufacturing processes and methods that may be required to meet long-term goals for environmental improvement at lower cost.

Pollution prevention R&D needs tend to be poorly defined; if defined, they are only now being acted on. The chemical industry has made perhaps the greatest effort to identify R&D needs. The Center for Waste Reduction Technologies developed a list of R&D needs related to chemical process industries.[80] Extensive research will be necessary to fully exploit pollution prevention opportunities.

As the importance of in-plant measures increases, environmental R&D will need to be better integrated into the ongoing R&D of industrial materials and capital goods suppliers. In addition to helping U.S. manufacturers produce more cleanly and cheaply, this R&D can stimulate economic growth by making the capital goods sector more competitive internationally, selling ''green' machinery and equipment.

Two kinds of R&D will be needed to further pollution prevention technology. The first is more basic research, particularly into chemical processes and reactions.[81] The second need is for more applied research in new industrial processes in two areas: infrastructural or generic technologies, where industry tends to underinvest because no one company can appropriate the full economic benefits (e.g., environmentally benign cutting fluids); and strategic environmental R&D, where business risks and financial constraints combine to slow the development of technologies important to environmental performance and industrial competitiveness (e.g., direct steelmaking, effluent-free pulp mills). Public and private R&D on environmental technology, including pollution prevention, is discussed in chapter 10.

TECHNICAL ASSISTANCE FOR POLLUTION PREVENTION AND ENVIRONMENTAL COMPLIANCE

Widespread diffusion of existing off-the-shelf technologies and management and process technology changes will go a long way to reducing pollution. However, many firms, particularly small and medium-sized ones, are not aware of these measures.[82] Technical assistance can help these firms identify and implement pollution prevention measures. Yet existing programs are small. By focusing only on prevention, most programs fail to develop synergies and working relationships with manufacturers that could contribute to pollution prevention and increased manufacturing competitiveness.

Government Pollution Prevention Technical Assistance Programs

Most States and a few localities have programs that provide information and direct technical assistance to firms on how to reduce pollution, The Federal Government provides a small amount of funding and technical support to these programs.

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79 New York State Center for Hazardous Waste Management, *Research and Development in Hazardous Waste Management* (Buffalo, NY: State University of New York, 1990).

80 Energetic he., *Report on the CWRT Workshop on: Waste Reduction R&D Opportunities in Industry* (Washington, DC: U.S. Department of Energy, Office of Industrial Technologies, September 1991).

81 These areas include understanding the chemical reaction processes at the molecular level, including advances in reaction engineering, thermodynamic modeling, and particulate formation. Other important technological areas include catalysis and reaction path selectivity, particle technology, process synthesis, and recycle theory. (Allen, op. cit.)

82 OTA *Serious Reduction of Hazardous Waste*, op. cit., p. 33.

STATE AND LOCAL PROGRAMS

Nearly all States have programs to help industry prevent pollution.[83] In addition, a number of localities, including at least 10 in California, have established pollution prevention programs. Most programs offer a variety of services, including information and referrals on State and Federal regulations and pollution prevention opportunities, including case studies, reports, and journals. Many have developed waste reduction manuals for particular industries, such as metal finishing, printing, etc. Programs also conduct seminars, workshops, and mailings to inform industry of opportunities for waste reduction. Finally, most programs provide some technical assistance to industry, either through telephone consultation or on-site visits. The latter often takes the form of detailed waste audits to help firms identify pollution prevention opportunities. These audits are often conducted by full-time program staff, but many programs also employ part-time retired engineers to conduct audits.

EPA EFFORTS

EPA supports State and local technical assistance through the Pollution Prevention Incentives for the States program (funding of $8 million in fiscal year 1994). EPA provides a small amount of funding for three hazardous waste minimization assessment centers located at universities in Colorado, Tennessee, and Kentucky. EPA also maintains a clearinghouse. Finally, EPA's Risk Reduction Laboratory Pollution Prevention Research Branch publishes manuals, fact sheets, and waste audit guides. EPA also offers indirect assistance by providing some flexibility in media-specific State grants for pollution prevention work.[84]

Limitations of Current Efforts

These pollution prevention efforts, while helpful, have significant limitations.

SMALL SIZE

In comparison to the need, State and local pollution prevention programs are very small with the average State program having three to four fill-time staff.[85] (e.g., Los Angeles' pollution prevention program conducted 100 on-site technical assistance visits in 1991. At that rate it would take them 200 years to reach all of the county's approximately 20,000 manufacturers.) Given the magnitude of the problem and opportunity, these programs are too small to have an appreciable impact. Moreover, the lack of funds has meant an emphasis on technical assistance, with relatively little going to applied R&D and demonstration and testing projects.

One reason programs are understaffed is that few charge fees for services, in part because they fear that their services would not be utilized and that they would be seen as unfairly competing with private sector consultants. However, this first fear may stem more from the fact that most programs do not have a long-term relationship with the manufacturing community. Among those that do, such as the Cleveland Environmental Services Program (see box 8-C), manufacturers pay a share of the cost.

These programs get little government money, because they generally receive low priority in EPA national and regional offices, as well as States, in relation to enforcement and compliance

133 For more information on State programs see: U.S. EPA, *Pollution Prevention 1991: Progress on Reducing* Industrial Pollutants, October, 1991; Robert E. Deyle, *Hazardous Waste Management in Small Business: Regulating and Assisting the Smaller Generator* (Westport, CT: Greenwood Press, 1989); and John Hodges Copple, "Strengthening State Pollution Prevention Programs" Southern Growth Policies Board, January 1990.

84 Memorandum from F. Henry Habicht II, Deputy Administer, EPA, "State Grants Guidance: Integration of Pollution Prevention," Nov. 12, 1992.

85 Leslie Scott and Renee Shatos, "Waste Reduction Technical Assistance Study," Social and Economic Sciences Research Center, Washington State University, spring 1991.

Box 8-C-Pollution Prevention Integrated Into Existing Industrial Extension Programs

At least 28 States have established, sometimes with Federal assistance, programs to help small and medium-sized manufacturers modernize their production processes and adopt new technologies. As these programs have gained experience in serving the needs of manufacturers, many have begun to broaden the range of services they offer. Several programs, such as Tennessee's Center for Industrial Services and the Cleveland Advanced Manufacturing Program, help firms address environmental requirements, including pollution prevention.

The Center for Industrial Services (CIS), a part of the University of Tennessee, was established in the early 1960s to help firms solve technical problems related to manufacturing. In the mid-1980s, firms started asking the Center for help on addressing RCRA hazardous waste matters. The center now employs 13 full-time waste reduction staff (and 20 part-time retired engineers) in addition to its regular extension staff. Its pollution prevention program is integrated into the industrial extension program, and it hires staff with plant and process engineering backgrounds. The center's extension field agents are trained in pollution prevention so they can spot opportunities and refer firms to CIS's pollution prevention staff for further consultation, In 1992, the program claims to have saved Tennessee industry$12 million through pollution prevention.

The Environmental Services Program (ESP) is a division of the Cleveland Advanced Manufacturing Program (CAMP). The state of Ohio formed CAMP in 1984 as one of its nine Edison Technology Centers. The center, through three university affiliates, provides research, application, and training in new manufacturing technologies. In 1989, CAMP was awarded a grant from the National Institute of Standards and Technology to establish and operate the Great Lakes Manufacturing Technology Center (GLMTC), one of seven NIST-funded manufacturing technology centers. GLMTC helps manufacturing firms adopt modern technologies by providing in-depth, 1 to 5-day evaluations conducted by an experienced, technical staff of 20 individuals.

Through consultation with industry, the staff became aware that their client companies were finding compliance with environmental regulations a major problem. They came to believe that pollution prevention was a logical extension of the continuous improvement philosophy associated with the manufacturing modernization process, and that as a result, they would have a significant capacity to provide services in this area. Toward that end they formed ESP in 1990.

In some ways, the environmental program is indistinguishable from the manufacturing modernization program. Both have an assessment component with a distinct protocol. ESP conducts an initial audit of environmental compliance procedures, followed by a pollution prevention assessment with recommendations. If a firm wishes to adopt the recommendations, ESP can work with the firm on implementation, which may involve applied development work.

SOURCE: Office of Technology Assessment, 1993.

activities. When measured against the resources devoted to Superfund and hazardous waste issues, EPA efforts in pollution prevention are quite small and ad hoc. The statutory mission of EPA and State regulatory agencies is to implement national laws and as a result, these efforts receive higher priority.

LACK OF TRUST

Because many firms are inherently suspicious of working closely with regulators, the fact many State pollution prevention programs are housed in regulatory agencies means that these programs must devote much effort to convincing firms to trust them.[86] Since a key component of successful technical assistance is the establishment of trust between the service provider and the recipient, firms must feel confident that information they reveal will not be provided to regulators. Moreover, many of the programs focus on the process of pollution prevention, rather than on industry-specific technical processes and how pollution prevention fits into them.

REACTIVE POSTURE

Many programs provide assistance to any requesting firm, even facilities that emit little pollution. Moreover, programs often respond to a fro's definition of its problems, when a redefinition might be more realistic. For example, to reduce the use of CFC-based cleaning solvents, programs sometimes help firms find solvent substitutes rather than examine whether solvents are needed at all.[87] The opportunity to help firms expand their capacity to look at the production process in new ways thus may be lost.

LACK OF FOLLOW-UP

Most programs visit firms only once and provide little follow-up to help implement recommendations.[88] As a result, the success rate of these interventions is often low. In many state programs without extensive follow-up, only about one-third of the firms assisted make any changes after consultation .89

LACK OF COORDINATION

With so many Federal, State, and local pollution prevention activities, duplication of effort is a danger. Programs do not share specific information on a regular basis. In an effort to increase coordination, EPA developed its Pollution Prevention Information Clearinghouse. The Clearinghouse provides a substantial amount of information on federal, State, and local pollution prevention efforts. However, many State and local users complain that the information is overly general and out-of-date. EPA is aware of most of these criticisms and is trying to add technical case studies. However, even with these changes, passive electronic clearinghouses normally play a limited role in information dissemination and coordination.

INADEQUATE TARGETING

The majority of pollution comes from larger firms in the materials producing industries. Yet EPA and State programs have emphasized pollution prevention efforts for small and medium-sized firms in fabrication and assembly industries. The technical requirements of working with firms in materials industries (e.g., chemicals, steel) is much greater but State programs cannot gain this level of expertise easily. One reason for targeting small and medium-sized firms is the belief that large firms have the technical and financial resources to support pollution prevention efforts, while small and medium-sized firms do not. However, large fins, particularly in some branch plant operations, are not as strong in prevention as these programs may believe.

86 One survey of State pollution prevention programs reported that 10 of 11 programs indicated that they felt business was hesitant to seek assistance from them because of their location in a regulatory agency. Washington State University, op. cit. Similar comments have been reported about the OSHA consultation program, which often has difficulty working with firms since technical assistance providers working with the fii cannot guarantee that they will not report OSHA violations.

87 Robert B. Pojasek, ' 'Is Your Quest for Solvent Substitutes Preventing You From Evaluating Other Options, " *Pollution Prevention Review* winter 1991/92.

88 Robert B. Pojasek and Lawrence J. Cali, "Contrasting Approaches to Pollution Prevention Auditing," *Pollution Prevention Review,* summer 1991.

89 For example, Rhode Island found that one-third of the firms it assisted made changes. Similarly, about One-third Of the firms assisted in the Blackstone Project in Massachusetts made changes. In Florida, about 40 percent of the firms made changes, Washington State University, op. cit., 1991.

FRAGMENTED SERVICES

In many States, more than one program provides pollution prevention technical assistance; some specialize in different kinds of waste (e.g., air, water, hazardous waste). EPA's own efforts contribute to this duplication, as evidenced by a recent EPA proposal to create a separate hazardous waste extension service. The new State technical assistance programs mandated in the Clean Air Act will add to the proliferation of assistance efforts by creating new programs aimed solely at air pollution, although some States are trying to avoid duplication of effort.

In addition to multiple pollution prevention programs, other government programs also aim to modernize production processes. In fact, at least three emerged before the interest in pollution prevention. In the 1970s, State and Federal Governments established programs to help manufacturers save energy, including adopting energy-efficient process technologies and modification of existing process and practices. In the absence of a visible energy crises, government funding for these programs declined, but funding by utilities has increased. In the mid-1980s, partly in response to the increased competitive threat to U.S. manufacturing, States and the Federal Government established programs to help manufacturers modernize their production processes. Some States also assist firms with training workers, especially when adopting new technologies or work practices. Funding for these programs is increasing. Finally, in the area of worker health and safety, OSHA funds State technical assistance programs to help manufacturers develop safer work practices.

Methods for providing technical assistance to small manufacturers for energy conservation, boosting productivity, improving safety and health, and reducing waste are similar.[90] All four activities focus on the manufacturing process. Much of the work involves convincing companies of the merit of change. Each area involves assessment, often usually using a standard protocol. The best approaches generate worker input and involvement, provide workforce training, focus on continuous improvement, and address both fundamental and incremental changes.

In spite of the considerable similarities in functions, these services are almost always provided by separate programs with little or no coordination.[91] These programs remain separate in large part because neither the various Federal Government departments nor the States think of them as part of an overall manufacturing strategy. Instead, they see each program as serving a specific government objective-+. g., energy conservation, environmental protection, or job retention.

This fragmented approach causes several problems. Separate programs make it hard for industry to turn to one source for technical assistance and makes it hard for programs to market their services to industry. Moreover, it becomes more difficult for programs to establish the *long-term* working relationships so important to instituting both pollution prevention and manufacturing modernization as a continuous process. Perhaps most importantly, single issue programs may fail to identify and promote cross-cutting solutions that promote more than one goal.

Pollution Prevention Built Into Comprehensive Industrial Service Organizations

Because of the similarity in process, and because of the significant advantages of combining industrial services in one organization, one

90 Kitty Weisman, David Harrison, and Alice Shorett, *Taming the Toxic Threat: Strategies To Reduce Hazardous Waste Generation in the Northwest* (Pacific Northwest Policy Center of the University of Washington, September 1990).

91 OTA interviewed several State pollution prevention officials who were not aware of manufacturing modernization technical assistance programs m their States, even though there was considerable similarity of function and potential for coordination. While many of the manufacturing modernization officials knew of the pollution prevention programs, none of them had contact with them.

TENNESSEE CENTER FOR INDUSTRIAL SERVICES

Waste minimization engineer from the University of Tennessee works with an equipment manufacturer's environmental coordinator and operator to reduce waste from a cleaning tank.

option for increasing the effectiveness of existing State pollution prevention programs would be to combine them with existing industry extension programs. These programs can have several advantages. First, many already have existing relationships with industry to help them solve technical and management problems. Second, this relationship can serve as the means by which other problems, including pollution prevention and environmental control, are addressed. Finally, these programs can bring firms together into cooperative networks to collectively solve environmental problems.

Sectoral and Industrial Network Approaches to Pollution Prevention

While industrial service organizations might provide pollution prevention services more effectively, most organizations still provide services to one firm at a time. Hence, meaningful ways of reaching out to more firms are still necessary. Several approaches can extend the range of these programs.

First, some programs have developed manufacturing net works to help firms cooperate in providing common services, such as training, joint bidding on contracts, joint purchasing, and common facilities and equipment. The area of pollution prevention is ideally suited for network cooperation. Firms in the same industry or same process can benefit from joint R&D, share solutions to reducing waste, and even exchange waste. A few networks have begun to address environmental problems. For example, Massachusetts' Center for Applied Technology convened a group of 6 firms involved in metal stamping, ranging from Gillette to a small firm with 20 employees, to examine the issue of lubricant replacement. Their goal is to identify a set of lubricants that optimize tool performance yet are environmentally preferable. Another example is the Pennsylvania Foundryman's network, which has developed a jointly owned corporation that runs a landfill for foundry sand contaminated with heavy metals, and is exploring pollution prevention solutions.

Firm networks can also be the basis of local industrial ecologies where the wastes of one firm become the inputs of another. In the United States this practice is facilitated by a number of formal waste exchanges. For example, the Northeast Waste Exchange in Syracuse, New York helps firms with wastes identify other firms that might want to use these wastes as useful inputs to their production process. However, while these programs are helpful, they essentially rely on passive information sharing-in a sense, waste want ads. More effective approaches are those that actively try to match fins. (See ch. 1 for a discussion of an innovative local waste network in Denmark.)

Second, there are economies of scale from focusing on the technological needs of firms in the same industry. Moreover, many of the technological issues in pollution prevention are unique to particular industries. As a result, sectorally based centers might provide a focus for pollution prevention.

These sectoral approaches are more common in Europe. For example, the Centro Ceramico in Bologna, Italy helps its members solve environmental problems. The Center is a research/ industrial services center funded by the 500 ceramics firms in the Bologna area that account of 70 percent of Italian ceramics production and 30 to 40 percent of the world market. The center conducts research aimed at quantifying the environmental impact of ceramic processes and to develop clean ceramic production technologies and technologies for sludge and residue reuse. In addition, the center works one-on-one with member firms to measure and reduce releases, solve individual plant problems, and help them come into compliance. It has developed close cooperative relationships with the local and national environmental regulatory agencies. The center also provides research and technical assistance to help firms reduce energy consumption, develop new materials and products, and put in place more efficient processes.

Most technical assistance in the United States is organized on a regional, rather than sectoral, basis. However, some sectorally based efforts may be emerging. For example, North Carolina State University Agricultural Extension program recently organized a meeting of the environmental managers of the major food processing firms in the nation to identify common problems and needs and discuss how a environmental food processing center could help solve them. There may be opportunities for such sectorally based centers are developed in a number of industries, including chemicals, lumber and wood processing, petroleum refining, pulp and paper, and steel.

Other Approaches to Technical Assistance

Even if existing government technical assistance programs are improved, other approaches to encourage adoption of pollution prevention practices will still be necessary. There are three major nonregulatory approaches: integrating technical assistance into the permitting and inspection process, using government procurement to stimulate pollution prevention, and encouraging private sector pollution prevention technical assistance efforts.

INTEGRATE TECHNICAL ASSISTANCE INTO THE PERMITTING AND INSPECTION PROCESS

State and Federal environmental permit writers and inspectors visit manufacturing plants routinely; some might be able to provide basic technical assistance. For example, the State of Maine is interested in having its inspectors promote pollution prevention and has approached EPA for guidance.

There are, however, several institutional barriers to this. First, in the past, some regulatory agencies, particularly EPA, have not actively supported combining enforcement and assistance roles. If State inspectors visited sites to provide technical assistance, EPA's formal policy was to not count these towards the inspection commitments made by the State in its EPA inspection grant.[92] In part this reflected EPA's traditional end-of-pipe, regulatory culture, which makes it difficult for them to move towards a more assistance-oriented role. However, recent guidance from EPA to the regional offices suggests that this policy may be changing.[93] Second, inspectors and permit writers may lack the expertise to provide technical assistance, although a number of State pollution prevention programs have begun to provide such training to regulatory staff. Still, some inspectors do not feel that they should even make referrals to technical assistance programs. Finally, even if permit writers and inspectors provide minimal levels of assistance, this will not take the place of the more in-depth assistance provide by extension programs.

92 See for example, letter from Julie Belaga, Regional Administrator, EPA Region 1, to Dean C. Marriott, Commissioner, Maine Department of Environmental Protection, *Mar.* 18, 1992. However, EPA may be softening this policy,

93 Memorandum from Henry Habicht H, op. cit.

FEDERAL PROCUREMENT

Federal procurement, particularly by DoD, could encourage companies to undertake pollution prevention.[94] However, DoD procurement practices often discourage pollution prevention. For example, an increasing number of fins, such as Allied Signal, Hughes, IBM, and Motorola, are using no-clean soldering systems to produce commercial electronics products. These systems save considerable money in avoided cleaning and flux costs, reportedly have as good or superior performance, and reduce environmental releases. However, DoD has not formally recognized these methods as acceptable alternatives to resin-based soldering .[95]

Unlike commercial industry, typical DoD specification changes take 3 months for simple administrative alterations and up to 3 years for complex, technical changes.[96] There are large numbers of specifications that contain environmental implications, such as the approximately 9,500 military specifications that contain either references or requirements for use of ozone-depleting solvents.[97] Many firms use a program-by-program, piecemeal approach of either applying for waivers or changing specifications one at a time. However this is a very time-consuming, paperwork-intensive process, dependent in part on the technical capacity and motivation of the involved industry and DoD personnel. As a result, the need to modify military specifications for materials and processes to cope with changing environmental requirements serves as a bottleneck in promoting pollution prevention among military contractors and subcontractors.

Recent Executive Orders issued by President Clinton have the potential to enlarge the role of Federal procurement in energy efficiency and some areas of pollution prevention. One order directs agencies to revise their practices to reduce procurement of substances that deplete the stratospheric ozone layer. Another directs agencies do procure energy efficient computers.[98]

ENCOURAGE OTHER ORGANIZATIONS TO PROVIDE POLLUTION PREVENTION TECHNICAL ASSISTANCE

Some private sector organizations have an interest in helping firms prevent pollution. Encouraging these efforts can expand the scope of current pollution prevention efforts.

Electric Utility Efforts-Many public utilities have tried to boost local economic growth, often by trying to convince industry to move to their service area.[99] However, recently, a small number of utilities have begun to focus instead on improving the economic competitiveness of their existing manufacturing customers, usually by helping them save energy, but increasingly by helping them prevent pollution.[100] For example, Duke Power established an electro-manufacturing technology center, located at North Carolina State University, to help textile firms adopt cleaner technologies.

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94 U.S. Congress, Senate on Governmental Affairs, Subcommittee on Oversight of Government Management, *Hearings on Buying "Green": Federal Purchasing Practices and The Environment, S. Hrg. 102-563, Nov. 8, 1991.*

95 Mark Crawford, *"pentagon Resists New* **Soldering Technology, " New** *Technology Week,* **Monday, Mar. 22, 1993, p. 7.**

96 **Karla M. Boyle, "Implementing Environmental Alternatives on Military Hardware, " Hughes Aircraft Co., Corporate Environmental Technology.**

97 **Ibid.**

98 **Executive Orders 12843 and 12845, respectively.** *Weekly Compilation of Presidential Documents,* **Monday, Apr. 26,1993, pp. 638-643. President Clinton also signed an Executive Order encouraging procurement of alternative fueled vehicles or conversion of existing vehicles to alternative fuels, and announced plans for an executive order for procurement of recycled materials,**

99 **For** example, eight public utilities actively try to recruit companies to move out **of California. Business** *Climate* **in** *Southern California* (Rosemead, **CA: Southern California** Edison, **November 1991.)**

100 **Di**me **De** Vaul and Charles Bartsch, "How Utilities Can Revitalize Industry, " *Issues in* **Science** *and Technology,* spring 1993, pp. *50-56.*

Southern California Edison fears that it could lose a significant component of its industrial rate base as firms either move or go out of business in response to the strict regulations. As a result, they developed the Customer Technology Applications Center (CTAC), which demonstrates new clean technologies and works with industry to solve technical problems, mostly with cleaner coatings technologies, such as ultraviolet curing, infrared curing, radio frequency and microwave drying, and powder coating. For example, Fender Guitar Company was having trouble meeting air quality standards for its coating process. CTAC came up with a new finish using a water-based coating with infrared drying that not only meets requirements but also has a significantly faster drying time and increases productivity.

Public Waste Collect ion, Treatment and Disposal Services-Publicly owned water treatment works (POTWs) receive and process sewage and wastewater. Under the Federal Clean Water Act, POTWs have authority to restrict industrial pollutants from the waste water they receive by establishing pretreatment programs. Through these programs, POTWs can require generators of waste water to reduce the toxicity of the water they send into the treatment plant. The 1,500 pretreatment POTWs, while representing only 10 percent of the total, treat 80 percent of the Nation's indirect industrial wastewater.[101]

POTWs often have significant contact with industry, and their wastewater inspectors often have extensive understanding of industrial process operations. As a result, they are well-positioned to promote pollution prevention.[102] For example, seven of North Carolina's POTW's provide technical assistance to industries as a routine part of compliance inspections. The Neuse River Waste Water Treatment Plant in Raleigh recommends, when possible, alternative compounds and processes that eliminate toxics discharges. Other POTWs, including those in Milwaukee, Austin, and Orange County, have also made significant efforts.

In spite of the potential for promoting pollution prevention, many pretreatment POTWs have not implemented aggressive pretreatment programs either because they do not know how, or because they don't want to impose requirements on local industry. Moreover, those that do restrict pollutants often encourage end-of-pipe treatment. In addition, beyond a small grant program to POTW's for source reduction initiatives, EPA does little to promote POTW pollution prevention activities. In fact, EPA management of the pretreatment program leads POTWs to focus on meeting narrow regulatory requirements that are sometimes not related to actual environmental performance, serving as a disincentive for them to aggressively and creatively pursue pollution prevention.[103]

Customer/Supplier Linkages-In the last 10 years some U.S. manufacturers have begun to form closer links with their suppliers to help them improve quality, lower cost and in a few cases prevent pollution.[104] For example, Motorola is now working with its suppliers to ensure that they eliminate the use of CFCs. The Big Three U.S. automakers, with several State and Canadian provincial governments, have established a program to reduce persistent toxic substances that are contaminating the Great Lakes; as part of this

101 "POTWs, Pretreatment, and pollution Prevention," unpublished paper, U.S. Environmental Protection Agency, June 1992.

102 National Advisory Council for Environmental Policy and Technology, State and Local Environment Committee, *Building State and Local Pollution Prevention Programs* (Washington, DC: U.S. Environmental Projection Agency, December 1992); also, Local Government Commission "Reducing Industrial Toxic Wastes and Discharges, The Role of POTWs, ' Sacramento, CA, December 1988.

103 National Advisory Council for Environmental Policy and Technology, January 1992, op. cit.

104 Michael Robe rt Berube, *Integrating Environment Into Business Management: A Study of Supplier Relationships in the Computer Industry*, Master's Thesis, Department of Civil Engineering, Massachusetts Institute of Technology, February 1992.

program they are encouraging their suppliers to meet the same goal through pollution prevention.

Trade Associations-Because of their close contact with industry, industrial trade associations have the potential to assist their members with pollution prevention. European trade associations have been more active in this area. For example, the Cologne (Germany) Chamber of Commerce advises its members on the selection of clean technologies and provides referrals to universities and private consultants to solve environmental problems.[105]

Most U.S. trade associations provide relatively little technical help to their members in solving environmental problems. A few trade associations have become interested in promoting pollution prevention, although they usually lack the staff or resources to do more than provide general information. For example, the National Association of Metal Finishers has distributed to its members a pollution prevention checklist developed by California for the plating industry, and is developing a pollution prevention handbook. The Chemical Manufacturers Association (CMA) created its Responsible Care initiative to help member companies improve performance in the areas of worker health and safety and environmental quality. The initiative includes specific codes of manufacturing practices in a number of areas, including pollution prevention. Each CMA member is required to make good faith efforts to implement the program elements.[106] The American Petroleum Institute has a similar effort for its members.

EPA is working more with trade associations to promote pollution prevention. For example, in conjunction with EPA, members of the Ecological and Toxicological Association of the Dyestuffs Manufacturing Industry developed a pollution prevention guidance manual for the dyestuffs industry which they distributed to their members. However, it is not yet common practice for EPA and the State pollution prevention programs to involve either trade associations or industry consultants.

FINANCIAL ASSISTANCE

Government financial support to industry for the cost of environmental compliance can lessen the competitive impact of environmental regulations. There are two principal possible sources of support, tax incentives (e.g., tax credits and accelerated depreciation) and direct financing (e.g., loans, loan guarantees, and grants).

However, there are possible tensions between financial assistance for polluters and the "polluter-pays principle. OECD adopted some conditions under which they are not incompatible. Financial assistance should be limited to: target groups where severe difficulties would occur otherwise; well-defined transitional periods; and situations where international trade is not distorted significantly.[107] Supporting development and diffusion of innovative equipment and clean technologies is not inconsistent with the polluter-pays principle.

As discussed in chapter 7, a number of other countries, including Germany and Japan, take the approach that if firms cannot pay the full costs of implementing needed environmental technologies, the government can legitimately help them through tax incentives, funding R&D, or direct subsidies. In the United States, however, Federal financing of pollution control equipment for private industry has diminished. A number of other countries offer more generous accelerated depreciation schemes. In addition, the limited

105 Alan C. Williams, "A Study of Hazardous Waste Minimization in Europe: Public and Private Strategies to Reduce Production of Hazardous Waste," *Boston College Environmental Affairs Law Review*, vol. 14, winter 1987, p. 210.

106 See "Responsible Care: Small Chemical Companies Struggle to Meet the Program's Daunting Challenges," *Chemical and Engineering News*, Aug. 9, 1993, pp. 9-14.

107 Organization for Economic Co-operation and Development *OECD and the Environment* (Paris: 1986).

U.S. tax incentives favor end-of-pipe equipment over pollution prevention.

It is unclear the effect of government financing programs on environmental behavior. Because the limited U.S. support tends to be tied to environmental investments required by law, the effect appears to minimize financial hardship, rather than stimulate increased environmental investment. An OECD study suggests this maybe the case in many member nations.[108] However, OECD argues that while financial assistance for industry in complying with regulations is being reduced, financial support for clean technologies is likely to continue. While it is not clear that the Federal Government should do more in this area, its relative lack of support compared to some of our major industrial competitors could have a detrimental competitive impact, however small. Moreover, it appears that more could be done, without violating the polluter-pays principle.

Environmental Issues in Private Sector Lending

Many smaller enterprises lack the capital needed to invest in new environmentally sound technologies. Because pollution control loans are low collateralized loans, marginally profitable ventures may have difficulties in obtaining outside financing, or may face higher interest rates and shorter terms. Environmental issues may also hinder small and medium-sized firms in the United States in obtaining financing for any type of activity. A regulated firm subject to high environmental capital and operating costs can be a less attractive financing prospect than another firm not subject to these demands. More importantly, lender liability for environmental claims related to customers' property may reduce lending.

In particular, liability under "Superfund" may make lenders less willing to loan to companies with potentially contaminated sites.[109] While the original statute does exempt lenders,[110] courts have interpreted this narrowly, so that in some cases lenders can be liable for cleanup costs for companies to which they have made loans.111 While it appears that the actual extent of liability asserted against lenders has been insignificant,[112] the uncertainty of the exemption appears to be making lenders more conservative. This issue of lender liability may apply to other types of pollution covered by other statutes, such as RCRA and the Clean Water Act. If these concerns lead lenders to be more cautious in their financing of small and medium-sized manufacturers, either capital availability will suffer or interest rates will increase.113 In addition, firms may choose to not obtain loans if they have to fund expensive tests to determine if their site is contaminated. Either way, U.S. manufacturing competitiveness could be affected.

To address this uncertainty and resulting caution by the lending community, EPA issued a final rule interpreting the security interest exemption in April, 1992. However, this rule has been challenged and as of August, 1993 was still pending.

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108 Organization for Economic Co-Operation and Development, *Economic Instruments for Environmental Protection* (Paris: July, 1989).

109 These are provisions under the Comprehensive Environmental Response, Compensation, and Liabilities Act.

110 The exemption protects from habilit,apq"who, without participating in the management of a ., . facility, holds indicia of ownership primarily to protect [a] security interest in the . . . facility. " (42 U.S.C. 9601 (20)(A).

111 Ibid., pp. 54-55.

112 In the first 10 years of CERCLA's existence, EPA issued more than 18,000 notices to potentially responsible parties. Only 8 were sent to banks and EPA has recovered only $1.5 million in cleanup costs. (Ludwiszewski, p. 63),

113 John M. Campbell, Jr. "~n(jcrL1abi]ity for Environmental Cleanup: Effect on the Financial Services Industry' U.S. *Waste Management Policies: Impact on Economic Growth and Investment Strategies* (Washington, DC: American Council for Capital Formation, May 1992), pp. 45-61.

Regulations and Economic Incentives in a Competitive Context 9

While the regulatory system that has evolved in the United States over the last two decades to control industrial pollution is complex, there is widespread agreement about some of its more prominent features. (Some are shown in table 1-3 in chapter 1 in the column labeled prevailing system.) Emphasis remains on treating pollution once it has been released (end-of-pipe approach) rather than on preventing it. A single media approach to pollution predominates, with separate laws, regulatory offices and enforcement procedures for air, water, hazardous waste, and other media. Rather than setting an overall emission limit for a facility, regulations and permits often separately specify emission rates for individual sources within the plant. The system is characterized as command and control. In addition, there are overlapping local, State, and Federal laws and reporting requirements. The system is adversarial, with frequent challenges taken by all sides long after laws are first passed. Finally, there is little emphasis on technology development and innovation or on technical assistance to help industry meet pollution control requirements (discussed in chs. 7 and 8).

Much progress has been made to control industrial pollution under this system. Still, it is hard to argue that the level of environmental protection enjoyed today could not have been achieved in a more cost-effective fashion, As a result, there is considerable interest in finding ways to adjust the U.S. regulatory system so that comparable or even higher levels of environmental protection could be achieved at lower costs and with less adverse competitive impacts on U.S. industry. Other countries and regions, including the European Commission, also are looking for new approaches.[1]

This chapter examines the potential to use new regulatory approaches and economic incentives in the regulatory system in ways that would achieve comparable or higher levels of environmental protection at lower costs and with less potential for adverse competitive impacts on U.S. industry.[2] It is assumed in this discussion that these alternatives are carried out in the context of a regulatory system with strong standards and vigorous enforcement. Otherwise, the environmental objectives might not be achieved.

PRINCIPAL FINDINGS

Regulatory Reform

- For the most part, the current regulatory system is characterized by a one-pipe-at-a-time approach to environmental protection, with separate legislative, regulatory, and implementation systems dealing with the different media. Moreover, the current permitting system requires individual sources to be controlled and permitted, and sometimes establishes permit limits that are defined by particular technologies. Finally, regulators often rely on strict interpretation of statutes and regulations regardless of the environmental record of the facility.
- Federal and State regulators and industry in many parts of the country are experimenting with innovations that, if widely replicated elsewhere in an appropriate manner, could ease adverse competitiveness impacts while reducing pollution and waste.[3] As shown in the third column of table 1-3, these experiments include multimedia regulation, permitting, and inspections; use of facility-wide emission caps and performance standards; giving more regulatory options to good environmental performers; a focus on pollution prevention; and more emphasis on technological innovation and technical assistance. Taken as a whole, these experiments, in addition to efforts to institute economic incentives, have promise as a way to expand the regulatory tool kit, but they have yet to be widely adopted.
- As long as strong regulation and enforcement are fully maintained, a number of steps could be taken to reduce the competitive burden on industry while still achieving environmental goals. The top leadership of EPA in the current and last administrations has recognized the need for change (including greater emphasis on pollution prevention), some people in various EPA offices have been proponents of new methods, and a limited number of pilot projects and small programs in alternative regulatory approaches have been started. However, widespread and systematic rethinking and reshaping of the traditional regulatory system has yet to take place.

Economic Incentives

- The marginal costs of pollution control usually differ between firms, and between processes and facilities within the same firm. Therefore, requiring equivalent pollution reductions by both high-cost and low-cost sources and polluters can be an expensive way to control pollution. When used as part of a strong regulatory

[1] **For example, the European Commission reports that, ". . . achieving integration of the requirements for competitiveness and the environment requires the implementation of a strategy based on the coordinated recourse to a wide variety of instruments, within the fields of both environmental and industrial policy." European Commission** *Industrial Competitiveness and Protection of the Environment,* **Communication of the Commission to the Council and to the European Parliament (Brussels: European Commission, 1992). A similar consideration of alternatives is underway in Germany. Udo E Simonis, "Environmental Policy in the Federal Republic of Germany," paper of the Science Center Berlin, 1991.**

[2] **Another OTA assessment, due to be completed in early 1995, is examining new approaches to environmental regulation in more detail.**

[3] **For example, see Bradley I. Raffle and Debra F. Mitchell,** *Effective Environmental Strategies: Opportunities for Innovation and Flexibility Under Federal Environmental Laws,* draft **(Chicago, 111: Amoco Corp., June 1993).**

system, economic incentives can lower environmental compliance costs by obtaining more reductions from polluters who can reduce most cheaply, and fewer reductions from those who face higher marginal control costs.

- Two principal incentive approaches are marketable permits and taxes and fees. Marketable permits allow firms to meet regulations by either releasing no more than permitted levels of pollution, or buying the rights to pollute from a firm that has reduced pollution below permitted levels. Alternatively, emissions can be taxed so that firms with high marginal costs of control would choose to pay the tax while firms with low costs would reduce emissions. In theory, with both approaches, total emission levels would be no higher than with a command and control system, while compliance costs would be lower and firms would possess a greater incentive to develop innovative technical approaches to reducing pollution.
- Incentive systems have limits. The necessary accuracy and timeliness in monitoring may be difficult to achieve in some situations. Depending on the type of pollutant, the covered geographic area might have to be defined quite narrowly to avoid excessive local concentrations of emissions. Unlike tradable permits, reliance on taxes or fees makes it difficult to predict the amount and pace of emission reductions. There is no assurance that, on net, firms will choose reducing emissions over paying the tax, However, fee and tax systems are likely to have lower administrative cost associated with them than with tradable permit systems. While incentive approaches promise much in theory, their use may be more limited in practice.

Linkages Among the Alternatives

- There are important linkages between and among these alternatives for regulatory reform and economic incentives. A shift in emphasis to pollution prevention (detailed in ch. 8) will produce more projects that do not fit the standard regulatory framework. More use of tradable permits might require greater delegation of authorities to the States and, at the same time, a closer working partnership between the States and EPA. Firms able to sell or trade pollution rights will likely have more incentives to undertake pollution prevention to lower emissions below what is required. Full facility permitting facilitates pollution prevention, since it enables firms to examine all issues at once and understand cross-media impacts. Heightened cooperation between industry, other affected interests, and regulators in regulation development fosters pollution prevention since industry can see in totality all upcoming requirements and plan for them. An emphasis on pollution prevention requires more effort devoted to technology development and diffusion. Organizing regulatory activities more by industrial sector, rather than media, enables greater levels of consultation, reduces paperwork requirements, and facilitates pollution prevention.

REGULATORY REFORM

A number of experiments are underway in the United States that are testing new ways to achieve high levels of environmental protection while minimizing competitive impacts for firms. In some cases, these efforts lower costs; others provide more opportunity for technological innovation and production flexibility, and still others reduce administrative burdens associated with compliance.

Interest in these new approaches, including use of incentives, can be expected to increase as further incremental reductions in emissions become more expensive. So far, for a number of reasons, their adoption has been relatively slow. First, many of these ideas have only recently emerged. Moreover, momentum for change will be based on the results of policy experiments underway in testing these approaches. Second, some in the regulatory and environmental communities view regulatory reform the same as regulatory relief, which reduces environmental protection. Third, regulators have few resources (time or money) to devote to policy and program innovation; instead many have their hands full implementing existing laws. Fourth, ways to overcome monitoring and administrative difficulties will need to be addressed before widespread replication occurs.

Most regulatory agencies, including EPA, have focused principally on developing command and control regulations, and have made less effort to develop and implement innovative alternatives. Still, a small, but growing number of experiments are underway. EPA has initiated a number of projects to test new approaches, though these have yet to fully permeate the mainstream of EPA's culture. In contrast, a few States and localities are farther ahead in initiating and testing these approaches. So far, EPA has made only a few efforts to develop State-Federal regulatory partnerships to support these innovative State efforts, and to evaluate, actively use and diffuse the regulatory innovations.[4]

Formulation of Environmental Regulations

In the United States, affected interests, including industry and environmental organizations, compete to influence environmental decisions by legislative bodies and regulatory agencies. After laws are passed, the rulemaking process allows these interests to participate through comments on proposed rules.

Many view the current system of notice and comment rulemaking as slow, cumbersome, and adversarial. Even some informal rulemaking procedures allow opposing parties to present formal arguments and proof, similar to legal hearings. Currently, four out of five EPA decisions are said to be challenged in court, suggesting the difficulties of achieving consensuse[5] The adversarial process encourages polarization, which makes achieving effective solutions more difficult. Industry often initially overestimates the costs of compliance and the technical difficulties in achieving it, while environmental organizations often promote solutions with little evaluation of costs. Consultation is sometimes less extensive than optimal because EPA is often under time pressures for rule development, and finds it difficult to engage in more consultative efforts, even though more consultation might reduce the total time because implementation could then be made swifter and less contentious.

Some other countries involve regulated parties more fully in developing regulations.[6] For example, regulation formation in the Netherlands involves close tripartite cooperation between government, the scientific community, and industry. Because issues of technological feasibility, compliance deadlines, and cost are taken into account at an early stage, it is less likely that decisions will be challenged legally or politically by industry.[7] However, these systems also have drawbacks. As practiced elsewhere, they are usually less open and less accessible to environmental groups or other nongovernmental organizations (NGO) outside of industry. As a result,

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[4] **A task force of state and federal regulatory managers was formed by former Administrator William Reilly in** *1992* **to formulate better organization of state-federal relations. Under current Administrator Browner, EPA is developing a management plan to implement their recommendations. See State/EPA Committee, "State Capacity: Building the Future for Environmental Management" (Washington DC: U.S. Environmental Protection Agency, Oct. 13, 1992; also** *Report of the Task Force to Enhance State Capacity: Strengthening Environmental Management in the United States,* **(Washington, DC: U.S. Environmental Protection Agency, June 21, 1993).**

[5] **Don Clay, ' 'New Environmentalist: A Cooperative Strategy, "** *Forum for Applied Research and Public Policy,* **Spring, 1993, pp. 125-126.**

[6] **Sheila Jasanoff, "Negotiation or Cost-Benefit Analysis: A Middle Road for U.S. Policy, "** *The Environmental Forum,* **July 1983, pp. 37-43.**

[7] **There arc significant institutional and cultural differences between these European nations and the United States that preclude simple adoption of these policy processes. However, they do point to the advantages of more cooperative approaches.**

there may be less incentive for vigorous enforcement and possibly weaker regulations,

Some experimentation is underway in the United States to involve all affected interests (including environmental organizations) in more cooperative approaches.[8] For example, negotiated rulemaking (reg-neg) processes use informal bargaining among affected groups and regulators that may culminate in an agreement that becomes the basis for the rule.[9] In theory, these processes may have several advantages over more adversarial processes.[10] First, better outcomes are possible because all views are heard and can be woven together as parties become more aware of the needs and constraints of the other stakeholders. Second, negotiated rulemaking may increase rule acceptability and make implementation easier, since parties involved in making the rule are less likely to oppose its implementation. Third, negotiation may speed acceptance of new technologies and approaches once a law or regulation requiring an outcome is in place. For example, several major petroleum companies engaged in negotiations with the California Air Resources Board on reformulation of fuels and, as a result, reduced the time needed for approval of new reformulated gasoline products.[11]

Cooperative approaches can also be used in implementation. For example, a cooperative effort between EPA and Amoco Corp. provided an opportunity for industry officials and regulators to jointly examine emissions, regulatory requirements and control technologies for Amoco's Yorktown, Virginia refinery, The 2-year project resulted in a detailed emissions inventory of the facility. Moreover, it allowed industry and regulators to identify the lowest cost sources to control and the most cost effective control technologies—most involving pollution prevention. Besides developing a large amount of useful knowledge about the plant, the cooperative project also allowed industry officials and regulators to better understand each other's concerns and orientation to the problem. While the project itself was successful, the approach has yet to be widely replicated. However, both the President's Council on Sustainable Development and EPA Administrator Browner have indicated interest in further Amoco-like cooperative projects.

Not all issues are subject to negotiations. For example, it would be difficult to negotiate a statutory ban on a particular substance, although the timing, uses covered, and extent of technical assistance might be negotiated. Moreover, negotiated rulemaking and other cooperative approaches can be time-consuming and costly for stakeholders and regulatory agencies, especially on the front-end of regulatory development, Finally, care needs to be taken to ensure that all affected parties are included, particularly the unorganized or marginally affected. When many parties are involved, reg-neg may not be viable.

Integrated Regulation

As has been mentioned, the current regulatory system emphasizes a one-pipe-at-a-time approach to environmental protection, with separate legislative, regulatory, and implementation systems dealing with the different media. As a recent report suggests:

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8 For example, EPA began negotiations in 1992 with industry, unions, environmental organizations, and state regulators to craft coke oven emission rules that all parties would agree to and not challenge in court.

9 "Rethinking Regulation: Negotiation as An Alternative to Traditional Rulemaking" (research note), *Harvard Law Review*, vol. 94, 1981, pp. 1871-1891.

10 Peter Bohm and Clifford S. Russell, "Comparative Analysis of Alternative Policy Instruments," *Handbook of Natural Resources and Energy Economics, vol. 1,* edited by A.V. Knees and J.L. Sweeney (New York: North Holland, 1985).

11 When ARCO developed reformulated gas, it involved technical staff from the California Air Resources Board (CARB) in the development process from the beginning. Staff knew how the work was progressing and what the issues were and, as a result, ARCO was able to reduce the time taken to get the new formulation approved by about a year. Similarly, Chevron worked with CARB to generate rules governing reformulated diesel fuel, allowing the company to develop a less-expensive fuel.

> EPA is caught in a structure that is oriented to environmental media or a particular problem, while its research, enforcement, and planning and evaluation staff struggle for broader approaches. The separate laws that guide each program use different standards for action and provide no overall mission for the agency.[12]

This single media approach has been criticized both for failing to adequately protect the environment[13] and for unnecessarily adding to U.S. industry's regulatory burden.

The one-pipe-at-a-time focus makes it difficult to take an integrated approach with multimedia benefits.[14] Sometimes efforts to clean up one kind of pollution create problems in another media. Scrubbing of stack gases, for example, creates sludge that needs treatment and disposal.

A facility may produce several different kinds of pollution, each subject to requirements that can run at cross purposes. Firms often report the same information to different media offices and agencies.[15] Monitoring, permitting, and reporting requirements for the various media offices use different timetables and measurement standards.

The media-specific organization of EPA and most State regulatory agencies has been a barrier to moving more towards lower cost pollution prevention approaches.[16] While some progress has been made in supporting pollution prevention, media office staff have more incentives to promulgate single-media pollution control regulations.[17] EPA funding reflects the emphasis on end-of-pipe programs.

The result has been the development of a corp of experts primarily focused on the problems in a single medium.[18] Sharing of expertise and information among media programs is often limited, a circumstance that can cause delays in rulemaking. Moreover, this structure hinders industry in finding a single point of contact in the agency to address data duplication, conflicting rules, or strategic planning for all media.

An alternative would be to seek to develop multimedia regulations and rules, perhaps organized around particular sectors (e.g., pulp and paper, petroleum refining). For example, the Swedish environmental program is focused in part on sectoral industry councils (e.g., pulp and paper, iron and steel). A few States have begun to organize more along industry lines. The Wisconsin Department of Natural Resources has set up eight technology teams for particular industries.

EPA also has made some efforts to organize its activities along industrial lines. In the late 1970s, it established the Integrated Environmental Management Program.[19] The agency undertook a series of industry studies to assess the joint effects of air, water, and solid waste regulations, both those in effect and forthcoming, on particular industries.[20] The studies found that sometimes the risks were much higher in a particular media and it made little sense to concentrate equally on all

12 National Commission On the Environment, *Choosing a Sustainable Future* (Washington DC: Island Press, 1993), p. 100.

13 Barry Rabe, *Fragmentation and Integration in State Environmental Management* (Washington, DC: The Conservation Foundation, 1986).

14 The National Advisory Council for Environmental Policy and Technology, *Transforming Environmental permitting and Compliance Policies to Promote Pollution Prevention* (Washington, DC: U.S. Environmental Protection Agency, Office of the Administrator, February 1993).

15 Wendy Cleland-Hamnett and Joe Retzer, "Crossing Agency Boundaries,' *The Environmental Forum,* March/April, 1993, pp. 17-21.

16 National Commission on the Environment, *Choosing a Sustainable Future,* Op. cit., footnote 12.

17 The National Advisory Council for Environmental Policy and Technology, *Transform-ng Environmental permitting and Compliance Policies to Promote Pollution Prevention,* op. cit., footnote 14, p. 25.

18 Mahesh Podar and Howard Klee, "~te~ated Environmental Management: A Cost-Effective Approach to Protecting the Environment," *The Journal of Resource Management and Technology, vol.* 21, No. 1, March 1993, pp. 33-43.

19 Personal conversation with Michael Gruber, former EPA official, June, 1993.

20 These industries included chemicals, copper refining, iron and steel making, metal finishing, petroleum refining, and pulp and paper.

media. Some studies questioned the cost-effectiveness of such approaches. While these exploratory studies unearthed useful information, they were not linked in a direct way to decision-making. The effort was phased out in the mid-1980s.

EPA has recently reinstituted similar efforts. Under the Agency's regulatory cluster team concept, a team from relevant EPA offices approaches particular problems from a broader viewpoint.[21] Four industry clusters have been formed (petroleum refining, oil and gas production, pulp and paper, and the printing industry).[22] EPA is using clusters to jointly develop effluent guidelines for discharges to water and Maximum Achievable Control Technology (MACT) standards for toxic air pollutants for the pulp and paper industry.

EPA is also piloting a revised regulatory development process through its Source Reduction Review Project (SRRP), which commits the agency's single media programs to jointly investigate and promote pollution prevention during the rule development process. The SRRP is EPA's response to the 1990 Pollution Prevention Acts requirement that EPA ascertain the effect of its regulations on source reduction.[23] Its short-term goal is to ensure that source reduction measures and multimedia issues are considered during the development of air, water, and hazardous waste standards affecting 17 industrial categories. The long-term goal is to provide a model for a new regulatory development process for EPA.[24]

However, these cluster and source reduction review projects are still small and have not yet been broadly assimilated within the agency. There are several reasons for this. EPA often focuses on single media due to statutory requirements or court-ordered deadlines. The pressure to respond to tight deadlines makes it difficult to coordinate efforts involving several offices. Moreover, the current organization of media programs creates institutional barriers to more coordinated efforts.

Greater emphasis on industrial sectors might offer several advantages. Permit writers and inspectors could focus on a narrower range of industries and processes in order to develop more indepth knowledge of the nature of the pollution problems in those industries, the regulations covering them, and the most effective ways to solve them, including through pollution prevention, Regulators would be more knowledgeable about industry leaders and laggards in controlling and reducing pollution. Officials would better understand pollution prevention and industrial process technology, since, unlike treatment technology, pollution prevention technology is often specific to particular sectors. At present, some efforts to develop integrated regulations suffer from lack of indepth understanding of the sector being examined. Moreover, a sectoral orientation could stimulate new opportunities to experiment with cooperative interaction among industry, environmentalists, and government. Finally, because all parties would be examining the workings of regulation on an industry, it might be clearer when incongruities arise among proposed requirements.[25]

There are several potential drawbacks to such an approach. Regulators might be more easily captured by industry interests if they dealt exclusively with that industry. Moreover, some indus-

21 Cleland-Hamnett and Retzer, op. cit., footnote 15.

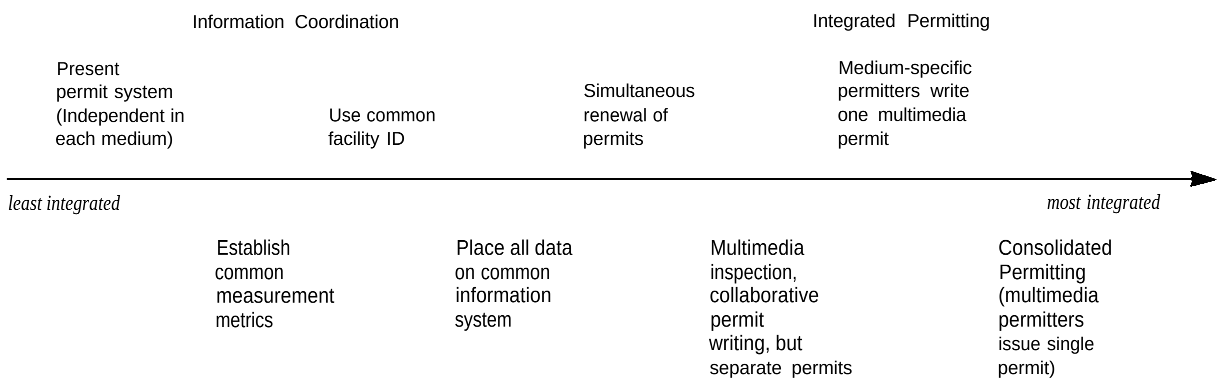
22 EPA has formed 17 clusters, most of which do not focus on specific industries but rather on chemicals (e.g., lead) or on activities (e.g., non-point source water pollution).

23 Lynn L. Bergeson, "The SRRP: Making Pollution Prevention Work," *Pollution Engineering,* July 1993, p. 73-76.

24 Discussion with Lym Vendenello, EPA Pollution Prevention Office, May 1993.

25 Among the alternatives being considered by EPA for reorganizing its Enforcement Office, is to organize it according to major industrial sectors.

Figure 9-l-Spectrum of Integrated Permit Options



SOURCE: James Cummings-Saxton and Robert G. Black, "Integrated Permits: What Are the Data Requirements," contract report for U.S. EPA, prepared by Industrial Economics, Inc., September 1990.

tries might argue that others are not regulated as heavily.

Integrated Permitting and Inspection

Presently, each medium's program operates separately, maintaining separate databases, using different reporting requirements, issuing separate permits with different timing, and even using unique definitions and nomenclature.[26] Less than 15 percent of EPA inspectors perform inspections in more than one program area.[27] One study concludes:

> Relatively few regulated facilities and regulators have begun to think in terms other than single-medium pollution control.[28]

More integrated approaches to permitting are possible--even including a fully consolidated permit system where each facility receives one permit, with allowed releases to the environment to be determined in a coordinated manner[29] (see figure 9-1). Other less comprehensive approaches include coordinated and concurrent permitting. With any of these approaches, permitting to achieve administrative streamlining can be coordinated to prevent pollution and avoid cross media transfers. For example, the principal purpose of New Jersey's integrated permitting program is to promote pollution prevention and reduce total releases from a facility.

Several European countries are aggressively pursuing integrated permitting and inspections. For example, in Sweden many larger regulated facilities have only one permit for all emissions.[30] The United Kingdom has passed legislation that proposes that covered installations be regulated

26 Manik Roy, "Pollution Prevention, Organizational Culture, and Social Learning," *Environmental Law*, *vol. 22,* 1991, pp. 189-251.

27 U.S. Environmental Protection Agency, Office of Cooperative Environmental Management, *EPA Inspector Profile* (draft) September *1989. There has* been some growth in multi-media inspections since then.

28 The National Advisory Council for Environmental Policy and Technology, Technology Innovation s-rid Economics Committee, *Transforming Environmental Permitting and Compliance Policies: To Promote Pollution Prevention* op. cit., footnote 14, p. 24.

29 James Cummings-Saxton and Robert G.Black, ' 'Integrated Permits: What are the Data Requirements,' Contract for U.S. Environmental Protection Agency, prepared by Industrial Economics, Incorporated, September 1990.

30 Frances H. Irwin, ' 'An Integrated Framework for Preventing Pollution and Protecting the Environment,'' *Environmental Law*, vol. *22., No.* 1, 1992, pp. 1-77. See also, Graham Bennett and Konrad Von Moltke, "Integrated Permitting in the Netherlands and the Federal Republic of Germany," in *Integrated Pollution Control in Europe and North America* , edited by Nigel Haigh and Frances Irwin (Washington, DC: Conservation Foundation, 1990).

Box 9-A—integrated Inspections in Massachusetts

Traditionally, the Massachusetts Department of Environmental Protection (DEP) conducted multiple, separate media inspections of each polluting facility. However, since 1987 DEP has been developing an approach to environmental protection that treats each regulated facility as a whole entity.' Under a pilot program named the Blackstone Project, individual inspectors conducted multimedia inspect ions of facilities regulated as major in one media program and m i nor in others, while teams conducted inspections for facilities regulated as major in more than one media program. The inspectors were trained to identify and promote pollution prevention opportunities. When more technical information was required, firms were referred to the State's pollution prevention technical assistance program.

The project was quite successful in the eyes of both the State and the business community. Business liked the team inspection approach because it saved them time and money through the promotion of pollution prevention. The State liked it because the inspection system took up to 50 percent less time than conventional inspections, which account for nearly one-fourth of the agency's $51 million operating budget. In addition, inspections were able to find more violations. Multimedia inspections also better facilitated pollution prevention. Based on the Blackstone model, the State launched its Waste Prevention Facility-wide Inspections to Reduce Sources of Toxics (FIRST) Initiative for inspections and resulting enforcements of industrial sources. DEP is developing teams in regional offices, training inspectors to work together, and training them in proficiency in all regulatory areas. Inspectors also receive training to identify and communicate pollution prevention opportunities. Through an agreement with EPA regarding use of Federal grants, DEP is expanding this approach. Two work groups will seek ways to improve reporting requirements and documentation of inspections. A few other States are making similar efforts. A pilot program in New Jersey will designate 18 industrial facilit ies for facilitywide permits, which, in some cases, could replace the hundreds of individual air emission and water discharge permits with varying requirements and expiration dates.

1 Manik Roy and Lee A. Dillard, "Toxics Use Reduction in Massachusetts: The Blackstone Project," *Journal of Air and Waste ManagementAs sociation,* October, 1990, 40:10, pp. 1368-1371.

under a single permit.[31] The European Commission is considering policies related to pollution prevention and integrated regulations. The OECD has also promoted integrated regulations and pollution prevention.

Several U.S. States, including Massachusetts, Minnesota, New Jersey, and Kansas, have taken steps in this direction.[32] For example, Minnesota is attempting to develop a computerized database containing all regulatory information on sources and allowing firms to apply for permits and permit modifications directly by computer modem. Massachusetts is establishing an integrated inspection program across all media (see box 9-A). New Jersey has initiated a pilot program to promote pollution prevention through integrated permitting.[33]

31 John Falks, "Legal Profile: EC Integrated Pollution Prevention and Control, " European *Environment*, vol. 2, Part 6, December 1992, pp. 10-12.

32 For more information on the New Jersey efforts, see Barry G.Rabe, "Environmental Regulation in New Jersey: Innovations and Limitations," *Publious*, Winter 1991, pp. 83-103.

33 Steven Anderson and Jeanne Herb, ' 'Building Pollution Prevention Into Facilitywide Permitting, " *Pollution Prevention Review,* vol. *2, No.* 4, Autumn, 1992, pp. 415429.

Such projects are few and address only a handful of firms in the States implementing them. While EPA is providing a small amount of seed money and technical assistance to these projects and working to disseminate lessons, the Agency does not appear to have used the lessons arising out of these experiments to make significant changes in its own approach to pollution control regulation, or to actively encourage other States to adopt these approaches. Nor has EPA given States much encouragement to implement these innovative approaches.[34] Moreover, single-medium statutes can contain their own permitting requirements and compliance deadlines, making coordination more difficult.

Multimedia approaches have some limitations. First, it is unclear whether these projects r-night require more agency resources than the conventional single media approach. If they prove to be more costly, firms wanting multimedia inspections and permitting might be willing to accept higher fees in order to cover the marginal cost differences. Second, while multimedia approaches might work for both very large facilities where teams of inspectors are needed and small ones that don't have complex operations, they may be less suitable for mid-sized facilities.

Third, a single media focus can manage the complex interactions among laws, environmental emissions, and industrial processes. Regulators may not know enough about the tradeoffs between emissions in one media to another to make intelligent choices in granting a multimedia permit. Increased training of regulators and inspectors, particularly to recognize other media issues and pollution prevention opportunities, could address this issue. Finally, EPA's ability to fund multimedia approaches is made more difficult because of statutory limitations.

Performance Standards and Facility Bubbles

Normally firms must have a large number of separate permits, for different media (e.g., permits for air emissions, water discharges) and often for individual sources within the plant. Many regulations require sources to be controlled with release limits defined by particular technologies. These technology-based standards specify the method, and sometimes the equipment, that firms must use to comply with a regulation. Performance standards set a uniform standard of control for firms and often for their individual processes, but allow them flexibility in how to meet it. However, even most performance standards are usually based on some form of best available technology (BAT) prescribed in reference technology documents, which, in practice, the regulatory community and industry usually rely on to ensure compliance (see table 9-3).

These technology-based standards can discourage firms from developing or adopting more innovative and cheaper methods.[35] If standards describe one type of technology, and if firms choose a different type of technology they can have difficulty getting approval, since permit writers often do not have the time or inclination to approve approaches different from those normally prescribed.[36] Moreover, EPA will sometimes disallow technologies even if they are approved by State regulators.

Some performance standards limit flexibility. For example, concentration-based standards for effluent limitations may discourage pollution prevention approaches if they result in higher concentrations of the pollutant due to reduced water volume, even though the total amounts of pollutants are lower. In contrast, mass-based

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34 For example, most EPA grant funds are tied to single media permitting and inspection.

35 The National Advisory Council for Environmental Policy and Technology, *Improving Technology Diffusion for Environmental Protection*, U.S. Environmental Protection Agency, October 1992.

36 Discussion with Howard Klee, Amoco Corporation, April 1993.

standards that measure total pollutants may better promote pollution prevention.[37]

The current permitting system also affects industry's cost-effectiveness in meeting regulations, Permitting is time-consuming, procedurally intricate, and technologically complex, both for industry and government. This is evidenced by the fact that nearly 50 percent of States' permitting resources are used for the routine reissuance of permits.[38] Moreover, the trend toward more specific operating permits risks loss of firm proprietary information.

Most significantly, the regulatory system sometimes has the effect of requiring control of those sources of emission that are the most expensive to control. It is often difficult for government to know what sources at a plant pollute the most, and it is virtually impossible for government to identify which emission sources in a plant cost more to control than others. Facilities in the same industry can differ in terms of pollutants because of use of different materials, equipment, products, and practices.

For example, the joint Amoco-EPA study of the cost of environmental control at Amoco's Yorktown, Virginia refinery found that marginal control costs differed significantly by source, and that regulations mandated control of the highest cost sources while allowing the lowest cost sources (which in this case could have been dealt with through pollution prevention options) to be significantly uncontrolled.[39] The Benzene Waste Operations National Emission Standards for Hazardous Air Pollutants (NESHAP) focuses on one emission source to one medium-benzene emissions to air from wastewater treatment operations. Yet, by measuring emissions to air from all sources, the joint EPA/Amoco team concluded that seven times more benzene reductions could have been achieved for one-eighth the costs of mandated controls by such actions as controlling marine loading losses and installing secondary seals on tanks. Significantly, the required controls reduce air emissions, but also create other wastes in the form of spent activated carbon and regenerator waste gases.[40] In part this stems from the fact that rules are developed for particular sources and applied to all facilities, rather than based on facility-specific plans that try to reduce pollution most cost-effectively.

Some other countries approach permitting differently. For example, Japanese and Swedish plants are often subject to discharge limits for the plant as a whole, not specific discharge points. Many Dutch plants are subject to only three permits, one each for air, water, and hazardous wastes, and within a few years may be subject to one permit for discharges from all media. Some argue that inspectors and permit writers in some European countries have more technical experience and as a result are able to provide flexibility and not require adherence to strict standards with a tight timetable. This flexibility allows European firms to cut costs they might otherwise bear with enforcement of more inflexible standards.

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37 For example, if a permit limits the pH of discharge water, firms may simply add water in order to dilute the chemicals until the pH reaches permitted levels. (The National Advisory Council for Environmental Policy and Technology, *Transforming Environmental Permitting and Compliance Policies to Promote Pollution Prevention,* op. cit., footnote 14, p. 34.)

38 Eighty-five percent of New York's NPDES permitting resources were used to review permit renewals with no significant change (Ibid, pp. 54 and 67.

39 *Amoco—U.S. EPA Pollution Prevention Project: Yorktown, Virginia, Project Summary* (Chicago, Illinois: Amoco Corporation, and Washington, DC: U.S. Environmental Protection Agency, June 1992). A similar study was done in Sweden of several petrochemical plants, which came up with similar results. Don Hinrichsen, "Integrated Permitting and Inspection in Sweden, " *Integrated Pollution Control in Europe and North America*, ed. Nigel Haigh and Frances Irwin (Washington DC: The Conservation Foundation, 1990).

40 The source reduction options had an average cost of $650/ton of pollutant recovered while the other options (largely treatment and disposal) had an average cost of $3,200/ton, nearly five times higher. It is important to note that these are Amoco, and not EPA, cost estimates, although EPA and Amoco did generally agree on the results.

Some U.S. States are experimenting with alternative permitting. Also there are some limited efforts at the State and Federal levels to move toward true performance standards and facility discharge limits. Under the 1990 Clean Air Amendments, firms that reduce emissions of air toxics 90 percent get a 6-year extension on having to implement Maximum Achievable Control Standards (MACT). But many in industry are dubious as to whether this is an advantage, since they will have already reduced emissions substantially and prior to the regulatory deadlines (although reducing the first 90 percent should be marginally cheaper than further reductions). Moreover, there is concern that approval for this extension will be onerous and complex.

The 1990 Amendments also include some provisions that move in the direction of bubbles. For example, in the air toxics programs, the MACT regulation of Hazardous Organic NESHAP (HON) allows firms to either control all points with reference MACT technologies, or use alternative controls at selected points, so long as total emissions equal the sum of all emissions that would occur if each point source were controlled using the MACT technology. However, this does not allow averaging across source categories and emissions credits obtained through averaging are discounted.

In a Minnesota pilot program, a 3M plant has been given one air permit for 5 years, and can change the process with little or no approval, as long as total emission levels are not exceeded (see box 9-B). As discussed above, the advantage to industry of such a system is being able to choose what sources to control and how. The advantage to the regulatory agency is not having to spend scarce resources approving small permit modifications and instead being able to focus on significant violators.

It is not practical to control all sources with performance standards, particularly sources that are difficult to measure. In these cases, installation of reference control technology may be the only way to ensure compliance. However, with better monitoring and compliance strategies it may be possible to move more in the direction of facility emission caps and performance standards. In addition, prescribing a number of alternative means of compliance (including pollution prevention or substitute materials), in addition to a reference end-of-pipe technology, would give industry more options in how they meet regulatory requirements. Finally, potentially large costs of collecting information and measuring releases could occur with these approaches. However, emphasizing performance standards and facility bubbles, as opposed to source-specific technology standards, might provide more than offsetting savings, and could better enable both industry and regulatory agencies to reduce pollution at the lowest possible cost.

Regulatory Flexibility

Manufacturing firms differ greatly in their level of environmental awareness, ability to meet environmental objectives, and commitment to pollution prevention. However, the same regulatory procedures govern both firms seeking exemplary solutions to environmental problems and laggards resisting regulations.[41] Moreover, permit writers and inspectors have little incentive or information to make the system more flexible. Instead, they often rely on strict interpretation of statutes and preference for prescribed methods and technology, generally in the name of creating a level playing field. As a result, companies have little leeway to try solutions that are potentially more risky, yet more environmentally and economically sound, including pollution prevention.

Pollution prevention often entails significant learning, engineering modifications, and changes in the production process before the best solutions

[41] The National Advisory Council for Environmental Policy and Technology, *Transforming Environmental Permitting and Compliance Policies to Promote Pollution Prevention,* op. cit., footnote 14, p. 27.

Box 9-B—Flexible Permitting Systems: 3M and the Minnesota Pollution Control Agency

Under the current regulatory system, environmental regulatory agencies often tell industry how to control their pollution rather than letting industry determine how to best operate its plants within the confines of emission limits in a permit. The result is both large work overloads for the regulatory agencies with the incumbent delays, and increased costs and delays for industry. With shorter product lifecycle times and increased manufacturing flexibility, the ability to adjust the manufacturing process is increasingly critical for manufacturing competitiveness. The current regulatory system does little to recognize this new need for speed.

A new flexible permit recently issued to a 3M plant by the Minnesota Pollution Control Agency offers an alternative approach. 3M operates a Tape Manufacturing Division plant in St. Paul, Minnesota, that produces over 2,000 different pressure-sensitive tape and label products on 17 different production lines. These products are primarily manufactured by coating various solutions containing proprietary solids and solvents onto a substrate of paper or film. The major source of pollution is from evaporating volatile organic compounds (VOCs) from the coatings. In order to remain competitive in specialty tape markets, the Division will need to continuously upgrade and modernize its coating and mixing equipment and provide better and more timely service to its customers.

The area in which the plant is located meets EPA ozone standards; source modifications fall under the Prevention of Significant Deterioration (PSD) requirements. Many changes potentially could require lengthy analysis by the Minnesota Pollution Control Agency (MPCA), EPA, and 3M to determine applicability of PSD rules. While the PSD regulations allow 3M to “net-out” of PSD requirements, determination of whether 3M qualifies is time-consuming and complicated. It can take from 4 to 12 months or longer to obtain a PSD permit or determination, and this time may increase as new permit applications require more information. Moreover, changes to individual lines would normally require separate permit modifications.

3M proposed that MCPA issue a 5-year, full facility permit (a cap) for VOC emissions for the entire facility (rather than the current individual process permits currently used). Under the permit, 3M is allowed less total emissions from the plant than before, but 3M can modify processes as long as t he cap is not exceeded. The permit requires 3M to notify MCPA 10 days before beginning construction of the modifications authorized by the permit. 3M has anticipated a host of modification categories it may wish to implement. If the State does not respond within 10 days, 3M can proceed.

Compliance with the VOC emissions cap will be determined daily. A sophisticated emissions tracking system and Continuous Emission Monitoring (CEM) system will be used to factor daily emissions into a rolling annual total.

3M benefits from the flexible permit as it will be able to make needed changes in production lines without delays. In addition, near real time compliance determination reduces environmental liability resulting from regulatory or legal action, The State regulatory agency benefits because the system frees up permitting resources that can be devoted to other environmental and administrative priorities. Finally, the environment benefits because of the lower cap on emissions, and because the heightened monitoring allows quicker responses to problems.

3M is looking to expand this system to other plants in Minnesota. MCPA is viewing it as a possible model for regulation for other emission sources in the State. However, this model may work best for larger facilities with the resources to cost-effectively monitor releases.

are found.[42] In the process, firms may technically be in violation and may have no assurance that the solution will meet the standards. This is particularly true in cases where regulations are promulgated with limited time allowed for implementation. It is common for regulations to require implementation within 6 months to 3 years of promulgation. Not surprisingly, firms often rely on tried-and-true, but more expensive, end-of-pipe treatment methods that ensure compliance, even though these may be neither environmentally nor economically preferable.[43]

Moreover, the permit system itself is cumbersome and impedes flexibility. If firms change their production process, even sometimes to reduce pollution, they are often required to obtain anew permit, which often takes over 6 months for approval.[44] Efforts to streamline the permitting process have been limited. Permit writers often do not have clear instructions or manuals on what regulations and rules require from particular sources. In addition, as State permitting decisions are sometimes challenged or overriden by EPA, States are hesitant to make decisions that might lengthen the permit process.

When U.S. manufacturing was characterized by long runs of mass-produced products that changed slowly, such a permitting system would have only incidental impacts on competitiveness. However, in the new manufacturing environment, with more rapid changes in production processes, shorter product life cycles, and more rapidly changing market demands, the permitting system can inhibit needed flexibility.

Some specific regulatory measures impede flexibility and, in turn, pollution prevention. In particular, the regulatory process of defining and managing waste limits pollution prevention.[45] One of the principal barriers to reusing some wastes stems from a RCRA-derived rule that designates as hazardous waste "any solid waste generated from the treatment, storage, or disposal . . . of a hazardous waste. The rule makes it difficult and costly for firms to employ reuse/recycling approaches to these wastes.[46] Regulations governing storage, transportation, and reuse can all impede pollution prevention and recycling.[47] While firms can apply to have wastes delisted under RCRA, this process is expensive

42 OTA has feud that regulatory flexibility is also important in promoting green design of products and new processes. U.S. Congress, Office of Technology Assessment, Green *Products By Design,* op. cit., footnote 3.

43 For example, according to one study, one reason why metal finishers in a number of cities did not develop centralized treatment and recycling facilities was because they were under the gun to comply with metal finishing rules under the Clean Water Act and would technically be out of compliance for a year or two until centralized facilities could be put in place. Valjean McLenighan, *Sustainable Manufacturing (Chicago:* Center for Neighborhood Technology, 1990).

44 For example, one pharmaceutical manufacturing facility has more than 200 permits just for air emissions. To get a new permit to modify their process takes significant time. The state employs one person to process regulatory agency air permits for companies in the region. Because competitiveness in the drug industry is increasingly related to development of new generations of drugs, using new processes that lower-wage competitors can't duplicate, such delays impede the ability to compete.

45 For example, see R. Lee Beyers, "Regulatory Barriers to Pollution Prevention" *Pollution Prevention Review,* Winter, 1991-92, p. 19-29; also SRI International, *The Role of Recycling in Hazardous Waste Management,* report prepared for The Business Roundtable (New York March, 1992); also Jack H. Goldman and Jeffrey S, Holik, "Regulatory Impediments to the Reclamation and Reuse of Spent Potliner from Primary Aluminum Production,'' in *Proceedings: International Conference on Pollution Prevention: Clean Technologies and Clean Products* (Washington, DC: U.S. Environmental protection Agency, Office of Research and Development, September 1990).

46 Matthew Weinberg, Gregory Eyring, Joe Raguso, and David Jensen, "Industrial Ecology: the Role of Government,'' in *Greening Industrial Ecosystems* (Washington DC: National Academy of Engineering Press, forthcoming, 1993).

47 Robert A. Frosch, ''Industrial Ecology: A Philosophical Introduction" *Proceedings of the National Academy of Science,* Feb. 1992, p. *802;* R. Lee Byers, op. cit., footnote 46.

and time-consuming, and has had limited success.[48] EPA resources to consider delisting petitions are limited and such petitions apply to a single site, rather than to the waste wherever it is generated. No consensus exists about how to regulate or encourage the recycling of industrial wastes.[49]

There are several approaches regulators could take to increase regulator-y flexibility without reducing environmental protection. Regulators could employ fail-soft strategies to go easy on innovators who come close to standards but fail.[50] Similarly, firms could be granted innovation waivers that allow limited noncompliance while developing new approaches .51 Fail-soft and waivers would still need to protect health and environment, but would allow near-misses for a limited period of time.

These waivers and greater flexibility might be granted to those firms with good records, similar to how firms are treated under the Occupational Safety and Health Administration's Star program, where good performers are given incentives or allowed to use flexible approaches. These incentives might expedite permitting, exempt some changes resulting in pollution reductions, and provide for more efficient inspections, streamlined paperwork requirements, and flexibility on timing and technology. In some cases, the possibility of moving to single permit, whole-facility, performance-based permits could be pursued. Safeguards, including strong monitoring systems, would have to be in place to avoid abuse of the system. Moreover, if it was demonstrated that firms were abusing the flexibility, regulators could impose the conventional system on them.

A number of States have begun to provide increased flexibility to good performers, although they cannot grant exemptions from Federal requirements. Some States are more lenient with firms that commit to work with the state pollution prevention technical assistance organizations to solve problems. California and Texas expedite permit reviews for businesses that implement pollution prevention. At the Federal level, EPA has recently proposed an environmental excellence program, but one with very few tangible incentives for industry participation.[52]

Finally, EPA rules often do not concisely or clearly State compliance needs. This makes it difficult not only for firms, especially small and medium-sized businesses, but also for inspectors and permit writers, to understand regulatory requirements .53

INCENTIVE-BASED REGULATIONS

Many economists make the case for giving firms incentives to look for more cost-effective

48 Energetics, Incorporated, *Federal Legislative and Regulatory Incentives and Disincentives for Industrial Waste Reduction*, prepared for the U.S. Department of Energy, Office of Industrial Technologies, Industrial Waste Reduction program (Washington, DC: 1991).

49 See U.S. Congress, Office of Technology Assessment, *Managing Industrial Solid Wastes From Manufacturing, Mining, Oil and Gas Production, and Utility Coal Combustion-Background Paper*, OTA-BP-O-82 (Washington DC: U.S. Government Printing Office, February 1992).

50 The National Advisory Council for Environmental Policy and Technology, *Permitting and Compliance Policy: Barriers to U.S. Environmental Technology innovation* (Washington, DC: U.S. Environmental Protection Agency, Office of the Administrator, 1992).

51 Nicholas Ashford, Christine Ayers, and Robert F. Stone, "Using Regulation to Change the Market for Innovation," *Harvard Environmental Law Review, vol. 9, 1985,* pp. 419-466.

52 Environmental Protection Agency, "Environrnentat Leadership Program," *Federal Register*, vol. *58,* No. 10, January 15, 1993. This proposal, at least in its current form, may be dead.

53 For example, the rule for the Hazardous Organics NESHAP is 700 Pages.

54 OTA is conducting a separate assessment on the impact of alternative forms of regulation, including incentive approaches, on environmental protection.

ways of controlling pollution.[55] The marginal costs of pollution control usually differ between firms and between processes within the same firm. These variations in compliance cost stem from differences in size, age, and kind of technology, cost of substituting inputs, location, management practices, and other factors.[56] Therefore, requiring equivalent pollution reductions by both high-cost and low-cost sources can be an expensive way to control pollution.

The argument is that market incentives, while theoretically producing the same aggregate amounts of pollution control, would do so more cheaply by achieving more reductions from the sources that can do it for less, and fewer reductions from the sources that face higher marginal control costs. While incentive systems offer the opportunity to lower compliance costs, and in so doing reduce the competitive impact of regulations on U.S. manufacturers, they cannot be applied in all cases, and hence are best seen as a supplement, rather than a replacement, of the present regulatory system. This section discusses incentive approaches principally in relation to their role in more cost-effectively reducing pollution from industrial sources.

Types of Incentive Systems

There are two major incentive approaches that apply principally to pollution from industrial sources: marketable permits, and taxes and fees. With marketable permits, firms are allocated permits to release a certain amount of pollution, specified by statute or regulation. Firms that wish to release more pollutants than their permits allow are able to buy allowances from firms that have reduced their releases below the level of their permits. In theory, firms facing high control costs could buy allowances from firms facing low control costs and comply more cheaply than they could by reducing the pollutants themselves.[57] This is the approach taken in the 1990 Clean Air Act with respect to utilities' sulfur dioxide emissions. Another example is the bubble concept, where a facility could trade emission credits among various sources within a facility. This approach is discussed above in the section on regulatory reform. With fees, firms are charged for each unit of pollution they release.[58] Ideally, the fee would be set at a level equal to the marginal costs caused by the pollution. Theoretically, this would lead firms with low cost control options to cut emissions and firms with high cost control options to pay the fee, while achieving sufficient overall reductions to meet environmental objectives.

There are several other incentive systems.[59] Deposit-refund approaches have been used to ensure recycling or proper disposal of certain products, such as batteries or packaging materi-

[55] For an overview of incentive approaches, see Robert N. Stavins (cd.) *Project 88- Harnessing MarketForces to Protect Our Environment: Initiatives for the New President,* A Public Policy Study sponsored by Senator Timothy E. Wirth, Colorado, and Senator John Heinz, Pennsylvania (Washington, DC: December 1988). Also *Project 88—Round II, Incentives for Action: Designing Market-Based Environmental Strategies* (Washington DC: May 1991).

[56] The EPA New Source Performance Standards (NSPS) were originally developed from a concept that the environmental controls on a new unit can be installed more cheaply than on an existing unit.

[57] For example, under the NO_x trading scheme in the Clean Air Act, Wisconsin Power and Light sold credits to Tennessee and Pennsylvania utilities, It was able to do so, because Wisconsin law is more strict than national law, and it had already installed abatement technology that allowed it to exceed the national guidelines (*International Environmental Reporter, May 20, 1992.)*

[58] For example, *see* U.S. *Congress,* General *Accounting Office, Environmental Protection: Implications of Using Pollution Taxes to Supplement Regulation* (Gaithersburg, MD: U.S. General Accounting Office, February 1993).

[59] For a discussion of a wide variety of incentive approaches to protect the environment see: Alan Carlin, *The United Stares Experience With Economic Incentives To Control Environmental Pollution* (Washington, DC: U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation, July 1992); Economic Incentives Task Force, Economic Incentives: *Options for Environmental Protection* (Washington, DC: U.S. Environmental Protection Agency, OPPE, March 1991); John L. Moore, eal., *Using Incentives for Environmental Protection: An Overview (U.S.* Congress, Congressional Research Service, June 2, 1989).

als. They have also been proposed to reduce the generation of hazardous waste.[60] Buyers of a toxic chemical would pay a deposit at the time of purchase and receive it back when they took the chemical to a certified recycler or, in cases where recycling is not possible, to a certified disposal site. Making information on discharges public, such as through EPA's Toxic Release Inventory reporting requirements, can lead to public pressure on polluters, which induces them to reduce pollution. Liability rules, such as the strict and several liability conditions under Superfund, encourage polluters to reduce wastes, since they may be held liable for future cleanup. Finally, removal of government subsidies for practices such as below-cost timber sales and agricultural price supports are often advocated as a way to increase economic efficiency.[61]

Past Experience With Incentive Systems

Limited versions of marketable permit systems have been in place since the 1970s, when EPA introduced its emission trading program for certain air pollutants (see table 9-l). The first trading scheme, developed by EPA in 1974, concerned trades within plants that were expanding. Rather than stringently control new sources of emissions, plants could reduce sources of pollution in other parts of the plant so that no *net* increase in emissions occurred. A firm using netting must obtain the necessary emission reduction credits from its own sources within the plant.

In 1976, EPA developed its offset policy to allow major new sources or source modifications to be sited in nonattainment areas (under the Clean Air Act), so long as best control technology is applied and total emissions reductions are achieved. The new emissions have to be *offset* by emissions reductions from other sources in the area. Since 1976 there have been approximately 2,500 offset trades.[62]

Offsets and netting apply only to new sources. In 1979 EPA developed its bubble policy to provide benefits to existing sources. The name

Table 9-l—EPA Market-Based Environmental Incentives

Incentive Program	Date
Offset Program	1976
Offset Banking Program	1977
Bubble Program	1979
Netting Program	1980
Point Source Trading in Water	*1981*
Wetland Mitigation Banking	*1981*
Steel Industry Effluent Bubble in Water	1982
Lead in Gasoline Phasedown: Trading Program	1983
Point-NonPoint Source Trading in Water	1984
Lead in Gasoline Phasedown: Banking Program	1985
Heavy Duty Truck Engine Emissions Averaging	1985
Emissions Trading Policy	1986
New-Source-Performance-Standards Compliance Bubble Policy	1987
Stack Height Emissions Averaging	1987
CFC Trading Program	1988
Extended Heavy Duty Truck Engine Emissions Averaging (Banking and Trading)	1990
Acid Rain Industrial Source Opt-in Program	1991
Acid Rain NO_x Averaging Program	1991
Air Toxics Early Reductions Program	1991
Air Toxics Offsets Program	1991
Oxygenated Fuels: Averaging and Trading	1991
Reformulated Gasoline: Averaging and Trading	1991
Economic Incentives Rules Expansion	1992
Mobile-Stationary Source Trading Guidance	1992
Air Toxics MACT Averaging	1992
Scrappage of Old Cars	1992
Point-Nonpoint Source Trading	1992
Privatization of Wastewater Systems	1992
Safer Pesticides Incentives	1992
Streamlining Regulations of Premature Notification	1992
Municipal Solid Waste Pricing	1992
State Grants for Air Incentives	1992

SOURCE: Council on Environmental Quality, *Environmental Quality*, 1992, p. 56.

60 Molly K. Macauley, Michael D. Bowes, and Karen L. Palmer, *Using Incentives to Regulate Toxic Substances* (Washington, DC: Resources for the Future, 1992).

61 Robert W. Hahn and Robert N. Stavins, "Incentive-Based Environmental Regulation: A New Era from an Old Idea?" *Ecology Law Quarterly*, vol. 18, No. 1, 1991, pp. 1-42.

62 Barry S. Elman, Tom Tyler, and Michael Doonan, "Economic Incentives Under the New Clean Air Act' (Washington DC: Regulatory Innovations Branch, Office of Policy, Planning and Evaluation, U.S. EPA, May 1992).

derives from the placing of an imaginary bubble over a group of sources within a plant and treating all emission sources as one. Bubbles give plant managers the option of proposing an alternative configuration of emissions controls for a particular pollutant, as long as the configuration is adequately enforceable and equivalent reductions are achieved.

Finally, emissions banking allows firms to store emission reduction credits for future use in the offset, netting, or bubble programs, or for sale to others. The development of banking rules and administration of banking programs has been left up to the States. These programs were codified in EPA's Final Policy Statement on Emissions Trading in 1986, but, as discussed below, their use, particularly of the bubble policy, has been less than expected by some analysts.

More recently, EPA used trading and banking to achieve a nine-fold reduction of lead in gasolines between 1982 and 1987. The purpose of the provisions was to allow gasoline refiners greater flexibility while the amount of lead in gasoline was being reduced. Refineries were allocated credits based on the amount of gasoline they refined. EPA estimated that the savings to refineries from banking alone would be $228 million, but savings may have been greater because of high participation rates.[63] This program was much closer to the notion of a true marketable-permit system than the more limited efforts discussed above, which in part accounts for its effectiveness. The acid rain control systems in the 1990 Clean Air Act Amendments incorporate tradable permits that may save an estimated $1 billion annually, compared with a baseline cost of $6 billion.[64] EPA is promulgating new rules allowing States and firms to get credits for generating extra reductions from motor vehicles (e.g., by scrapping old, high-polluting cars), and to use these credits to meet reduction requirements in the stationary source sector. EPA also instituted some effluent trading schemes. The frost was used for in-plant trading (between two outfalls of the same plant) in the iron and steel effluent guidelines EPA issued in 1982.[65]

Some regions, States and localities are developing trading programs. The South Coast Air Quality Management District in California has proposed a NO_x trading program (see box 9-C). Massachusetts plans to issue rules for a NO_x trading system. Other States are considering such approaches, as well.

The savings achieved under EPA's trading programs, particularly netting, have been moderate, although trading has been applied to only a small share of pollution control efforts. Use of and savings generated by bubbles and banking, however, have been more limited relative to their potential. Because trading is not allowed under the bubble policy, actual savings are below potential savings.[66] (Table 9-2 lists the number of trades and estimated savings from these policies.)

Other incentives to control industrial pollution include taxes on hazardous waste, established by a number of States, increased tipping fees for disposal of waste, and sewarage discharge fees,

63 us. Environmental **Protection Agency, "Costs and Benefits of Reducing Lead in Gasoline, Final Regulatory Impact Analysis, " (Washington DC: EPA, Office of Policy Analysis, February, 1985).**

64 **Robert W. Hahn and Robert N. Stavins, "Economic Incentives for Environmental Protection: Integrating Theory and Practice,"** *The American Economic Review, vol. 82, No. 2, May, 1992,* **pp. 464-468.**

65 **See Mahesh Podar and Mark Luttner, U.S. Environmental Protection Agency, Office of Water, "Economic Incentives in the Clean Water Act: Some Preliminary Results, " paper presented at the 86th Annual Meeting of the Air and Waste Management Association Denver, Colorado, April 12, 1993.**

66 **Robin W. Hahn and Gordon L. Hester 'Where Did All the Markets Go? An Analysis of EPA's Emission Trading Program,''** *Yale Journal of Regulation,* **vol. 6, No. 1, pp. 109-153, 1989; Daniel J. Dudek and John Palmisano, "Emissions Trading: Why is This Thoroughbred Hobbled?"** *Columbia Journal of Environmental Law,* **13:2, 1988, pp. 218-56; Scott Atkinson and Tom Tietenberg, "Market Failure in Incentive Based Regulation: The Case of Emissions** *Trading' 'Journal of Environmental Economics and Management,* **vol.** 21, 1991, **pp. 17-31.**

Box 9-C-RECLAIM: Marketable Permits in Southern California

In 1992, the South Coast Air Quality Management District (AQMD), the regulatory agency responsible for air pollution in the Los Angeles region, proposed a major new approach to regulating air emissions. The Regional Clean Air incentives Market (R ECLAIM) is a proposal to allow firms to generate and trade emission reductions credits.[1]

Air quality in Los Angeles violates the national standard and improvement will require dramatic emission reductions through 2010.[2] On the other hand, the region's economy has been suffering from recession, defense cuts, and outmigration of industry to other States and Mexico. This means that air pollution needs to be reduced, but at the lowest possible cost. Moreover, because drastic reductions are necessary, innovative approaches to reach these goals are needed. Because of this, AQMD proposed to progressively ratchet down permissible air emissions by 85 percent over the next 20 years, while allowing firms to meet these tougher standards by installing add-on controls, reformulating their production process, purchasing excess emissions reductions from other sources, and/or reducing mobile source emissions, including retiring old cars.

All major stationary sources with NO_x (488 facilities) and SO_2 (47 facilities) emissions, generally greater than 4 tons per year, will receive an emissions cap and an annual rate of reduction.[3] In turn, the emission reduction requirements of more than 30 adopted rules and over 12 future rules are replaced by a single permit that encompasses all NO_x or SO_2 emission sources at the facility.

The District developed rule language in May 1993 and proposes to fully implement the program by January 1994. There will be two separate markets in the program, for NO_x and SO_2. Mobile sources and companies emitting less than 4 tons of the pollutants are exempt from the program.

In some ways RECLAIM represents a significant departure from the command and control approach. While facilities will still be required to obtain permits to pollute, the new permits encompass all NO_x or SO2 emission sources at the facility, rather than individual pieces of equipment. Each facility will have an overall declining emissions cap that it must meet. However, if a firm believes that it can meet

1 South Coast Air Quality Management District, *RECLAIM Rules* (Diamond Bar, CA: SCAQMD, May 1993).

2 Approximately 50 percent of air pollution in the Los Angeles area comes from mobile sources (e.g., cars and trucks), 30 percent from area sources (e.g., dry cleaners) and consumer products (e.g., perfume), and 20 percent from stationary sources (e.g., industry).

3 SCAQMD is considering separately the development of markets for reactive organic compounds (ROCs).

(continued on next page)

Tipping fees have increased significantly since the early 1980s, although in some places tipping fees do not makeup for the total government cost. The city of Phoenix recently instituted a toxic-based fee on the dischargers to the local POTW. However, these fees may not always be high enough to encourage significant changes in behavior. Incentive approaches have also been proposed for a wide range of environmental problems, including global warming,[67] municipal solid waste, and nonpoint source water pollution.

While the U.S. incentive approaches have concentrated on marketable permits, some European countries have more experience using fees

67 Robert W. Hahn and Robert N. Stavins, "Trading in Greenhouse Permits: A Critical Examination of Design and Implementation Issues," prepared for *Global Climate Policy*, edited by William Clark and Henry Lee (Cambridge, MA: John F. Kennedy School of Government, Harvard University, March 18, 1993).

Box 9-C-RECLAIM: Marketable Permits in Southern California-Continued

its cap more cheaply by purchasing emission reduction credits from other firms, it can do this. It is hoped that RECLAIM will spur innovative control technologies and other new ways of reducing pollution, and will allow AQMD to avoid the battles over what is and is not technologically possible. Moreover, by reducing emission limits significantly, RECLAIM hopes to force the development of technology to meet the new limits.

An important component to the success or failure of the program will be the accuracy of monitoring. AQMD proposes to monitor SO_2 and NO_x through continuous emission monitors attached to air emission sources. One advantage of the monitoring program is that it will result in a better understanding of emissions and air quality.

Compliance costs under RECLAIM, as opposed to a conventional approach, are expected to be lower. While it would cost $346 million to reduce emissions over the period of 1994 to 1999 under a command and control approach, AQMD estimates that under RECLAIM costs would be $182 million, or 47 percent less. Part of these savings are expected to come from advancements in pollution control technology stimulated by the RECLAIM incentives. RECLAIM also provides more flexibility for industry and gives facilities the ability to better engage in long-term planning and have more control over managing their emissions.

There are, however, a number of limitations in the program that might limit savings. To be consistent with Federal and State regulations, new, relocated, and modified (resulting in emission increases) sources must still meet Best Available Control Technology requirements, as do existing equipment currently permitted under BACT. Facilities that purchase credits to install a new source or increases above their annual allocation must obtain an amendment to their facility permit, and some facilities can only buy credits from facilities in the same geographic zone. Finally, because the future emission targets are so low, in some cases below currently available technology, firms may bank emission credits to meet future reductions.

Moreover, it is possible that the program could exacerbate the migration of industry out of the region, since firms in the program that relocate or shut down can obtain credits to sell. An additional possible problem is that the program could penalize firms that have already significantly cut pollutants. If emission baselines and credits are allocated to firms based on current emission levels, firms that have cleaned up get fewer credits than firms that haven't. AQMD is proposing to deal with this by basing credits on emission levels for the years 1989 to 1991. Facilities that today operate below their emission potential will receive a starting allocation commensurate with their emissions in 1987 or 1988. However, these credits cannot be traded and can only be used by the firm to offset emissions increases from increased output in the first 3 years of the program.

or taxes on releases, particularly for water pollution.[68] However, the purpose of these fees is often to raise revenues, rather than to induce industry to control pollution. For example, the French environment agency (ADEME) charges large emitters of SO_2, NO_x, and hydrochloric acid a tax of approximately $30 per ton, while France's six river basin agencies charge fees on effluents of

68 Organization for Economic Cooperation and Development, *Environmental Policy: How to Apply Economic Instruments* (Paris: OECD, 1991); Huppes, et. al. New Market-Oriented Instruments for Environmental Policies, (London: Graham and Trotman, for The Commission of the European Communities, 1991); Mikael Skou Anderson, "Green Taxes and Regulatory Reform: Dutch and Danish Experiences in Curbing Surface Water Pollution,' working paper, (Berlin: Wissenschaftszentrum Berlin (WZB), 1991); Gardner M. Brown, Jr. and Ralph W. Johnson, "Pollution Control by Effluent Charges: It Works in the Federal Republic of Germany, Why Not in the United States?' *Natural Resources Journal*, vol. 24, No. 4, October 1984, pp. 929-966;

Table 9-2—Estimates of Cost Savings From EPA Emissions Trading

Type	Number of trades	Amount of savings ($millions)
Offsets	2,500	$25*
Bubbles	132	$435**
Banking	100	very small**
Netting	5,000-12,000	$525-12,000'"

SOURCES: " Daniel J. Dudek and John Palmisano, "Emissions Trading: Why is This Thoroughbred Hobbled?" *Columbia Journal of Environmental Law,* 13:2, *1988,* pp. 218-256. •* Robert W. Hahn and Gordon L. Hester "Marketable Permits: Lessons for Theory and Practice," *Ecology Law Quarterly, VOl* 16, 1989, pp. 361-406.

BOD and suspended solids. However, in both cases the taxes are too low to have significant effects on firm behavior.[69] In a few countries, the fees are higher and may affect behavior, Holland charges higher fees on water pollution, which appear to have had an impact on reducing discharges.[70] Since 1974, Japan has charged a fee on SO_2 that may have encouraged some sources to install SO_2 scrubbers.

Advantages of Incentive Systems

There are several potential advantages of incentives in the regulatory system (see table 9-3).

COST SAVINGS

Many studies suggest that the total savings from using incentives rather than traditional regulations alone could be considerable, primarily because differences in compliance costs between sources can be substantial. For example, OTA estimated that the average costs for reducing volatile organic compounds (VOCs) may range from about $500 per ton for limits on fuel volatility to about $39,000 per ton for using methonal as a vehicle fuel,[71] and that the costs of reducing SO_2 emissions from eastern power plants by requiring wet scrubbers would cost between 40 and 110 percent more than allowing each utility to choose the lowest cost control option (coal washing, low sulfur fuels, and wet and dry scrubbers) .72

A number of studies have estimated that incentive systems could be two to five times less expensive than command-and-control.[73] However, many of these estimates, particularly those based on more theoretical models, may significantly overstate the savings from incentive approaches, in part because theoretically pure incentive schemes are unlikely to be workable in practice.[74] First, many firms with high control costs have already invested in abatement and therefore cannot reap savings available if they buy credits. Second, perfect markets for tradable permits may not develop. If firms are prohibited

69 @.French environmental Official argued that the taxes would&veto be 20 to 30 times higher in order to serve as an effective incentive for firms to reduce pollution.

70 Robert W. Hahn, ' 'Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders, *Journal of Economic Perspectives, 3, 1989,* pp. 95-1 14; also Hans Bressers, "The Role of Effluent Charges in Dutch Water Quality Policy," in *International Comparisons In Implementing PollutionLaws,* ed. by Paul B. Downing and Kenneth Hanf (Boston: K1uwer-Nijhoff, 1983),

71 Only the upper estimates are relevant, however, because most of the lower-cost options are already required. U.S. Congress, Office of Technology Assessment, *Urban Ozone and the Clean Air Act: Problems and Proposals for Change,* (Washington, DC: U.S. Government Printing Office, April 1989), pp. 106-108.

72 U.S. Congress, Office of Technology Assessment, AcidRain *and Transported Air Pollutants: Implications for Public policy,* OTA-O-204 (Washington, DC, U.S. Government Printing Office, June 1984).

73 For a discussion of the theoretical estimates of savings from emissions, see T.H. Tietenberg, "Emission Trading: An Exercise in Reforming Pollution Policy" (Washington: DC: Resources for the Future, 1985; T.H. Tietenberg, Economic Instruments for Environmental Regulation' *Oxford Review of Economic Policy,* 1990, vol. 6, No. 1, 17-33; and Robert W. Hahn and Robert N. Stavins, "Economic Incentives for Environmental Protection: Integrating Theory and Practice, " *The American Economic Review,* vol. *82, No. 2,* May, 1992, pp. 464-468.

74 Robert N. Stavins, "Transaction Costs and the Performance of Markets for Pollution Control," unpublished paper (Cambridge, MA: Harvard University, Kennedy School of Government, May 23, 1993).

Table 9-3—Advantages and Disadvantages of Different Regulatory Approaches

Type of Regulation	Advantages	Disadvantages
Uniform technology-based standards	Easier to ensure compliance Able to set overall release targets for facility and region Ensures large market for producers of best available technology	More difficult to focus efforts on low-cost sources within or between plants Reduces incentives for pollution prevention and technology development
Source-based performance standards (sources within a plant)	Some incentives for pollution prevention and technology development Able to set overall release targets for a facility and region Greater flexibility to use low-cost approaches on regulated sources	More difficult to focus efforts on low-cost sources within or between plants Monitoring may be difficult
Plant-based performance standards (facility bubbles, no trading)	Can focus efforts on low-cost sources within a plant Moderate incentives for pollution prevention and technology development Able to set overall release targets for a facility and region	Monitoring may be difficult
Tradable pollution permits	Can focus efforts on low cost sources within a facility or between facilities Stronger incentive for pollution prevention and technology development Able to set overall release targets for a region Greater flexibility regarding when and to what degree reductions are made	Monitoring may be difficult Can lead to regional/local pollution concentrations May not be appropriate for emissions with threshold damage functions Early reducers can be penalized Potentially large transaction costs, which may diminish cost savings If permits are auctioned, can raise total compliance costs
Pollution taxes	Can focus efforts on low-cost sources within a facility or between facilities Stronger incentive for pollution prevention and technology development Greater flexibility regarding when and to what degree reductions are made Require few regulatory approvals Set marginal costs of control Source of government revenues Potentially less new source bias	Monitoring may be difficult, if the tax is placed on outputs rather than input purchases Can lead to regional/local pollution concentrations May not be appropriate for emissions with threshold damage functions Difficult to set overall release levels Firms may choose to pay tax rather than cut pollution Because of increased taxes, can raise total compliance costs

SOURCE: Office of Technology Assessment, 1993.

from banking emissions credits for future use or sale they may engage in early, suboptimal sale of credits. The number of firms in the market maybe small, especially when the bulk of pollution comes from a small number of widely dispersed sources or where a few large sources dominate. Third, transaction costs, particularly with tradable permits, may be high. Firms may have to pay consultants to identify sellers or buyers, pay brokers to facilitate transactions, and spend time negotiating. In addition, for fees or tradable permits, firms may have to pay to document and monitor emission reductions, develop applications for a permit revision, and keep detailed records. Finally, environmental safeguards and other regulatory constraints can diminish the workability of incentives. In some cases firms have to wait up to 2 years to get certification that their reductions are legitimate and can in fact be sold, Requiring new sources to satisfy new source performance standards, rather than allowing them to install less stringent control technology and buy credits to make up the shortfall, reduces trading potential.

States and localities can further undercut trading as an option. For example, Illinois passed a law requiring some utilities to buy scrubbers so utilities would not buy low-sulfur coal from Western States and instead buy high-sulfur Illinois coal.[75] Atkinson and Tietenberg suggest that in reality, savings achieved would probably be 20 to 50 percent of the estimated ideal.[76] Notwithstanding these limitations, incentive systems can lower compliance costs, although not nearly as much as theory might suggest.

GREATER OPERATING FLEXIBILITY

The development and implementation of a new pollution control or prevention method entails certain regulatory risks for the business. One advantage of incentive approaches is that if firms choose to invest in a new control technology or a clean process solution that is low cost, but falls slightly short of meeting the regulation, or requires additional time to work out problems, they can buy credits (or pay a fee) to make up for the shortfall.

INCENTIVES FOR INNOVATION IN POLLUTION CONTROL

Under command-and-control, firms have little incentive to reduce releases below the required level since they receive no economic benefit. Moreover, regulated firms have limited interest in developing more efficient technologies for pollution control since, once developed, these technologies are likely to be mandated by regulators as standard for other sources in the future. Finally, designation of technology standards make it more difficult for firms to get alternative approaches accepted. As a result, command-and-control systems, particularly technology-based standards, can freeze the development of technology that could provide control at greater levels or lower costs.[77]

A potential benefit of incentive approaches is that they could provide firms with financial rewards for developing and adopting new pollution abatement and prevention technologies and other innovative control strategies that reduce releases below required levels.[78] Firms adopting innovative technologies that reduce pollution more than required would benefit financially, either through lower pollution taxes or saleable pollution rights.

While incentives may stimulate new ways of controlling pollution, these may not always lead to development of new technology. For example, firms may decide to use more straightforward approaches, such as fuel-switching or substitution of materials. Thus in some cases, in contrast to a technology-based standard that may force the development of a new technology, incentives could produce less technological innovation,

75 *Energy Daily*, Sept. 3, 1992, p. 2.

76 Scott Atkinson and Tom Tietenberg, "Market Failure in Incentive Based Regulation: The Case of Emissions Trading" *Journal of Environmental Economics and Management, 21, 1991,* pp. 17-31.

77 For example see, Matt Ridley, "How to Smother Innovation," *The Wall Street Journal*, June 9, 1993.

78 Paul B, Downing and Lawrence J. White, "Innovation in Pollution Control,' *Journal of Environmental Economics and Management*, vol. 13, *1986,* pp. *18-29.*

79 A final advantage of incentives is that they provide an additional set of regulatory tools to address problems or pollution sources that may not be effectively addressed using traditional regulatory tools. See Michael H. Levin and Barry S. Elman, ' 'The Case for Environmental Incentives, ' *The Environmental Forum,* January/February 1990, pp. 7-11.

even though they produce lower cost means of control.[79]

Limitations and Disadvantages of Incentive Systems

There are limits to incentive systems. Incentives seldom eliminate the need for regulations. Indeed, incentive systems must generally be implemented within a clear regulatory framework. An incentive-based approach, however, may offer more compliance options than a traditional regulatory system.

One key to incentive approaches is accurate and timely monitoring and enforcement. Unlike many conventional command and control standards where adoption (and proper operation) of a certified control technology ensures compliance, incentive systems normally require accurate monitoring of emissions over a period of time. While current monitoring procedures and technology appear adequate for some types of processes and pollutants, they are less so for others. As a result, the application of incentives may be limited to cases where adequate monitoring and enforcement are feasible.[80] It is one thing to monitor utilities trading sulfur dioxide emissions under the Clean Air Act's acid rain provisions, since there is a manageable number of facilities in the program and technology for continuous stack emission monitoring is available.[81] It is quite another thing to adequately monitor a vast number of smaller sources and releases associated with a wide array of industrial processes. However, advances being made in new continuous emissions monitoring processes are likely to increase the potential of incentive approaches.[82] Regardless, incentive approaches will generally increase the need for and complexity of detailed modeling, monitoring, and enforcement, which could increase the administrative cost to government and industry. Monitoring is more complex when emissions output is regulated and less complex when materials input is taxed (e.g., carbon taxes in fuels).

Geographical constraints can limit applicability of incentives. For some pollutants (e.g., air toxics) the market may have to be defined quite narrowly, so that trades do not significantly reduce environmental quality in an area. Safeguards would be necessary under a tax or trading system to protect the interests of persons living in a place where polluters chose to pay the fee or buy the rights, rather than control pollution. However, even with small trading areas, potential savings might be significant.[83]

In cases where environmental damage is severe, there may be a need to use all feasible means of control and to limit the ability of firms to buy pollution rights. For example, in Los Angeles, which has major environmental problems, achieving ambient standards may require strict controls on almost all sources of ozone-causing emissions. In this case, the cost advantage of market-based approaches over command-and-control will be less, but still may be significant (see box 9-C).

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79 A final advantage of incentives is that they provide an additional set of regulatory tools to address problems Or pollution sources that may not be effectively addressed using traditional regulatory tools. See Michael H. Levin and Barry S. Elman, "The Case for Environmental Incentives," *The Environmental Forum,* January/February 1990, pp. 7-11.

80 In some cases, though, tradable permits and taxes may be easier to monitor and enforce, particularly in the regulation of the use of particular chemicals, such as CFCs. Robert Rabin, "EPA Regulation of Chlorofluorocarbons, " in *Making Regulatory Policy,* edited by Keith Hakins and John M. Thomas (Pittsburgh: University of Pittsburgh Press, 1989).

81 Most large source emissions of NO_X and SO_X in Japan are monitored by Continuous Emission Monitors (CEMs) and this information is automatically fed to local, governmentally controlled monitoring stations by telemetry,

82 However, in some cases, current CEMs can impede industrial performance. See Gunsell S. Shareef, et. al., ''Selective Catalytic Reduction NO_X Control for Small Natural Gas-Fired Prime Movers,' presented at the 85th Annual Meeting and Exhibition, Air and Waste Management Association Kansas City, June 21-26, 1992,

83 T.H. Tietenberg, "Economic Instruments for Environmental Regulation" op. cit., footnote 73.

Taxes or fees make it difficult to predict the amount and pace of pollution reductions. More importantly, as discussed below, because managers may not optimize and choose low-cost options, firms may choose to pay the fee and continue to pollute, even if reducing pollution would save them money.[84] Unlike fees and taxes, tradable permits allow regulators to ensure an overall level of pollution reduction. It is difficult for government to set fees at the correct level to produce the desired change at the lowest cost.

Moreover, taxes and fees or the auctioning of permits could raise total compliance costs for industry, even if abatement expenditures were reduced.[85] However, fees and auction income can be rebated back to industry to be revenue neutral. For example, Sweden is planning to initiate a NO_x fee on 150 to 200 of the largest sources. In order to not discriminate against these, the revenues will be returned to the affected facilities through a rebate based on the amount of energy they produce.[86] Fees could also be returned to firms to help pay for the cost of pollution control equipment. For example, the revenues from the French air pollution charge are returned to those adopting pollution control equipment.[87] The revenue raised from fees can be used to offset other taxes (on industry or the general public), as well.

Assignment of credits or allowances can be inequitable. Depending on how these rights are allocated, firms that cleaned up early may be penalized. Similar to the current command-and-control system, a marketable permits program may penalize new firms and reward existing firms by making the former buy permits to enter the market. In addition, marketable permit systems may exacerbate industrial relocation, since firms moving out of areas with marketable permits may be able to sell their pollution permits, making it more profitable for them to leave. One way to deal with this would be to have closing and moving firms hand over credits to the local government, which can sell them or give them to firms relocating to the area.

Finally, under some systems, firms may get credit for reductions that they have already made, or for things they would have done anyway, such as shutting down an obsolete production line. In addition, existing permits under some State implementation plans may allow some sources many more releases than they are using. These excess releases have in some cases been available for trade; the results have been called paper trades.[88] The existence of historic emissions inventories can reduce this problem of measurement as can the assignment of more realistic emission caps. In addition, if the regulatory system explicitly accounts for the use of these paper credits by requiring lower emission limits from all sources, mandated reductions could likely be achieved.

Some oppose incentive systems because they feel that industry should not be given the right to pollute, and that every single reduction in releases possible is necessary, particularly in nonattainment areas.[89] But incentive systems can be designed to permit no more pollution than an equivalent command-and-control system.

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84 Some have argued that similar results occur with regard to adoption of industrial energy conservation practices. There is considerable evidence that there are proven, cost-effective, energy conservation technologies not widely used by industry. As in the case of pollution taxes, industry has market incentives (in the form of energy expenditures) to invest.

85 T H Tietenberg, "Emissions Trading: An Exercise in Reforming Pollution Policy," op. cit., footnote 74.

86 U.S. Environmental protection Agency, *Economic Incentives. Options for Environmental Protection*, (Washington DC: EPA, Policy, Planning and Evaluation, March 1991).

87 T.H. Tietenberg, "Economic Instruments for Environmental Regulation," op. cit., footnote 74.

88 peter Bohm and Clifford S. Russell, "Comparative Analysis of Alternative Policy Instruments," op. cit., footnote 10.

89 David Doniger, "The Dark Side of the Bubble," *The Environmental Forum*, July 1985, pp. 33-35.

Why Have Incentives Not Become More Widespread?

Despite their potential to reduce compliance costs, incentive programs have not been widely used as a pollution control strategy. Moreover, when the programs have been adopted, they have been used less frequently than expected. Most trades have been inside firms and, with the exception of the lead-trading program for gasoline and the mandatory offset trading, there have been few trades between fins. There are several reasons for the limited adoption of incentive programs.

First, with the notable exceptions of the 1990 Clean Air Act Amendments, Federal legislation has not encouraged incentives.[90] For example, while the Clean Water Act contains provisions that suggest that trading is allowed, it does not explicitly authorize its use. This has limited trading, because of the perceived risk that trades will be overturned by the courts or disallowed by regulators.[91] While the Clean Air Act authorizes a variety of incentives, the effects of these provisions are only beginning to be felt.[92]

Second, because incentive systems are the exception rather than the rule, it is much easier from an administrative standpoint for firms and regulatory agencies to work within the traditional regulatory system than to get new incentive programs up and running. Procedures for approving trades can further impede the process. For example, in the water pollution trading scheme on the Wisconsin Fox River, firms that entered into trades were required to either modify or receive new permits.[93] Because firms that applied for bubbles were subject to in-depth reviews of plant facilities, many were reluctant to use this tool.[94] Provisions in the 1990 Clean Air Act Amendments will, in some cases, reduce the need for indepth case-by-case reviews.

Third, clear and consistent leadership in support of incentives has been lacking. While the air office within EPA has been somewhat supportive of incentive approaches, other media program offices have not done as much.[95] As a result, State and local agencies have not received the guidance and support needed to put in place incentive approaches, nor has EPA aggressively sought to identify situations where incentives might be fruitfully applied. Finally, support from industry and environmental groups for incentive approaches has been sporadic.

There are also reasons why industry has not used existing programs more extensively. First, transactions costs have been high, particularly for nonuniformly mixed pollutants (e.g., air toxics and some particulate), where extensive air dispersion modeling has been required. Moreover, the practice that EPA, instead of the States, approve trades involving dispersion modeling, hindered trading in the early 1980s as few trades requiring modeling were approved.

Second, firms may not know about the programs or may prefer the security of command and control where regulatory agencies essentially tell them what device to buy and how to monitor it.

90 A number of bills recently have considered the use of incentives, See Regulatory Innovations Branch, Office Of Policy, Planning and Evaluation *Economic Incentives in Environmental Bills Introduced in the 102nd Congress* (Washington, DC: U.S. Environmental Protection Agency, February 1993).

91 U.S. Congress, General Accounting Office, *Water Pollution: Pollutant Trading Could Reduce Compliance Costs if Uncertain ties Are Resolved*, RCED-92-153 (Gaithersburg, MD: U.S. General Accounting Office, June 1992), p. 5.

92 EPA recently issue a proposed rule providing guidance to the states on economic incentive programs. EPA, "Economic Incentive Program Rules," *Federal Register, vol. 58, No. 34*, February 23, 1993. pp. 11110.

93 Robert W. Hahn, "Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders, " Op. cit., footnote 70. The major reason, however, for the failure of this program was that the marginal costs of reducing emissions did not differ significantly between the plants, reducing the benefits of trading to the firms.

94 For example, see Box *8-G* discussing 3M's experience with bubbles.

95 Robert Rabin, "EPA Regulation of Chlorofluorocarbons, " op. cit., footnote 80.

Industry may also worry that they will be required to install control technologies even after they have purchased credits. Finally, some firms may not want to be seen as polluters for fear of damaging their image with the public.[96]

Incentive approaches promise much in theory, but their application in the real world suggests that their use may be more limited. Notwithstanding these limitations, the potential for incentive-based approaches to cut costs (and stimulate innovation) has not been reached.

96 Some firms fear that they may be seen as buying their way out of controlling pollution. Some other firms are concerned about profit@ from controlling pollution. For example, 3M has a corporate policy that they will not profit from any money made by selling permits.

PART IV.

Government Support for Environmental Technology Development, Here and Abroad

Research, Development, and Demonstration 10

Research and development (R&D) on environmentally preferable technologies is important not only for solving environmental problems, but also for ensuring that U.S. environmental firms maintain competitive positions in world markets. R&D directed at lowering the costs of meeting and in some cases going beyond regulatory requirements can help both the environmental goods and service (EGS) and regulated sectors. But commercial benefits from much of the $1.8 billion the U.S. Government spends each year on R&D for the energy and environmental technologies covered in this report are limited.

Several factors are key. First, several agencies have mission-oriented programs, but there has been little strategic direction and coordination to Federal R&D efforts. Funding agencies generally have not worked closely with each other to identify critical environmental problems and common technology priorities, although the Clinton administration is making efforts in this direction.

Second, except for various cooperative R&D agreements (CRADAs) and a number of R&D and demonstration programs for cleaner energy technologies, individual programs pay scant attention to commercial applications. For example, a significant share of Federal environmental technology funds (over $650 million in fiscal year (FY) 1993) support R&D related to hazardous waste remediation technologies for Federal site cleanup. While these efforts could produce commercially relevant remediation technologies, their export potential is likely to be modest relative to other areas (see ch. 4 and ch. 5). Comparatively little R&D goes for pollution control, cleaner production, and recycling, which are of greater relevance to regulated industries and offer greater export potential. If recent legislation is vigorously implemented and new administration initiatives are pursued, this picture could change toward more government-wide coordination and commercial orientation; several pending bills before Congress aim in this direction (ch. 2).

Third, while CRADAs and other industry-government partnerships (e.g., SEMATECH) are becoming more prominent, programs operated principally by government agencies often have had only limited dialogue with industry. When industry is involved, it is often through single companies rather than through broad-based industry consortia. In such cases, government has not effectively leveraged and mobilized industry-wide resources, experience, and commitment to develop and deploy the most important environmental technologies for industrial application.

The picture is somewhat different in other nations. Government support for environmental technology R&D in Europe and Japan tends to center in agencies with industrial policy missions, such as Japan's Ministry for International Trade and Industry and Germanys Ministry of Research and Technology. In some cases, particularly in Japan, these missions are carried out by less bureaucratic quasi-public organizations, with industry involvement and governance, that usually focus on subjects and technologies with domestic and international commercial promise. R&D is also carried out in a manner designed to facilitate usefulness to industry; for example, Japan's New Energy and Industrial Technology Development Organization (NEDO) borrows industry researchers, who then return to their companies when the work is done, Moreover, industry-government cooperation in developing environmental technology is common, with emphasis on increasing communication of innovations among firms, including the use of industry research consortia. For example, Japanese steel producers formed the Steel Industry Foundation for the Advancement of Environmental Conservation Technology in 1973 to conduct joint R&D on pollution control and energy conservation technology in the steel industry. The Dutch and the Danish governments have focused their environmental technology policies on increasing successful cooperation between user companies, suppliers, developers, and consultants.[1] Such collaborative approaches appear promising in advancing technologies suited to industry environmental needs.[2]

In addition, at least one country, the Netherlands, has begun to think strategically about long-term technology development which supports principles of sustainable development. Its Sustainable Technology Development Program, funded at $2.9 million a year by five agencies, attempts to boost the capacity of Dutch institutions (industry, government, academia) to integrate environmental goals into technology development.[3] Througha‘‘backcasting process where they look at the demands which technology must meet in the future (e.g., low levels of resource use), the program attempts to identify and achieve consensus over sustainable technology goals in a variety of areas, including transportation, energy production, and manufacturing,

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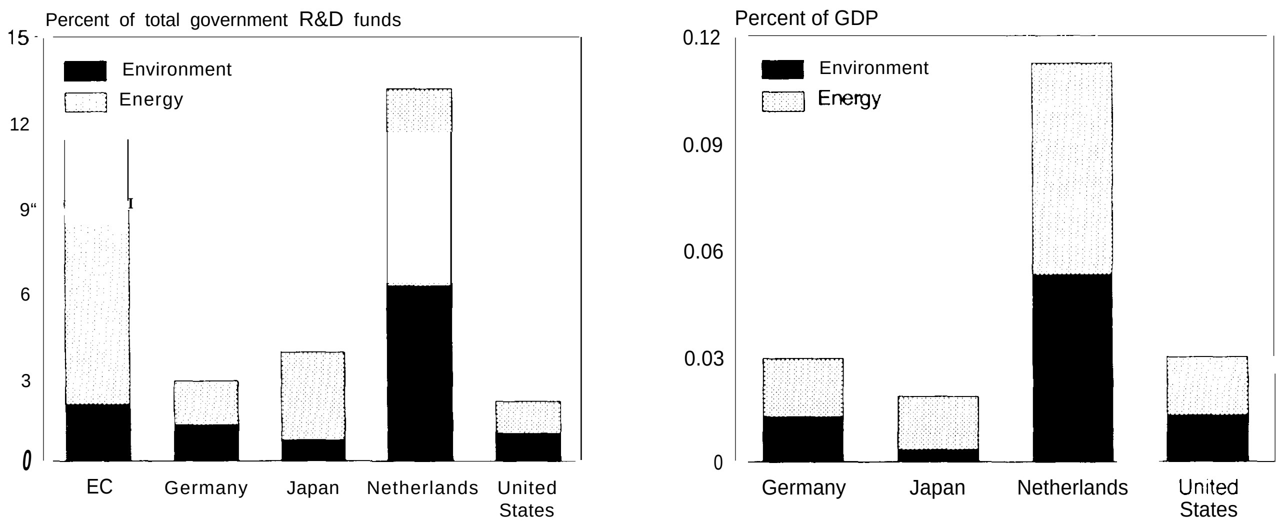
[1] Johan W. Scot, "Constructive Technology Assessment and Technology Dynamics: The Case of Clean Technologies,"*Science, Technology and Human Values* vol. *17, No.* 1, winter 1992, pp. 36-56.

[2] For example, the Canadian Government operated its Cooperative Pollution Abatement Research program in the 1970s to develop pollution control and prevention technologies for the pulp and paper industry. Development and guidance of the program were the responsibility of a joint industry-government committee, including representatives from Federal departments, pulp and paper companies, and the industry trade association and industry research organization, (Although many view the program as a success, it was eliminated in 1979 due to lack of government funds.)

[3] J.L.A. Jansen and P.J. Vergragt, "Sustainable Development: A Challenge to Technology" (Leidschendam, Netherlands: Ministry of Housing, Physical PIarming and Environment, Directorate-General for Environmental Protection June 10, 1992).

Table 10-1—National Government Funding For Selected Categories of Environmental Technology R&D in Most Recent Fiscal Year ($ million)[a]

United States	
Clean coal	$375
Renewable energy	230
Energy efficiency	365
Remediation	650
End-of-pipe and prevention	150
Total	1,770
Japan	
Clean coal	85
Renewable energy	175
Energy efficiency	310
Environment	130
Total	700
European Community	
Energy	255
Environment	55
Total	310
Germany	
Clean coal	47
Renewables and efficiency	250
Environment	230
Total	527
The Netherlands	
Energy	198
Environment	175
Total	373



a Estimates are for environmental technology categories emphasized in this report, but the estimates may not include all national government expenditures. State and local and private spending are not included. Estimates cover environmentally preferable energy (e.g. renewables, energy efficiency, and dean coal); end-of-pipe technologies; pollution prevention; and remediation. Spending on science and technology related to environmental science and modelling, nuclear waste handling, agriculture, and manufacturing not primarily related to environmental aims were not included. Most U.S. and Japanese expenditures are for FY 1993, most spending by other nations is for FY 1992.

SOURCE: See Tables 10-3,4,5,6 and 7. GDP figures and exchange rates are from International Monetary Fund, *International Financial Statistics*, selected issues.

There are some broad similarities in national support for environmental technology R&D (see table 10-1). The majority of funding in all countries examined goes for environmentally preferable energy technologies (e.g., renewable, efficiency, clean coal). With the exception of the Netherlands, much less is spent on end-of-pipe or cleaner manufacturing technology development. In addition, in many nations, including Japan and the United States, energy agencies or programs have major responsibility for environmental technology development.

This chapter examines environmental technology R&D by the United States and some major trading partners.

UNITED STATES

Fragmentation makes it difficult to quantify Federal support for environmental technology R&D. Not only is it difficult to identify all of the programs, but there is no standard definition of ''environmental. OTA estimates that the major R&D programs pertinent to environmental technologies covered in this report amount to approximately $1.8 billion, divided among energy ($1 billion), remediation ($650 million), pollution prevention ($70 million), and end-of-pipe technology ($80 million). Other studies offering higher estimates have defined environmental technology more broadly, to include spending on items such as mass transit, nuclear waste transportation and storage technology, chemical toxicity assessment, and climate modeling R&D. Also, agricultural, forestry, fisheries, biodiversity, and land use related technologies, which are not examined in this assessment, may be included in some definitions. For example, a 1992 Congressional Research Service (CRS) study identified $2.2 to $2.5 billion in FY 1992 Federal appropriations for environmental technology development.[4] The Carnegie Commission on Science, Technology, and Government estimated that Federal spending for environmental R&D was $5 billion in FY 1992, but much of that is for basic science and global monitoring technologies for "Mission to Planet Earth" rather than for technologies that prevent, control, or repair environmental damage.[5]

Most Federal support for R&D on environmental technologies is devoted to cleaner energy technologies and hazardous waste remediation technologies. The latter technology is supported in large part to serve agencies' mission requirements of cleaning up contaminated sites. With some exceptions (e.g., clean coal and renewable energy R&D, programs often shared with industry), export promotion potential has not been a major consideration in setting R&D priorities.[6] Some technologies with stronger export potential now, particularly cleaner production processes and end-of-pipe pollution control technologies, receive relatively little Federal R&D support.[7] Cleaner energy and production technologies may come to have an advantage in international trade since they almost always provide a lower cost means of environmental protection than end-of-pipe or remedial clean up.

There has been little coordination of Federal environmental technology R&D. So far, EPA and other agencies that support environmental and energy technology development have not developed the necessary dialogue on the interplay between environmental problems, future environmental regulations, and needed technologies. Cooperation is critical, since EPA's regulatory process will dictate not only the technological needs of many industries, but also the approaches that might be taken.

This situation may be changing. With the end of the Cold War and the reorientation of the Federal science and technology system toward civilian technology, the Federal Government may have opportunities to integrate environmental technology concerns into new civilian technology

[4] John D. Moteff (coordinator), U.S. Library of Congress, Congressional Research Service, *The Current State of Federal R&D in Environmental Technologies*, 92-675 -SPR, Aug. 25, 1992.

[5] Mission to Planet Earth consists of programs and projects to better understand the biological, chemical, and physical processes that influence and control the Earth's environment. Monitoring, modeling, and analytic technologies are key areas of technical development. Carnegie Commission on Science, Technology, and Government, *Environmental Research and Development: Strengthening the Federal Infrastructure* (New York, NY: Carnegie Commission, December 1982), pp. 35-37, 115-129.

[6] See Trade Promotion Coordinating Committee, *Towarda National Export Strategy*, Report to the United States Congress, Sept. 30, 1993, p. 43.

[7] Office of Conservation and Renewable Energy, Office of Industrial Technologies, *Federal Agencies Active in Waste Minimization and Pollution Prevention* (Washington DC: U.S. Department of Energy, July 31, 1992); also The Massachusetts Toxics Use Reduction Institute, *Toxics Use Reduction Research Directory* Owen, MA: University of Massachusetts Lowell, 1992).

initiatives. Recent and pending legislation call for more commercial orientation of federally funded environmental technology R&D (ch. 2), although funding and implementation are uncertain.

Both the Bush and Clinton administrations have taken steps to coordinate Federal R&D. At the end of the Bush administration, a Subcommittee on Environmental Technology was established within the Committee on Earth and Environmental Sciences of the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET), an interagency group chaired by the President's science adviser.[8] The Subcommittee is taking inventory of Federal environmental technology R&D, and considering how it might be better coordinated and ranked.[9] Pursuant to President Clinton's 1993 Earth Day address, the Commerce Department established an interagency Working Group on Environmental Technology and Trade, chaired by the Chief Scientist in DOC's National Oceanographic and Atmospheric Administration (NOAA). The working group, whose report was scheduled for release at press time, addresses environmental technology development, diffusion, and exports. It is working closely with the Environmental Trade Working Group of the interagency Trade Promotion Coordinating Committee (see ch. 6). FCCSET's Manufacturing Committee is also examining the place of environmental factors in federally supported manufacturing R&D.

The administration also established an Environmental Technology Initiative led by EPA to foster links with the Department of Agriculture, DOC, DOE, National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), and other agencies. The Initiative seeks to promote an interagency approach to identify environmental problems and work toward potential technical solutions.[10] EPA is still in early stages of implementing the initiative. It remains to be seen whether EPA will develop a systematic and strategic process, involving other Federal agencies and industry, to best target these funds. Industry involvement is critical for identifying the most relevant technological needs and opportunities for a specific industry, particularly cleaner production technologies.

The FCCSET efforts and the export report are being advanced by a high-level interagency working group, formed by the Office of Science and Technology Policy (OSTP) and other White House offices. That group is working "with the research agencies to ensure that all technology programs, not just those focused on environmental technologies, are considering the environmental applications of the technologies they are developing."[11] OSTP is developing an environmental technology strategy to guide near-term and long-term Federal policies. Whether these coordinating bodies can bring coherence to Federal policy for environmental technology and trade, and integrate regulatory and technology issues into the policy process, is still an open question.[12]

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[8] "Charter: Subcommittee on Environment Technology, Committee on Earth and Environmental Sciences, Federal Coordinating Council on Science, Engineering, and Technology," signed by D. Allan Bromley, Chairman, Federal Coordinating Council for Science, Engineering, and Technology, Jan. 4, 1993. The Subcommittee includes, among other agencies, NSF, EPA, DOE, NASA, the U.S. Department of Agriculture (USDA), and the Department of Health and Human Services (HHS).

[9] John H. Gibbons, *Assistant to the President* for Science and Technology, Director, Office of Science and Technology Policy, *testimony* at hearings before the House Committee on Science, Space, and Technology, Subcommittee on Technology, Environment, and Aviation, July 15, 1993, p. 8.

[10] Ibid.

[11] Ibid.

[12] The President's Council on Sustainable Development might also address how to prioritize Federal environmental technology efforts.

Public-Private and Private-Private Cooperation

The usefulness of Federal environmental technology R&D to industry depends to a large degree on the nature and extent of Federal/industry cooperation. Such cooperation is largely limited to some joint technology development at Federal labs and some direct funding of individual firms.

DIRECT FUNDING OF INDIVIDUAL PROJECTS

One common model for Federal-industry interaction is for the Government to directly fund specific industry projects proposed in response to a Federal solicitation. In many cases, industry must finance part of the research. A number of programs follow this model. The National Institute of Standards and Technology's (NIST) Advanced Technology Program (ATP) makes project specific grants for half of the cost of R&D. In ATP's first 3 years, NIST awarded $187 million in grants; 7 percent was for "energy and environment."[13] Many DOE programs, including the Clean Coal Technology Program, the Office of Industrial Technology's industrial waste minimization and energy conservation programs, the Photovoltaic Manufacturing Technology Program, and several other renewable energy R&D programs, also fund specific industry projects.

Such efforts can provide companies with funds to conduct research on specific projects that might be too risky to undertake alone. The programs fund promising projects—whether proposed by one firm or many. However, research by one firm does not necessarily diffuse through the industry. This is a drawback for many environmental technologies, for which wide industrial participation is often a key to effective diffusion. Moreover, funding of individual projects may not be enough to catalyze broader action on a longer term research agenda.

FEDERAL LABORATORY TECHNOLOGY COOPERATION AND TRANSFER

Since 1980, Congress has passed laws to promote the transfer of technology from Federal laboratories to industry .14 Mechanisms include licensing of patents, industry use of laboratory facilities, researcher exchange programs, research for hire by companies, and research collaboration between a laboratory and industry, either informally or through work agreements.

One kind of formal agreement is the CRADA.[15] CRADAs have one major restriction: while the partner may contribute both money and in-kind resources (personnel, facilities, etc.), the lab may contribute only in-kind resources. Because industry puts up resources, it is likely to support only technology with commercial promise. This cooperative arrangement enables industry to tackle risky, long-term, or expensive projects that it might not be able to afford on its own. This leveraging of a fro's R&D resources is multiplied when the labs work with an industry consortium rather than just one firm.

It is difficult to accurately determine how much environmental R&D, including CRADAs, the laboratories do. One survey of the labs reported

13 "Technologies Funded by ATP: As a percent of $187 M Awarded: ATP Competitions 90-01, 91-01, 92-01," chart in presentation by George Uriano, NIST, entitled "The ATP: Current Status and Strategic Plan for Expansion," printed in Institute of Electrical and Electronics Engineers, Inc., United States Activities, "1993 National Forum: Conversion Modernization% and Restructuring of U.S. Resources: Goals, Strategies and Incentives: Proceedingraphs [sic]: June 29-30, 1993."

14 See u.S. Congress, Office of Technology Assessment *Defense* Conversion: *Redirecting R&D,* OTA-ITE-552 (Washington, DC: U.S. Government Printing Office, May 1993), pp. 97-99; 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), pp. 184, 193.

15 Congress explicitly permitted CRADAs in 1986 for government-operated Federal laboratories and in 1989 for contractor-operated Federal laboratories (e.g., DOE's national labs). See Office of Technology Assessment, *Defense Conversion: Redirecting R&D,* op. cit., footnote 14.

environmental technology CRADAs and funding for some labs, but not others.[16] For example, the Army's Edgewood Research, Development and Engineering Center reported spending $1.8 million and signing four environmental technology R&D CRADAs in 1992. EPA reported having 50 active CRADAs in FY 1993, with over $5 million of total Federal funding (although $3.1 million is for a CRADA with Exxon for oil spill cleanup research).[17] Some of these CRADAs may be for technologies not covered in this report, such as climate modeling.

OTA found that of the 382 CRADAs signed by DOE through April 1993, with Federal funding totaling $321 million, 18 ($6 million) were in the areas of environmental restoration and waste management, and 68 ($24 million) were in the areas of energy efficiency and renewable energy (some of those, such as for superconductivity and bulk power transmission technologies, are beyond the scope of environmental technologies considered in this report).[18] DOE's Office of Industrial Technology also relies on the DOE laboratories to conduct joint research with industry on some clean technology and energy conservation technologies.

While CRADAs provide an opportunity to link the government's expertise in environmental technology with industry-they have proven to be cumbersome to negotiate, particularly at DOE's large weapons laboratories (Los Alamos, Sandia, and Lawrence Livermore).[19]

GOVERNMENT SUPPORT OF INDUSTRY CONSORTIA

Perhaps the model that brings industry and government in the closest partnership is government support of industry consortia. A well-known example is SEMATECH, a government-industry partnership to develop semiconductor manufacturing technology. Its industry members, including semiconductor manufacturers, contribute $100 million a year, matched by DOD's Advanced Research Projects Agency (ARPA), formerly the Defense Advanced Research Projects Agency (DARPA). While ARPA exercises some supervision over SEMATECH's operations, industry members are largely free to choose how to spend SEMATECH's budget. The conference report on SEMATECH's FY 1993 funding authorization states that at least $10 million of the $100 million in government funds ''should be utilized for development of pollution-preventing, environmentally safe microchip manufacturing processes.''[20] SEMATECH believes that more than $20 million of its calendar year 1992 R&D spending met this requirement. This figure takes into account both projects with environment as the sole or principal motivation (e.g., alternatives to the use of CFCs), and an appropriate share of funding for projects with environment as a subordinate motivation (e.g., efficiency improvements that reduce the waste generated).

The National Center for Manufacturing Sciences (NCMS), funded by industry and the Federal Government, established its environmentally conscious manufacturing program in 1991

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[16] "Cooperative Technology RD&D Report,' Federal Technologies Profile Series, Profile 02: Federal Environmental Technologies and R&D Programs, issues January 1993, vol. 3, No. 1 through June/July 1993, vol. 3, No. 6.

[17] Discussion with Larry Fradkin, Federal Technology Transfer Act Coordinator, EPA, Office of Research and Development, Office of Science, Planning and Regulatory Evaluation, October 1993.

[18] Office of Technology Assessment, *Defense Conversion: Redirecting R&D*, op. cit., footnote 14, pp. 103-105 (entry for funding source "ER" in tables 4-1 and 4-2). The tables mistakenly report these amounts as $321,000 and $6,000. However, the amounts represented are millions, not thousands, as indicated by the text on p. 103.

[19] Ibid; also Don Walkovicz, Executive Director, U.S. CAR, personal communication, June 18, 1993.

[20] National Defense Authorization Act for Fiscal Year 1993 [Public Law 102-484], Conference Report to Accompany H.R. 5006, House Report 102-956, p. 633.

Table 10-2—R&D Consortia Formed by the United States Council for Automotive Research*

1. Automotive Composites Consortium
2. Auto OII/Air Quality Improvement Research Program
3. United States Advanced Battery Consortium
4. CAD/CAM Partnership
5. High Speed Serial Data Communications Research and Development Partnership
6. Environmental Science Research Consortium
7. Vehicle Recycling Partnership
8. Low Emissions Technologies Research and Development Partnership
9. U.S. Automotive Manufacturers Occupant Safety Research Partnership
10. Low Emissions Paint Systems Consortium
11. Automotive Materials Partnership
12. Supercomputer Automotive Applications Partnership

•Items listed in **bold** type are concerned entirely or in substantial part with environmental technology

SOURCE: United States Council for Automotive Research.

and developed a list of clean technology projects where increased collaboration and sharing would produce significant benefits. NCMS has funded approximately 35 projects to date, about half on ozone-depleting substitutes and solvent free alternative processes, and others on technologies including sensor development for better process control, plating emissions controls, reduced lead use in electronics manufacturing, and waste remediation. NCMS also established a program to help companies build environmental concerns into the design process.

The United States Council for Automotive Research (USCAR), an umbrella organization serving the big three U.S. automobile manufacturers (General Motors, Ford, and Chrysler), was formed in June 1992 to promote U.S. automobile manufacturing competitiveness, to monitor and coordinate cooperative R&D efforts, and to recommend further areas for cooperation.[21] Twelve R&D consortia are under this umbrella (see table 10-2).

For example, the Low Emissions Paint Systems Consortium will conduct research on alternatives to reduce volatile organic compound (VOC) emissions, including electrocoating, powder-based primers, surface coats, clear-coat paint systems, and water-based base coats (see ch. 7). Some consortia have Federal or State participation and funding, The Environmental Research Consortium, for example, cooperated with the Michigan Department of State's Bureau of Automotive Regulations and U.S. EPA to evaluate the effectiveness of remote vehicle emissions sensing devices and to measure the impact of routine maintenance on exhaust emissions.

The auto consortium with the most significant government funding is the Advanced Battery Consortium (ABC). Through ABC, industry funds are matched equally by DOE money. Total funding (industry plus DOE) for the ABC is $264 million. DOE's share is spent primarily through research contracts to participating companies; also, five DOE laboratories have signed a total of eight CRADAs with ABC.[22]

Although USCAR has not surveyed foreign country participation in its consortia, it is reportedly not very large.[23] At times, however, participation of a foreign firm with a key technology is deemed necessary. For example, the French fir-m Saft Batterie is participating in ABC because it holds the rights to a technology (lithium polymer battery) that is necessary for the progress of the project.

The Clinton administration recently announced a partnership with the Big Three automakers (through USCAR) aimed at strengthening U.S. competitiveness, in part by developing technologies for a new generation of vehicles up to three

21 In part, information about U.S.CAR comes from Don Walkovicz, Executive Director, USCAR, personal communication, June 18, 1993.

22 In addition, Calstart, a non-profit consortium designed to foster the development of an electric vehicle industry in California, received $4 million in Federal funds under the 1991 Intermodal Surface Transportation Efficiency Act.

23 Don Walkovicz, op. cit., footnote 21.

times more fuel efficient than today's car. The proposal relies heavily on the capabilities of the national laboratories to conduct the research in partnership with the automakers, and will be managed by the Undersecretary of Commerce for Technology.

Although not specifically intended to do so, coordination among U.S. auto manufacturers through US CAR has facilitated cooperation with Federal entities such as DOE's national laboratories. It is easier for those laboratories to work with an industry consortium than individual fins, because issues such as fairness and intellectual property are easier to address. (U.S. subsidiaries of foreign auto companies are not members of the consortium.) USCAR estimates that the number of CRADAs in which its consortia participate lies somewhere in the teens.[24]

Several other industry technology organizations cooperate with the government on R&D and demonstration projects.[25] The Electric Power and Research Institute (EPRI) and Gas Research Institute (GRI), which are supported by member utility companies but receive some Federal funds, are well-known examples. EPRI's 1993 R&D and demonstration plan includes $56 million for management of air and water quality and utility wastes; $30.4 million for improved energy-use technologies (including electric vehicles); and over $36 million for environmentally significant nonnuclear energy supply and storage technologies.[26] EPRI also supports research **germane to** manufacturing industry, in part to develop electrotechnologies. These include Brayton-cycle heat pumps to recover solvents in air, reverse osmosis for reusing water in the food products industry, and thermal reclamation of foundry sand.[27] GRI budgeted $39.3 million for environmental R&D in its 1993 plan, and much of the $64.9 million allocated for gas-use technology R&D might also be environmentally beneficial.[28] The American Water Works Association (AWWA), an organization of U.S. and Canadian water supply utilities, funded about $6 million of R&D related to drinking water quality and water conservation in 1993.[29] The Water Environment Research **Foun**dation of Water Environmental Federation (WEF) funded approximately $2.6 million in research in 1993.[30]

EPRI, GRI, AWWA, and WEF all conduct or fund R&D jointly with Federal and State agencies, member firms, and each other in order to leverage their resources. As utility associations (except for WEF, which also includes manufacturers and services providers), these organizations may be better positioned to conduct cooperative R&D than some other kinds of industry associations. This is because utility companies do not usually compete directly against one another for business. In other industries, disputes over sharing technical data and patent rights could be more of an issue. However, such disputes may be less

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24 **Ibid.**

25 **Individual utilities also conduct environmental R&D relevant to their own operations and to help their customers mee**environmental **requirements. For example, Southern Co., an electric utility holding company, has funded the development of several** electro-technologies **important to industrial customers.**

26 Electric **power Research** Institute, **Research,** *Development& Delivery Plan 1993-1997* (Palo Alto, **CA:** Electric Power Research Institute, January 1993), **p.** 21.

27 **John Svobada,** *Foundry Technology—An Overview* **(Pittsburgh, PA: The** EPRI **Center for Materials** Production, **Carnegie Mellon Research Institute, January 1991).**

28 **Gas Research Institute, 1993-1997** *Research & Development Plan and 1993 Research & Development Program (Chicago,* IL: Gas Research Institute, April 1992), p. 40.

29 James F. Manwaring, Executive Director, American Water Works Association Research Foundation, personal communication, Sept. 21, 1993.

30 Water Environment Research Foundation, *1992-1996 Research & Development Plan* **(Alexandria, VA: Water Environment Research Foundation, 1992), p. 13.**

prominent for environmental technologies, particularly add-on technologies, than for non-environmental product or process technologies closer to core areas of business.

Some consortia receive little or no government money, but could possibly serve as institutional vehicles for government to support environmental technology. For example, the Center for Waste Reduction Technologies of the American Institute of Chemical Engineering, which includes most of the leading U.S. chemical manufacturers, spends over $1 million a year principally to support university-based and industrial R&D on pollution prevention related to the chemical industry. Research projects include ultrafiltration, mass exchange networks, VOC emissions recovery, and total water reuse. It recently received a $25,000 grant from EPA to promote the development and dissemination of innovative pollution prevention technologies.[31] The Center also promotes transfer of cleaner technology to industry and supports educational and training efforts in pollution prevention.

Through the Petroleum Environmental Research Forum (PERF), 24 petroleum companies have privately funded a small number of environmental research projects, many addressing pollution prevention.[32] Member companies can fund specific projects. PERF projects so far have not involved government funding.

Channeling government research funds through industry consortia and associations has several advantages. First, industry members are more likely to know more about which of the many technical options for addressing environmental matters have the most promise for commercialization. Second, industry consortia can speed deployment of new technologies, due to strong internal communication links. Third, consortia can help avoid duplication in research, thus conserving funds. Fourth, working with a broad coalition, the government avoids favoring individual fins. Finally, the consortium can own the intellectual property developed on terms that give all members access. This lessens the possibility that the owner will not commercialize it or license it to others.

Specific Agency Programs

DEPARTMENT OF ENERGY

DOE supports more than $1.3 billion in R&D pertinent to environmental technologies covered in this report; most focus on energy and remediation. See table 10-3 for a list of selected U.S. Government environmental technology programs.

Remediation and Waste Management—DOE's Environmental Restoration and Waste Management Technology Development program supports R&D to cleanup environmental contamination from DOE facilities such as those for manufacture of nuclear weapons, and to manage radioactive and other hazardous waste generated at such facilities.[33] Funded at $362 million in FY 1993, this is one of DOE's largest environmental technology R&D programs. Almost half the funding goes to demonstration, testing, and evaluation of new technologies. Developing more cost effective ways to clean up contaminated Federal sites is likely to be a key Federal environmental priority for many years to come-given the tens of billions of dollars expected to be spent on this Federal responsibility. While these technologies have potential for use in other cleanup efforts in the United States, foreign efforts for cleanup are now much more limited than here. Even though the need for cleanup in areas such as Central and Eastern Europe and the former Soviet Union is high, it is unclear the amount of effort that will be devoted to this. Similarly, many developing nations are placing a higher priority on prevention

31 At one time it was slated to receive close to $500,000, but EPA reduced the ~@ available.

32 In 1992, 18 studies had been completed or were in progress, and 19 others were expected to begin shortly.

33 DOE has 3,700 hazardous, radioactive, and mixed waste release sites, although many are quite small.

Table 10-3-Selected Federal Programs for the Development of Environmental Technologies

Program	Public Funding ($ millions)	Period
Department of Energy		
Clean Coal Demonstration Program	225	1994
Coal R&D pertinent to cleaner coal[a]	142	1994
Solar and Renewable Energies	233	1993
Environmental Restoration Technology Development Program	362	1993
Energy Efficiency—supply and use (includes waste reduction)	316[b]	1993
Fuel Cells	51[c]	1993
National Industrial, Competitiveness through Efficiency Environment, Energy and Economics (NICE3)	2.5[d]	1993
Department of Defense		
Defense Environmental Restoration Program (DERP) Technology Program	26	1993
R&D in Environmental Compliance	129	1993
Strategic Environment R&D Program (SERDP)	170	1993
SEMATECH (supervised by ARPA)--environmental component	10[e]	1993
National Defense Center for Environmental Excellence	5[f]	1992
Environmental Protection Agency[g]		
Superfund Innovative Technology Evaluation Program (SITE)	17	1993
Environmental cleanup (excluding SITE)	19	1993
Global change and air pollution	24	1993
Pollution prevention, exploratory grants, and special projects	16	1993
Water and waste management	18	1993
Other Departments/Agencies		
Bureau of Mines -Environmental Technology	17	1993
National Science Foundation, environmental technology R&D	25[h]	1992

a Share of coal R&D devoted to cleaner burning, more efficient coal combustion; does not include liquefaction.
b Includes funding on energy efficient building technologies, industrial technologies including waste reduction, transportation technologies.
c Additional funds are spent on gas turbines and advanced engines.
d EPA also contributes a share of funds to the program.
e National Defense Authorization Act for Fiscal Year 1993 [public Law 102-484], Conference Report to Accompany H.R. 5006, House Report 102-956, p. 633. At least $10 million is earmarked for environment; actual spending on environmental R&D could be greater.
f NDCEE is a nonprofit organization separate from DOD.
9 EPA figure only includes activities funded through EPA's R&D account. Of the total listed, $39 million is for technology related regulatory support acitivites. Technology related regulatory support activities separately funded through media offices are not included.
h Estimates derived from U.S. Congress, Congressional Research Service, The *Current State of Federal R&D Environmental* Technology (Washington, DC: CRS, August 25, 1992).

and control of current sources of pollution than on clean-up of contaminated sites. However, there is growing concern in Western Europe and Japan over contaminated sites.

Fossil Fuels--DOE's Clean Coal Technology Program (CCTP), started in FY 1986, aims to develop and commercialize technology to burn coal with increased efficiency and reduced emissions from its use, including through end-of-pipe treatment and prevention. CCTP's funding grew to $415 million by FY 1992, making it DOE's largest program for environmental technology R&D, and one of the largest such Federal programs. The administration requested $250 million for FY 1994; funding beyond that year is uncertain. CCTP is oriented toward commercializing technology for sale at home and abroad. For example, it emphasizes demonstration projects, some aimed at foreign buyers; a subprogram, the Coal and Coal Technology Export Program, emphasizes development of technologies with export potential. In addition, DOE supports clean coal R&D that is not directly linked to CCTP demonstration projects ($141 million was requested in FY 1994). DOE R&D for improved engines and turbines and for fuel cells could allow fossil fuels to be used more cleanly and efficiently.

Renewable Energy—[34] DOE received $233 million for renewable energy R&D in FY 1993 ($327 million was requested for FY 1994).[35] Most of the money went to solar energy technology, including photovoltaics (PV), solar thermal energy, biofuels, and wind energy. The rest went to geothermal energy, electric energy systems and storage, and hydropower. Funding of renewable energy R&D has been quite uneven. It was highest in FY 1979 ($1.24 billion in 1992 dollars) under President Carter, at the height of the oil crisis, much lower under Presidents Reagan and Bush ($92 million in FY 1990 in 1992 dollars), before recently rising again, as environmental concerns increased and the Gulf War heightened energy security concerns.

The National Renewable Energy Research Laboratory in Golden, CO is the major Federal renewable energy laboratory, although other DOE labs, including Sandia and Los Alamos, have long-standing renewable energy research programs. Several R&D programs jointly funded by industry and DOE aim at improving commercial prospects for solar, wind, and geothermal energy. In 1992, the Photovoltaic Manufacturing Technology Program matched $20 million from seven companies with $30 million of DOE funds to improve PV manufacturing processes.[36] The Photovoltaics for Utility Scale Applications (PVUSA) program seeks to promote demand of PV technology by bringing together government, utilities, and suppliers of PV systems and components to field-test systems and identify initial utility markets. A multiyear $75 million program to lower wind energy costs to 5 cents per kilowatt-hour by the mid-1990s awarded its first $5 million (half from industry, half from DOE) to eight companies in late 1991.[37] DOE funds geothermal R&D jointly with industry.

The unevenness in Federal renewable R&D funding has made potential investors wary. Although funding is now increasing, there is no guarantee that it will not be reduced once again.

Energy Efficiency—DOE's Energy Efficiency (EE) (formerly called Conservation) budget for R&D in FY 1993 was $316 million, including $140 million for the transportation sector, $117 million for the industrial sector (including waste

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34 Another OTA project, *Renewable Energy Technology: Research, Development, and Commercial Prospects,* due for completion in early 1994, will examine this area extensively.

35 U.S. Department of Energy, *Budget Highlights: FY 1994* (Washington DC: DOE, April 1993), p. 31.

36 Mark Crawford, "Seven Companies Awarded DOE Solar Grants," *Energy Daily,* Apr. 24, 1992, p. 3.

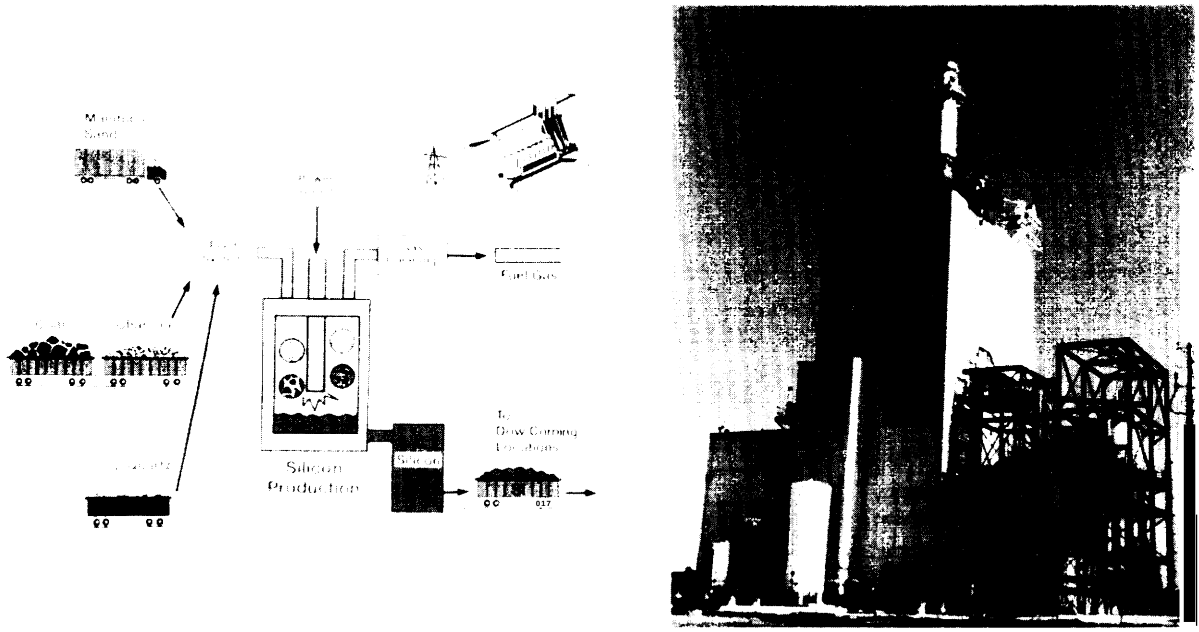
37 "NREL Launches Solar Projects," *Energy Daily,* Nov. 4, 1991, p. 4.

DEPARTMENT
OF
ENERGY

Direct Current, Closed Furnace Silicon Technology

INDUSTRIAL WASTE REDUCTION PROGRAM

U.S. DEPARTMENT OF ENERGY



Silicon production technology demonstration supported by the U.S. Department of Energy, Office of Industrial Technology. OIT supports the development of cleaner and more energy efficient industrial production processes.

minimization, discussed below), $53 million for the buildings sector, and $5 million for the utilities sector.[38] The FY 1994 funding request is $427 million.[39] Improving energy efficiency in these sectors has the potential to make them both less polluting and more competitive.

Waste Minimization—Pollution prevention activities at DOE are directed at reducing wastes at both Federal weapons production sites and in private industry. The latter effort is centered in DOE's Office of Industrial Technologies (OIT). OIT focuses principally on energy conservation in industry, but also addresses waste minimization, particularly in such technological areas as separations, sensors and controls, and materials processing. These programs constitute the major Federal industrial clean technology effort. Moreover, unlike most other Federal and State clean technology efforts targeted at the less-polluting assembly and fabrication industries, much of OIT's effort addresses the more-polluting process industries.

OIT's industrial waste minimization program was funded at $17 million in FY 1993, with expected funding of $23 million for FY 1994. Slightly over half is for waste reduction, while the remainder is for waste utilization. Costs for technology R&D are split evenly with industry; industry interest in participation exceeds supply

38 *Budget of the United States Government, Fiscal Year 1994* (Washington, DC: U.S. Government Printing Office, 1993), App.-580.

39 Ibid.

of DOE funds. Some of the projects involve companies and DOE labs. For example, Hughes, Boeing, IBM, Inland Technologies, Honeywell, and other companies have CRADAs with Los Alamos, Sandia, and Pacific Northwest Laboratories for supercritical CO_2 cleaning. Six technologies have been commercialized so far, including an ultrasonic tank cleaning process with Dupont and Merck and a no-clean soldering process developed by Motorola with Sandia and Los Alamos National Laboratories. The program has also investigated waste data needs and institutional barriers to pollution prevention, and has conducted R&D needs assessments.

DOE and EPA jointly manage the National Industrial Competitiveness Through Efficiency: Energy, Environment and Economics program ($NICE^3$), which provides small research grants to develop technologies that save energy, reduce waste, and improve competitiveness. Funding is modest; $2.5 million was appropriated in FY 1993, but funding for FY 1994 is will likely exceed $7 million, with most of the funds provided by DOE. Other OIT programs have pollution prevention aspects. For example, a number of projects in DOE's Metal Initiative have significant environmental and energy efficiency benefits. DOE has provided over $25 million and the American Iron and Steel Institute has provided over $7.6 million to develop direct steelmaking that would eliminate the highly polluting and energy-intensive cokemaking process. DOE's Metal Casting Competitiveness Research Program supports two applied R&D centers, which are partly funded and administered by industry. One of the projects involves reuse of waste foundry sand.[40]

The Energy Policy Act of 1992 (EPACT, Public Law 102-486) authorizes DOE to expand its industrial energy efficiency and waste reduction programs. For example, it authorizes a 5-year program aimed at cost-effective pollution prevention in industry and a 5-year program on advanced pulp and paper technologies. Several provisions of the Act are directed at improving energy efficiency in industry through advanced technology, thereby reducing adverse environmental impacts of manufacturing. In addition, DOE is investigating a more comprehensive role in promoting cleaner technology .41

Several factors limit the effectiveness of DOE's industrial energy efficiency and waste minimization programs. First, DOE has not integrated and coordinated waste programs directed at industrial problems and those directed at Federal weapons facilities problems. The labs' waste programs are more visible within DOE than the industrial waste reduction program efforts.

DOE's energy conservation mission requires its waste reduction projects to provide some form of energy savings.42 While other factors are considered, such as wastes reduced, cost savings, and resource use reduction, the emphasis on energy savings may cause some high toxicity but low volume waste projects to be overlooked or left to other agencies such as EPA. EPA involvement in the program has been relatively limited, although efforts to increase cooperation are being attempted.

Finally, DOE funds projects principally with individual firms or small groups of companies. Even though some industry organizations have worked with the program to identify technology needs and solutions, the program has not funded ongoing industry consortia to cooperatively develop clean technologies. As a result, widespread industrial involvement and commitment has been harder to attain. However, the program is inter-

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~ "Profitable Recycling," *EPRI Journal*, March 1992.

41 For example, see "National Clean Industry Initiative Implementation Plan, Draft,' U.S. Department of Energy, June 8, 1993.

42 National Materials Advisory Board, National Research Council, *Industrial Waste Reduction and Utilization* (Washington DC: National Academy Press, 1993).

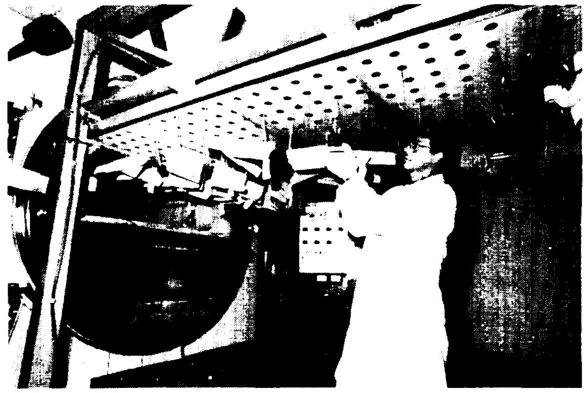
ested in working more with consortia on industry directed longer term projects.[43]

DEPARTMENT OF DEFENSE

DOD has several environmental technology R&D programs aimed at addressing the environmental impacts of its own activities, particularly remediation of contaminated sites. The Defense Environmental Restoration Program (DERP) provided about $26 million in FY 1993 to develop technology to assess and clean up contaminated DOD sites.

A program with broader relevance to industry is the Strategic Environmental Research and Development Program (SERDP), which supported $170 million of R&Din FY 1993. Created by the National Defense Authorization Act for FY 1991,[44] SERDP supports not only environmental restoration and waste management R&D, but also pollution prevention technologies. Technology transfer is an explicit part of SERDP's mission. As SERDP is authorized to apply industrial technology to DOE and DOD environmental problems, the program could increase U.S. Government purchases of innovative environmental technology from U.S. fins.

ARPA supports some environment-related R&D, although it is unclear how much. In 1992 ARPA issued a solicitation for up to $12.8 million in clean technology projects related to defense manufacturing. ARPA funds the government's share of SEMATECH as discussed above. ARPA includes environmental technology as one of 11 broad R&D areas that it emphasizes in the Technology Reinvestment program, which in part attempts to put defense technology to commercial use. In particular, ARPA will emphasize environmentally conscious electronic systems manufacturing and environmental monitors.[45]



U.S. AIR FORCE

U.S. Air Force ion vapor deposition R&D. Although most DOD environmental R&D is for remedial cleanup of contaminated sites, some work is dedicated to developing advanced manufacturing processes that lessen environmental impacts.

Many Army, Navy, and Air Force units dealing with materials, construction, and maintenance have pollution prevention R&D programs. Other DOD technology development programs, including the Manufacturing Technology Program (MANTECH) and the Industrial Modernization Incentives Program (IMIP), include modest funding for clean technology projects.

In 1990, DOD established the National Defense Center for Environmental Excellence (NDCEE) a private non-profit organization in Johnstown, PA, to lead and support DOD facilities and the associated industrial base in adopting pollution prevention and addressing other high priority environmental issues. NDCEE identifies, evaluates, demonstrates and transfers environmentally acceptable manufacturing processes to its client base and provides related information services. Issues addressed included waste minimization, air and water pollution control, and waste management and remediation. It also operates a 185,000 sq. ft. demonstration factory to perform

43 In part, this stems from limitations in Fe&~ acquisition regulations governing contracts and from the fact that OIT does not have funds set aside for unsolicited proposals.

44 Public Law 101-510, sec. 1801 (a), codified at 10 U.S.C. 2901-2904.

45 ARPA, "Program Information Package for Defense Technology Conversion, Reinvestment, and Transition Assistance," Mar. 10, 1993, pp. A-1, A-4. The Technology Reinvestment project is an interagency project, with ARPA as the lead agency.

process demonstrations, and training. DOD funded NDCEE initially at $5 million a year, and between 1994 and 1998 plans to provide $150 million.

ENVIRONMENTAL PROTECTION AGENCY

EPA's expenditures for technology development are modest. The CRS study discussed above[46] found that EPA was spending $330 million on R&Din FY 1992, but $240 million of this was for monitoring, assessing health and environmental risks, ecological assessment, and university-based exploratory research. As shown in table 10-3, EPA estimates that it spent $94 million on technology related activities funded through its R&D account in FY 93. (This figure does not include separately funded media program technology related regulatory support activities.)

As discussed in ch. 2, the Clinton administration has proposed a major increase in EPA's role in developing environmental technology. The administration requested $36 million for fiscal year 1994 and plans $80 million for fiscal year 1995 for an EPA-led interagency Environmental Technology Initiative.[47] Up to half (based on Appropriations Report language) of first year funding would be for R&D conducted through other government agencies. But, EPA is still in the early stages of developing a planning and decision process that involves other Federal agencies as well as industry. The initiative is also linked to administration objectives to reduce impediments to technology development and to support export promotion, and to U.S. Technology for International Environmental Solutions for provision of technical assistance and adaptation of U.S. technologies abroad.

EPA is focusing increased attention on the relationship between regulations and technological innovation. An internal Innovative Technology Council has broad agency participation. An outside advisory group to the EPA's administrator, the Technology, Innovation and Economics Committee of the National Advisory Council for Environmental Policy and Technology, has produced several reports and recommendations on the subject.

Most of the SITE program's funds ($17 million for fiscal year 1993) are for demonstrating innovative remediation and monitoring technologies on Superfund sites. Technology vendors operate the technology at their own expense, but EPA bears the costs of preparing sites for the demonstration, evaluating the results, and disseminating the information through bulletins, reports and electronic data bases.[48] The Municipal Innovative Technology Evaluation program (MITE-$1 million for fiscal year 1993) conducts similar evaluations of innovative technologies for recycling or disposing of municipal solid waste. EPA also conducts some R&D through CRADAs with industry (see above).

EPA, along with other agencies, provide a total of $15 million to Hazardous Substance Research Centers at universities, for basic research, technology development, and technology transfer.[49] While most of the centers concentrate on treatment and remediation, the Center for Clean Industrial and Treatment Technologies at Michi-

~ John D. Moteff, The Current *State of Federal R&D in Environmental Technologies,* Op. Cit., footnote 4, Pp. 47-49.

47 Gibbons, op. cit., footnote 9.

48 U.S. Environmental Protection Agency, "The Superfund Innovative Technology Evaluation (SITE) Program: An Evaluation of Program Effeetiveness" (Washington DC:EPA, Sept. 1992), p. ES-1.

49 Dale Manty, EPA Office of Exploratory Research, personal communication, Sept. 29, 1993.

gan Technological University partly addresses pollution prevention.[50]

EPA support for clean technology development is modest, but could grow as part of the priority placed on pollution prevention by the Administrator. EPA's R&D program has focused on developing tools for assisting pollution prevention implementation, such as opportunity assessment guides and life cycle analysis techniques, and has evaluated pollution prevention technologies. EPA's Office of Pollution Prevention and Toxics manages a design for environment program that has developed collaborative effort with specific small business sectors. (EPA also has a series of 'Green Programs' focused on voluntary adoption by industry of more efficient lighting, computers, appliances, etc.)

Although not an EPA R&D institution per se, the National Environmental Technology Applications Corp. (NETAC), a nonprofit corporation affiliated with the University of Pittsburgh Trust, was established by EPA to support environmental technology commercialization. Starting with $9 million of initial EPA funding but now financed through contracts with private, Federal, and State clients, NETAC provides independent technology evaluation services, and offers technical, marketing, and regulatory assistance to environmental technology innovators.

NATIONAL SCIENCE FOUNDATION (NSF)

CRS identified $36.6 million of NSF support for environmental technology in FY 1992.[51] Through a partnership with the chemical industry's Council for Chemical Research, NSF established the Environmentally Benign Chemical Synthesis and Processing program to stimulate university pollution prevention research.[52] The program allocates only about $2 million annually in research grants. Industrial participation in the research is required.

In addition, some of NSF's Industry/University Cooperative Research Centers (I/U Centers) and Engineering Research Centers (ERCs) investigate environmental technology. The I/U Center for Hazardous and Toxic Substances includes NJIT, Princeton University, Rutgers University, and the University of Medicine and Dentistry of New Jersey, and conducts research principally on waste treatment and remediation. Rutgers also houses a plastics recycling I/U Center.[53] One ERC based at the University of California at Los Angeles is dedicated to research on hazardous materials. The Advanced Combustion ERC at Brigham Young University is another center directly relevant to environmental technology.

Some I/U Centers and ERCs, while not focused explicitly on environment, could contribute to pollution prevention in areas such as improved process monitoring, thin films, steelmaking, and automation. For example, the Center for Process Analytical Chemistry at University of Washington studies problems of chemical process monitoring and analysis. This area is important to improved chemical process control and efficiency and environmental performance.

OTHER AGENCIES

Several other agencies fund R&D for environmentally related technologies pertinent to this assessment. They include the Department of Commerce (including the activities of NIST described above), NASA, and the Bureau of Mines. Within DOC, at least three of the seven NIST Manufacturing Technology Centers (MTCs) provide technical assistance to help industry address environmental concerns, including pollution prevention (see ch. 8).

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50 Some of these EPA Centers receive funds from other agencies. For instance, the New Jersey Institute of Technology (NJIT) is part of both an EPA center and a National Science Foundation Industry/University Cooperative Research Center for hazardous and toxic substances.

51 John D. Moteff, The *Current State of Federal R&D in Environmental Technologies,* op. cit., footnote 4, pp. 39-42.

52 Ivan Amato, "The Slow Birth of Green Chemistry," *Science,* vol. 259, Mar. 12, 1993.

53 The New Jersey Commission on Science and Technology also funds these centers.

STATE AND LOCAL PROGRAMS

Many States fund environmental technology through broader technology programs designed to commercialize new technologies and create jobs. Often these programs fund technologies for energy conservation and renewable energy. For example, the New Jersey Corp. for Advanced Technology was recently established to support development and commercialization of environmental technologies. The California Environmental Technology Partnership is another example of a new State environmental technology initiative. In addition, a number of States have coal development programs, some of which concentrate on clean coal technology.

Some programs provide a small amount of support to small business for clean technology R&D. California, Illinois, New Mexico, New York, North Carolina, and Washington fund the development of pollution prevention or industrial waste recycling technologies. The programs concentrate on areas such as metals recovery in plating, painting, and alternative cleaning. California's South Coast Air Quality Management District provides $25 million a year for a wide variety of technology projects, including technologies related to reduced mobile source pollution (e.g., electric cars, electrically heated catalytic converters, natural gas vehicles) and pollution prevention (e.g., low VOC coatings).

U.S. Private Sector R&D

It is difficult to measure private-sector environmental technology R&D, partly because of the definitional issues already discussed. Pollution abatement R&D is only a small share of total industrial R&D. According to the Commerce Department's Bureau of Economic Analysis (BEA), private environmental R&D amounted to about $2.4 billion in 1991 (and $2.2 billion in 1990).[54] To make these estimates, however, BEA assumed that the same ratio existed between total industrial R&D and pollution abatement R&D in 1991 as in 1978, the last year for which this data was broken out by media (e.g., air, water). The ratio of environmental R&D to total R&D probably declined between 1978 and 1991,[55] hence the share of environment R&D in 1991 could be less than the figures reported by BEA. According to NSF, industry R&D for pollution control (including product and process R&D and excluding energy-related R&D) was $950 million in 1990, or approximately 1.28 percent of total R&D expenditures by industry.[56] As discussed below, industry estimates of pollution control R&D (including product and process R&D and excluding energy-related R&D) are higher, suggesting that perhaps as much as 50 to 100 percent more than the NSF estimate is being spent.

The NSF data shows wide variation among sectors. In the electrical equipment industry (SIC 36), which has relatively low environmental compliance costs, pollution control R&D is less than one-tenth of 1 percent of total R&D. However, in the petroleum industry, which has relatively high compliance costs, pollution control R&D in 1992 ($72 million) accounted for 3.4 percent of total R&D. In the pulp and paper industry, which also has relatively high compliance costs, pollution control R&D ($18 million) accounted for 2.4 percent of total R&D. Data generated by industry associations indicate a higher share of R&D arising from environmental considerations. The American Petroleum Insti-

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S4 Gary L. Rutledge and Mary L. Leonard, ''Pollution Abatement and Control Expenditures, 1987 -91,' *Survey of Current* Business, May 1993, pp. 60-61. This compares with about $43 billion in 1991 total private sector environmental compliance costs, including R&D (table 7-l).

55 In large part this may be due t. reduced expenditures (in constant dollars) by automakers on R&D [o reduce vehicle emissions. In 1978 (the last year data was separately available from NSF), automakers accounted for 55 percent of environmental R&D.

56 NSF asks firms to report R&D related to &@@ pollution abatement products or product characteristics or to designing pollution abatement features into processes. Presumably, this would include R&D performed by environmental goods and services firms, clean product R&D (e.g., reformulated gasoline), and cleaner process R&D performed by regulated industry (either end of pipe or pollution prevention), National Science [illegible] *of* [illegible] *Research and Development* (Washington, DC: NSF, various years),

tute reports that the petroleum industry spent $175 million on environmental R&D in 1990, including an estimated $50 million on reformulated gasoline. Nonproduct pollution control R&D amounted to about 6 percent of total R&D.[57] Similarly, the pulp and paper industry reports spending $32.3 million in 1990 on environmental R&D (most nonproduct) or about 4.4 percent of total R&D.[58]

Finally, one source concluded that industry spends approximately 13 percent of R&D funds on environmental technology, or roughly $10 billion; however, the conclusion apparently was based on inaccurate interpretation of a survey by the Industrial Research Institute (IRI). Pollution control R&D is probably closer to the 1 to 2 percent figure .59

The limited evidence that is available suggests that half or more than half of U.S. private environmental R&D is conducted by regulated industry rather than by environmental fins. It appears that environmental firms as a whole are less research-intensive than manufacturing as a whole, which spends approximately 3.3 percent of sales on R&D.[60,61]

Some estimates for environmental equipment firms show R&Din the range of 1 to 2 percent of sales. Research-Cottrell, an air pollution equipment manufacturer, spent between $3 and $5 million on R&D in 1992, or 1.1 to 1.9 percent of sales. Members of the Manufacturers of Emission Controls Association (MECA) expect to perform R&D on catalytic converters and diesel falters amounting to about 1.8 percent of sales of those items.[62] Ionics, a maker of membranes and falters and a designer and builder of water filtration units, spent 2.1 percent of sales on R&D. The Institute of Clean Air Companies, which includes both equipment and service providers, estimates R&D at 3.2 percent of sales, based on a survey of half of its 50 members. (For turnkey system suppliers, the estimate was about 1 percent.)[63] The 18 firms on the board of the Water and Wastewater Equipment Manufacturers Association informally estimated that they spent about 4 percent of sales on R&D.[64] Allied-Signal's Engineered Materials Division, which produces environmental catalysts for vehicles and fixed sites, spent $117 million or 4.8 percent of 1991 sales on

57 This is similar t. the share in the early 1980s, when nonproduct environmental R&D in the petroleum refining and extraction industry (SIC 13 and 29) accounted for approximately percent of total R&D. American Petroleum Institute, *Environmental Expenditures of the United States Petroleum Industry, 1975-19&$* (Washington DC: API, 1985); API, *Petroleum Industry Environmental Performance, 1992* (Washington DC: API, 1992); National Science Foundation Survey *of Industrial Research and Development,* op. cit., footnote 56.

58 National Council of the Paper Industry for Air and Stream Improvement, Inc., *A Survey of Pulp and paper Industry Environmental Protection Expenditures-1990* (New York, NY: NCASI, October 1991).

59 Brian Rushton, "HOW Protecting the Environment Impacts R&D in the United States,' *Research Technology Management,* May-June 1993, p. 13. The IRI survey asks 246 firms to list the 10 process-related R&D areas expected to be the most important over the next 5 years. Sixty-nine firms responded, listing an average of about 6 areas perfirm. Of 416 total listings, 47 (1 1.4 percent) were in environmental areas. Firms were also asked to report what areas the government should fund, and 13 percent of the responses were for environmental technology. However, the responses do not allow inferences to be made about the relative importance of environmental R&D to firms or the amount spent in industry. Moreover, even if the 11.4 percent figure represents the share of funds, it is as a share of process R&D, not total R&D, and would total approximately $1.9 billion, not the $10 billion reported by Rushton.

60 Unpublished data, National Science Foundation.

61 Data are not available on other nations' environmental industry R&D intensity. However, OECD reported that in 1981, the German pollution control industry was 33 percent more R&D-intensive than the rest of German industry in terms of R&D spending per employee. "Clean Technologies: A Dilemma For Industry," *OECD Observer,* November/December, 1987.

62 MECA members expect to spend $200 million in R&D related to these products "in the 1990s, " and expect domestic sales of these items to 'approach $8 billion between now and the end of the decade, " with foreign sales of $250 to $450 million a year. MECA press release titled "Clean Air Act Spurs Growth of U.S. Motor Vehicle Emission Control Industry," April 1993.

63 Jeff Smith, Executive Director, Institute of Clean Air Companies, personal communication, July 21, 1993.

64 Dawn Kristoff, Water and Wastewater Equipment Manufacturers Association, personal communication, July 12, 1993.

R&D, a high percentage for U.S. manufacturing.[65] Instrument manufacturers probably spend more on R&D than other environmental equipment manufactures. Thermo Instrument Systems, a subsidiary of Thermo Electron that manufacturers analytical and monitoring instrument widely used in environmental applications, dedicates nearly 7 percent of sales to R&D.[66]

Environmental service fins, including waste management firms, appear to spend much less than manufacturers. For example, Waste Management of North America (the solid waste subdivision of WMX Technologies) spent less than 0.25 percent of its $4.3 billion in sales on R&D in 1992. However, some other WMX divisions do spend more for R&D and may transfer technology to Waste Management.[67] Some environmental companies do not conduct formal R&D, but work on product and service development with customers and suppliers. For example, Safety Kleen has been working with other companies in developing better chemical recovery and recycling processes and alternative solvents, although there is no formal R&D division in the company.

Small, R&D-intensive start-up firms might spend more as a share of sales, although total expenditures are likely to be small. These firms are a source of new technology for larger firms that often either acquire the firm or license the technologies. Because of this, formal R&D expenditures by large environmental firms may understate their efforts in obtaining new technology.

Assuming that the U.S. pollution control equipment sector has annual sales of around $30 billion annually and that it spends 2.5 percent of sales on R&D, and that the service sector (excluding water supply, resource recovery, and environmental energy sources) has sales of around $60 billion and spends around 0.2 percent on R&D, then the environmental industry sector would be spending on the order of $750 million to $870 billion per year on R&D. While this figure is just a guess, it does suggest, together with the estimates above, that regulated industry, as opposed to environmental firms, may conduct half or more of the private environmental technology R&D in the United States.

JAPAN

Within the Japanese Government, the Ministry for International Trade and Industry (MITI) has a lead role in supporting energy and environmental technology R&D, although the Environment Agency also funds a small amount (see table 10-4). Most of MITI's effort is managed by the New Energy and Industrial Technology Development Organization (NEDO), a quasi-government organization that funds industry R&D directly. The vast majority of government support for environmental technology R&D is for energy technology, including renewable energy. MITI also supports R&D for more productive manufacturing process technologies that also have related environmental benefits. With the exception of work to develop CO_2 recovery technologies, relatively little is spent on technologies related directly to pollution control and waste remediation.

Mill Programs

MITI's Agency for Industrial Science and Technology and its Bureau of Environmental Protection and Industrial Location manage at least two pertinent R&D organizations: NEDO, and Research Institute of Innovative Technology for the Earth (RITE). MITI's involvement in these programs could enhance potential commercial

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65 Stephen Lipmann, "U.S. Environmental Companies' Competitive Strategies: Eleven Case Studies," contractor report prepared for the Office of Technology Assessment, April 1993.

66 Ibid.

67 For example, Wheelabrator, a subsidiary of WMX that develops and operates waste-to-energy, air pollution control, and wastewater treatment facilities, spent about 1.7 percent of 1992 sales on R&D.

Table 10-4--Selected Japanese Environmental Technology R&D Programs

Ministry/program	Funding ($ million)
Ministry for International Trade and Industry	
New Energy and Industrial Development Organization (1993)[a]	
Clean coal	85
Renewable energy	170
Energy efficiency	265
Environmental technologies[b]	20
Research institute of Innovative Technology for the Earth (1993)	88
Agency for Industrial Science and Technology	
Pollution control projects (1992)	10
Direct steelmaking (1993)	50
Environment Agency	
Pollution control projects[c] (1 990)	14

a Only NEDO funding directly related to environmental or environmentally related energy was included. Industrial technology funding, coal resources development and industry rationalization, and production of alcohol was not included.

b $77 million was budgeted for global environmental projects, but $60 million was in turn allocated to RITE.

c In 1990.

NOTE: Exchange rate for 1993 is 110 yen_ $1; 1992120 yen_ $1, 1990145 yen_ $1. See table 10-1 for technologies included in this table.

SOURCES: NEDO and RITE, personal communication, October 1993; Agency of Industrial Science and Technology, "program brochure" 1993; Research and Development Corp. of Japan, "National Laboratones and Public Research Organizations in Japan" (Tokyo: JRDC, 1992).

benefit, and after new technologies are developed, MITI has the capacity to promote exports of resulting goods and services. This can facilitate technology transfer to developing countries through MITI's Green Aid Plan, which is separate from Japan's general development assistance program.[68]

NEDO

NEDO, a quasi-government agency, government-funded and under MITI's supervision, was established in 1980 in response to the 1979 oil shock to promote the development of non-oil energy technologies. As the central organization responsible for coordinating energy and some industrial-related technologies in Japan, NEDO administers, coordinates, and funds research, development, demonstration, and testing of technologies related to its mission. Much of the work is carried out by industry through contracting, although the national laboratories play a small role. Governed by a board of industry representatives, one third of NEDO's employees are corporate employees assigned to the agency for 2 to 3 years, during which time their salaries are paid by the government.[69]

NEDO's FY 1993 budget amounted to about $1.76 billion. Approximately $255 million was for clean coal and renewable energy technologies, including solar, wind, geothermal, ocean energy, alcohol, and biomass.[70] A similar amount was for energy conversion and storage technologies, including superconducting technology for electric power, advanced batteries, ceramic gas turbines,

[68] See U.S. Congress, Office of Technology Assessment, *Development Assistance, Export Promotion, and Environmental Technology Background Paper*, OTA-BP-ITE-107 (Washington, DC: U.S. Government Printing Office, August 1993).

[69] Curtis A. Moore and Alan S. Miller, The Technology Clearinghouse, "Environmental Technologies and Policies of Japan," contractor report prepared for the Office of Technology Assessment, February 1992, p. 24.

m Personal communication with NEDO official, October, 1993.

CURTIS MOORE

Tokyo Electric Power Company's 11 megawatt phosphoric acid fuel cell is the largest fuel cell installation in the world. Most of Japan's environmental R&D concentrates on improving energy technologies.

and fuel cells.[71] Another $339 million was for industrial technology, of which $77 million was for environmental technologies ($60 million of this went to RITE) .72

Because NEDO seeks to develop new energy technologies to a level where private industries can take over and commercialize them, it funds both development and demonstration projects. NEDO also supports several foreign energy demonstration projects, principally in the Asia-Pacific region, including fuel cells in Thailand and photovoltaics in Australia.

Fuel cells have been a particular focus of NEDO's R&D. Fuel cells, which convert fuel into electricity through chemical oxidation rather than combustion, emit less pollution and are quieter, more compact, and more energy-efficient than combustion engines. Thus, some believe that they will become an important source of electricity in the next century, both in central generating stations and in smaller applications that use both the electricity and the heat generated by the fuel cell. Vehicle applications are also possible.[73] NEDO has funded many fuel cell demonstration projects, including a 4.5-megawatt generator built for Tokyo Electric Power Co. in the early 1980s, and an 1 l-megawatt unit-the world's largest—put into operation in 1990.[74]

The industrial technology program is oriented toward developing advanced technologies that are of use to industry but 'have high development risks and require long lead times. ' '[75] Most of these projects, such as new materials, precision material processing, biotechnology, manufacturing technology, and medical equipment, are in areas not directly related to the environment. However, because advanced industrial process technologies will become increasingly important in pollution prevention, a number of the projects will have environmental implications. For example, large scale advanced chemical processing technology for high purity separations processes, research on ion implantation of metals, and high temperature materials for heat exchangers have potential to lead to cleaner production processes.

Because of an increased concern for global environmental problems, NEDO's industrial technology mission was expanded in 1990 to include technology that protects the global environment. To facilitate this work, RITE was established to fund and conduct research in this area, as a foundation more oriented to the private sector than NEDO (see below).

Many of NEDO's energy and environment programs were grouped into the Sunshine Project (developing new and renewable energy sources), the Moonlight Project (energy conservation), and the Global Environmental Technology Program; now, all three are rolled into the New Sunshine

71 NEDO, *Research and Development Project Plans for FY 1992 [1]* (Tokyo: NEDO, 1992).

72 The remainder was for non-environmentally related coal technology development and two separate NEDO missions, rationalization of the coal industry and production of industrial alcohol.

73 The recent Clinton administration initiative to produce a clean car emphasizes fuel cells.

74 Curtis A. Moore and Alan S. Miller, ''Environmental Technologies and Policies of Japan, " op. Cit., footnote 70.

75 NEDO, op. cit., footnote 71, p. 7.

Program, with a planned budget equivalent to $13.6 billion over 27 years, from 1993 to 2020 (an average of $500 million per year).[76] This program aims in large part to reduce carbon dioxide emissions, and thus contributes to MITI's New Earth 21 Concept, a 100-year plan to reduce and stabilize carbon dioxide emissions.

RITE

RITE is a public foundation which is commissioned by MITI, related prefectures, and the private sector to fund and conduct R&D, most of it related to global warming.[77] With a budget of $88 million in FY 1993 (about two-thirds provided by NEDO) RITE funds environmental projects, the largest being carbon dioxide separation, recovery, and fixation technologies, and CFC-substitutes, particularly non-CFC refrigerants.[78]

RITE projects typically involve a large number of corporate partners. For example, a project to increase use of scrap in steelmaking involves nine of the largest Japanese steelmaker as well as the Japan R&D Center for Metals. Industry researchers work on RITE projects for about 2 years; they remain at their firms, which continue to pay their salaries, but are given the title of ''RITE researcher and matching funds to support the research. RITE also makes matching grants for research by firms, universities, and other nonprofit organizations ($12 million FY 1991). International participation in RITE projects is encouraged, although only one such project (with Italian collaborators) is underway.

OTHER MIT! GROUPS

Some MITI institutes and laboratories conduct a small amount of environmental technology R&D.[79] AIST administers the National Institute for Resources and Environment (NIRE), partly dedicated to environmental technology. Other laboratories, including the National Institute of Materials and Chemical Research and the Government Industrial Research Institute, conduct some work on environmental technology. In 1992 AIST supported 40 pollution control projects at laboratories, spending the equivalent of $9.4 million .80 However, funding for these projects has declined by approximately half (unadjusted for inflation) since its peak in the 1970s. AIST has helped organize several private research consortia to work with its laboratories on environmental technology, including biodegradable plastics and emission reduction methods. AIST is spending $425,000 in FY 1993 to develop an eco-factory concept, essentially industrial processes to facilitate disassembly and recycling of manufactured goods.[81] Finally, AIST Spent approximately '[50] million in 1993 on a project to support development of direct ironmaking.

Another MITI agency, the Agency of Natural Resources and Energy (ANRE), funds relevant research, sometimes in coordination with AIST. For instance, both AIST and ANRE support clean coal and advanced combustion R&D. The Electric Power Development Corp., Center for Coal Utilization Japan, and the Central Research Institute of Electric Power Industry (Japan's equiva-

76 Personal communication with NEDO **official, October,** 1993.

77 "RITE: Research **Institute of Innovative Technology for the Earth, " program pamphlet,** undated.

78 Smaller projects include: bioreaction processes to produce chemicals; catalysts capable of reducing unwanted byproducts in chemical processing; biodegradable plastics; steelmaking processes capable of using larger amounts of scrap with less energy consumed; and catalytic NO_x removal from combustion. New Energy and Industrial Technology Organization, *The Innovation of New Technology* (Tokyo: NEDO, **October 1992).**

79 MITI, **"AIST: Agency of** Industrial Science and Technology, " program brochure, 1993.

80 ''AIST FY92 Industrial Pollution R&D Outlined,'' as cited in Foreign Broadcast Information Service, *JPRS Report: Environmental Issues, JPRS-TEN-93-025,* **Sept. 21, 1992.**

81 Hisayoshi **Sate,** ''Ecofactory—Concept **R&D Themes, " New** *Technology Japan, FY 1992,* special issue published by the Japanese External Trade Organization, 1992.

lent to EPRI) are organizations under ANRE's supervision.

AIST has also supported at least two large scale research projects related to environmental technology.[82] Between 1966 and 1971, AIST spent approximately $55 million (1992 dollars) on the desulfurization project, in large part focused on development of technology related to efficient removal of SO_2 contained in exhaust gases from power plants and other large-scale combustion sources. As discussed in ch. 5, the Japanese are now strong competitors in this technology. More recently, AIST spent approximately $70 million between 1985 and 1990 on the Aqua Renaissance project to develop new technologies for treatment of wastewater. Technologies included microorganisms and high-performance membranes. However, technologically this project did not appear successful and did not achieve its technical objectives.[83] However, interaction between participating companies was facilitated and some of the project teams generated commercially useful equipment.

Environment Agency and Other Programs-Japan's Environment Agency funds research in national research institutes and government ministries. In FY 1990 the Environment Agency funded the equivalent of $13.8 million of R&D in 45 research institutes and 13 ministries. This included work on traffic pollution by the National Police Agency, SO_2 and NO_x sensors by the Science and Technology Agency, and nonpolluting ship hull painting by the Ministry of Transport.

The Japan Sewage Works Agency supports research and technology development ($5 million in FY 1991) in sewage treatment technologies, including advanced wastewater treatment, sewage sludge handling, and small-flow wastewater technologies.[84] Finally, the Clean Japan Center, a quasi-public organization, funds demonstration of recycling and resource recovery technologies.

EUROPEAN PROGRAMS

In Western Europe, environmental technology R&D is supported and encouraged at different governmental levels. The European Commission (EC) supports and encourages cross-border R&D collaborations through the Framework program, while over 20 European countries, including the EC, are involved in the Eureka program. Both programs support environmental technology.[85] Some countries, including the Netherlands and Germany, have substantial environmental technology R&D programs. In all of these cases, environmental technology R&D is supported as part of a broader competitiveness strategy.

International Programs

EC PROGRAMS

The EC funds some R&D, primarily to increase industrial competitiveness.[86] The R&D is international in character, either involving a central EC

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82 The Large Scale Program was developed by MITI in 1966 to provide government support for large technology projects of particular national importance. MI'r I's 5th generation computer project is an example.

83 C. Judson King et. al., *JTEC Panel Report on Separation Technology in Japan* (Baltimore, MD: Japanese Technology Evaluation Center, Loyola College, March, 1993), p. 141.

84 Research and Development Corporation of Japan, "National Laboratories and Public Research Organizations in Japan' (Tokyo: JRDC, 1992).

85 For a more complete discussion of EC technology and industrial policy see U.S. Congress, Office of Technology Assessment, *Competing Economies: America, Europe, and the Pacific Rim*, OTA-ITE-498 (Washington, DC: U.S. Government Printing Office, October 1991), ch. 5, especially pp. 209-226.

86 See Commission of the European Communities, *EC Research Funding* (3d ed. 1992), pp. 3-8. EC-level support has increased from 2 percent of the civil R&D budgets of EC member states in 1980 to 5 percent in 1990. Ibid., p. 10.

Table 10-5-European Community R&D Programs Supporting Environmental Technologies

	Years covered	Estimated annual spending on environmental technology ($ million): total	per year[a]	Estimated percent of funds cost-shared with industry or other parties[b]
Framework programs				
Non-nuclear Energies[c]	1991-1994	290[d]	85	86
Environment	1991-1994	170	50	59
Measurements and Testing[f]	1992-1994	20	6.5	36
Other programs				
Thermie (energy technology demonstration and dissemination projects)	1990-1994	NA	170	100

a Thermie figure is for 1993, For the other programs, the figure shown is the total figure in the previous column, divided by the whole or fractional number of years the program is in effect. Two programs started mid-year: Non-nuclear Energies (Sept. 9, 1991), and Environment (July 16, 1991).

b For the program as a whole (not just the environmental technology part). For the Framework programs, this estimate *assumes* that the revisions in Council Decision 93/167/Euratom, EEC, Mar. 15, 1993, printed *in Official Journal of the European Communities, vol.* L 69/45 (Mar. 20, 1993), which kept Framework's total Joint Research Center funding constant, also kept the Joint Research Center funding constant for the specific programs listed. This estimate also assumes that 87 percent of the non-Joint Research Center funding for each program is for cost-shared research (87 percent is the approximate Framework-wide average).

c This program's predecessor was JOULE.

d Includes an estimated $37 million out of a $61 million supplement to Framework energy programs.

e This program's predecessor was STEP/EPOCH.

f This program's predecessor was B.C.R.

NOTE: The figures for spending on environmental technology are rough estimates: OTA estimated the share of each program devoted to the environmental technologies within the scope of this report, based on the EC's program descriptions containing limited or no budget breakdowns. The following shares were used: 95 percent of Non-nuclear Energies, 30 percent of Environmental, 10 percent of Measurements and Testing, and 80 percent of Thermie. See table 10-1 for technologies included in this table. An approximate exchange rate of 1 ECU -$1.22 is used. "NA" denotes not available.

SOURCE: Office of Technology Assessment. Estimates based on Commission of the European communities, *EC Research Funding* (3d *ad.,* January 1992); EC Council decision of Mar. 15, 1993, 93/167/Euratom, EEC, printed in *Official Journal of the European Communities,* vol. L 69/45 (Mar. 20, 1993) (increasing funding levels); EC Council decisions establishing particular programs.

facility or collaborations involving entities from at least two member states.[87] (See table 10-5.)

Much of the EC's R&D is conducted through its Third Framework program, an umbrella R&D program with a total budget of $8 billion, generally covering mid- to late 1991 through the end of 1994.[88] While this program is jointly administered by all of the EC's Directorate-Generals, in practice Directorate-General XII (Science and Technology) plays the lead role. Within Framework, the program for non-nuclear energies provides the majority of funds for environmental technology (an estimated $85 million annually). The program supports renew-

87 The EC seeks projects that can be performed more efficiently **at the EC level.** Ibid., p. 7. To some extent, the EC considers cross-border collaboration as also a good in itself (independent of competitiveness effects), because it promotes the EC'S economic and social cohesion.

88 Formally, the Third Framework Program covers 1990-1994. However, mOSt Of the programs b ecame effective during the third quarter of 1991. See Commission of the European Communities, *EC Research Funding,* op. cit., **pp. 69-100. The Third Framework Program overlapped with the** Second Framework Program during all of 1990 and 1991, and will overlap with the Fourth Framework Program during all of 1994.

able energies, including solar, biomass, and geothermal; fuel cells; more efficient industrial processes; more efficient energy generation from fossil fuels, including fluidized bed combustion; and CO_2 recovery technologies. Much of the environmental technology program focuses on climate monitoring, modeling, and environmental and socioeconomic assessment, areas not considered in this report. However, a share of the program concentrates on environmental technologies directed at reducing pollution (estimated at $50 million annually). For example, the program supports some research on technologies for treating toxic wastes and cleaner production technologies,

Some other Framework programs (not listed in table 10-5) incorporate environmental considerations into their goals. For example, the program for industrial and materials technologies reports that ‘‘environment aspects of products and processes’ are included as a ‘‘strategic element. . . in all parts of the program.”[89] That program is, for example, coordinating consortia to develop environmentally preferable polymers, e.g., biodegradable plastics.

Framework spending is heavily oriented to helping fins, universities, and research institutes. About 80 percent goes to cost-sharing R&D done by such entities.[90] Projects must be in a “pre-competitive" stage (prior to industrial development).[91]

EC’s Thermie program, administered by Directorate-General XVII (Energy), funds energy technology demonstration and dissemination projects (an estimated $170 million in FY 1992). Thermie’s goals are to improve efficiency in energy production, distribution, and use; promote renewable energy technologies; develop cleaner ways to use coal and other solid fuels; and develop technologies for oil and gas exploration, transport, and storage. Thermie will fund up to 40 percent of the costs of a first full-scale demonstration, and up to 35 percent for further dissemination of technology already demonstrated.[92] For example, Thermie made an initial award of$183 million toward a demonstration of Integrated Gasification Combined Cycle (IGCC) electricity cogeneration technology providing low emissions of SO_2, NO_x, and CO_2. Six electricity companies (four from Spain, and one each from Portugal and France) were to build a plant in Spain. The project called for a demonstration period during which many types of coal would be tested, after which the plant would operate on locally available coal.[93]

EUREKA

Like the EC’s Framework Program, Eureka aims to promote competitiveness through cross-border collaboration. Eureka is driven less by government policymakers and more by participating firms and universities, and projects do not have to be precompetitive. Public funding for Eureka projects comes from national governments. However, in addition to funding, Eureka provides its research participants with access to financing sources and to national and international bodies that make standards or promulgate regulations that could affect a project’s commercial success.

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89 Council Decision of Sept. 98, 1991, ‘‘adopting a specific programme of research and technological development in the field of industrial and materials technologies (1990 to 1994), ” 91/506/EEC, publLished in *Official Journal of the European Communities*, No. L. 269/30, Sept. 25, 1991. (See p. 269.)

90 Commission of the European Communities, *EC Research Funding*, op. cit., pp. 24-25. For firms, the EC normally pays 50 percent of the cost including overhead; for universities, the EC normally pays the entire additional costs related to the research, excluding overhead and most salaries.

91 Ibid., p. 41.

92 Commission of the European Communities, Directorate-General XVII-D, ‘‘Thermie’’ (brochure, not dated).

93 Ibid. The Commission is funding the development of an electricity generation technology which reduces CO_2 emissions by 20%. “Press Release”, Dec. 5, 1991.

Table 10-6—German Federal Environmental Technology R&D Spending, 1992

Budget category	Environmental technology portion (estimate)[a] ($ million)	Total BMFT funds as percent of total funds	Percent of BMFT funds cost-shared with industry
Environmental technology excluding energy	230	68	36
Renewable energy and energy efficiency	250	100	31
Fossil fuels (includes clean coal)	47	100	39

a OTA's estimated the share of R&D spending on environmental technologies covered in this report based on program descriptions without budget breakdowns. The following percentages were used: 100 percent of renewable and energy efficiency; 90 percent of environmental technologies; and 60 percent of fossil energy.

NOTE: Exchange rate used: $1 = 1.5617 DM. International Monetary Fund, *International Financial Statistics,* March 1993, p. 236. See table 10-1 for technologies included in this table.

SOURCE: OTA, based on the German Federal Ministry for Research and Technology (BMFT), *Bundesbericht Forschung 1993* (Bonn: BMFT, July 1993), pp. 71-72 (table II/5), pp. 74-75 (table n/6), pp. 97-98 (table 11/16), pp. 172-177.

In 1992, Eureka had 562 ongoing projects, with a total value of $10.8 billion. Of these, 130 projects, with a total value of $1.2 billion, were classified as environmental. Of these, 29 projects are for cleaner production processes; other categories include environmental monitoring and waste water treatment. Some of the environmental projects are beyond the scope of environmental technologies treated in this report, such as restoration of ancient monuments, and a $250 million project in atmospheric science.[94] An additional 23 projects, with a total value of $610 million, were classified as energy technology. Of these, two were for more efficient power plants, eight for efficiency in energy use, and seven for renewable energy (including five on photovoltaic cells). The rest were for fossil fuel exploration and transportation applications, beyond the scope of this report.

National Programs

GERMANY

The German Federal Government spent an estimated $230 million for environmental technologies, $250 million for renewable energy and energy efficiency, and $47 million for clean coal in 1992 (see table 10-6). Virtually all of the energy-related funding, and most of the rest, went to the Ministry for Research and Technology (BMFT), whose central mission is promoting industrial competitiveness.[95]

Germany attempts to link technology development to technology needs, based on regulatory targets. Many of the energy and environmental technology projects involve applied research and development, as opposed to more basic research. Roughly a third of BMFT's funds go for cost-sharing industrial R&D. BMFT funds technologies for prevention, control and cleanup. Areas of prevention research include optimization of processes, CFC-substitutes, no-chlorine pulp bleaching, and utilization of industrial wastes, including reprocessing of waste acids, alkaline solutions and salts. BMFT also funds air and water treatment technologies. In the past, BMFT supported research directed at removing inorganic pollutants from exhaust gases, including flue-gas desulphurization, denitrification, and fluidized bed combustion. Increasingly, BMFT focuses on technologies for removal of organic contami-

94 *Eureka 1992: Annual Progress Report 1992*, pp. 4, 18.

95 Germany's Länder (states) fund some environment-related R&D, but figures are not readily available.

Table 10-7—Environmental Technology Budget for Selected Programs in the Netherlands, 1992 ($ million)

Research and development		
- Innovation-oriented Environmental Technology Research Programme		**$6**
- Program to promote environmental technology In industry		**21**
- Scheme to Promote the Development of Environmental Technology		**8**
- National Research Programme Into the Re-use of Waste Substances		4
- Water pollution technology		6
- Energy saving/substainable energy/NOVEM programmed		58
- Cleaner exhaust gases		2
	Subtotal	105
Dissemination		
- Environment & energy advisory scheme		**2**
- General provision of information to environmental technology		1
	Subtotal	3
Demonstration/Application		
- Hydrocarbons 2000		6
- Accelerated depreciation for innovative environmental technology		47
- CFC action programme		4
- Grants scheme for clean and low noise lorries and buses		53
- Various demonstration schemes to reduce nitrogen oxide emissions (NO,)		12
- Tender for industrial energy saving		18
- Scheme for an environmental premium for wind energy		1
- Investment subsidy for wind		18
- Subsidy scheme for demonstration projects		3
- Investment subsidy energy saving techniques		103
	Subtotal	265
Total		**373**

NOTE: Exchange rate used: $1 -1.7 guilders. See table 10-1 for technologies included in this table.

SOURCE: Technology *and Environment* (The Hague, the Netherlands: Ministry of Economic Affairs, Technology Policy Directorate, April 1991).

nants, including selective high performance absorbents, catalytic systems, and biofilters.[96]

NETHERLANDS

The Netherlands relies heavily on incentives and subsidies to industry to help them meet environmental requirements, Spending on technology development is significant, given the small size of the country. In 1992, the government spent an estimated $375 million on environmental technologies covered in this report. If multiplied on a per-capita basis, this would be equivalent to over $6.7 billion in the United States[97] (see table 10-7). Moreover, relative to the United States, a greater share of this spending is devoted to environmental technologies, as opposed to energy, and about half of funding on environmental technologies advances pollution prevention.

The National Environmental Policy Plan (NEPP) and NEPP Plus, environmental strategic plans for the Netherlands, have as objectives reducing emissions of pollutants to between 10 and 30 percent of their 1985 levels by the year 2010. The

96 Federal Ministry for Research and Technology, Environmental Research *and Technology, Programme 1989-1994 (Bonn:* BMFT,1989).

97 The Netherlands has *a* population of approximately 14 million people, about 1/18th of the size of the U.S. population. Total environmental technology expenditures, including on environmentally sound agricultural technologies, exceeded $500 million.

Dutch Government believes that a key factor in meeting that goal will be the development and diffusion of environmental technologies. Toward that end, the Economic and Environment Ministries developed a plan, *Technology and Environment,* to lay out technology goals and objectives.

A key feature is close cooperation between government and industry sectors. The environment ministry has appointed a liaison director for each of several industrial sectors with significant impact on the environment, such as steel, chemicals, paper, and agriculture. Representatives from the targeted industry sectors meet with representatives from several government ministries. The meetings are used to apportion responsibilities for carrying out the plan, developing a schedule, working out government assistance, and establishing organizational provisions for cooperation and management. A similar joint process is used to develop a strategy to address specific problems, such as waste stream reduction. These collaborative processes help identify technology needs and opportunities. The Sustainable Technology Development program, funded at $2.9 million a year by five agencies, was developed to promote the integration of environmental goals into longer term technology development (discussed above),

The plan also features programs to promote development, demonstration, and diffusion of environmental technologies, including cleaner production technologies. A number of these programs are run by the Netherlands Agency for Energy and the Environment (NOVEM), a quasi-public organization created in the early 1980s to develop and promote energy conservation technologies. Its mission was recently expanded to include environmental technology. NOVEM is governed by a board with representatives from industry, government, and academia and therefore has close ties to industry. Government's role tends to be limited to policy, strategy, and funding; industry tends to choose and structure individual projects.

The environment ministry manages the Stimulation of the Development of Environmental Technology program, which provides $7.6 million per year to industry and research institutions. About half supports development of cleaner technologies; the other half supports end-of-pipe technology development. Roughly 80 percent of the Ministry of Economic Affairs' environmental technology grants ($20.6 million a year, averaging $750,000 per grant) goes to manufacturing firms to develop technologies that solve environmental problems, including remediation, monitoring, recycling, and packaging. Industry must pay 60 percent of project costs. The Innovation-oriented Environmental Technology Research program funds researchers at universities and institutes in the fields of environmental biotechnology, recycling and pollution prevention.

The Dutch Government supports demonstration of environmental technologies, with about half of these funds committed to demonstration of pollution prevention technologies.[98] The Ministry of Housing, Physical Planning, and Environment supports demonstration projects for new environmental technology. In addition to initial demonstrations, the government cofunds some subsequent demonstrations as the costs decline. For example, the government picked up about half the cost of the first flue gas desulfurization project in Holland (total cost was equal to $61 million).[99] The second project cost $28 million, with government paying one-quarter. Subsequent projects were much less (about $14 million) and had no government support. Demonstration subsidies support other technologies, including wind power and solar power.

The Netherlands also provides accelerated depreciation for environmental technologies that

98 Discussion with environment ministry official, December 1991.

99 The firm that did this, Esmil (part of the Hoogovenes Steel Works), licensed the technology from Japan and is now selling the technology in other countries, such as Spain. (Interview with environment ministry official.)

have been proven technologically sound but are not yet widely used or required by regulation. Through negotiations between the Environment Ministry and industry, about 120 technologies have so far been chosen, including ultrafiltration membranes, catalytic oxidation devices, ultrasonic cleaning, and low-NO_x boilers. For the technologies on the list, companies may write off the cost of purchases in 1 year rather than the usual 10. When a technology is used in sufficient volume to bring down the price, it is taken off the list.

Appendix A: Effects of Environmental Regulations on Economic Growth: A Review of Research

Attempts to assess the impacts of environmental regulation on the economy-including trade flows and foreign investment, Gross Domestic Product (GDP) growth, and productivity—have been going on at least since the early 1970s, These studies differ in methodology, assumptions, and conclusions. This appendix reviews some of the studies.

Effect on GDP and Social Welfare

The effect of environmental regulation on the economy and social welfare hinges principally on whether the benefits of regulation outweigh the costs. Unfortunately, few studies have included the benefits, primarily because while estimates of compliance costs are readily available, estimates of benefits are not. [1]

Several studies have attempted to evaluate the impact of environmental regulation on GDP. Most studies find that while environmental expenditures may increase economic growth in the short term, particularly in recessionary periods when economic stimuli are needed, this stimulus is out-weighed by the costs in the medium and long term.[2] Production cost increases lead GDP-producing activities to grow more slowly because an increased share of economic activity is producing effects that GDP measures do not include (e.g., clean air). In part, as discussed below, this reflects a failure of current national income accounting measures to adequately reflect national welfare.

The majority of studies find that environmental regulations have had a negative, but relatively small, impact on GDP growth.[3] For example, Denisen found that, in the absence of environmental regulation from 1973 to 1982, annual U.S. Gross National Product (GNP) growth would have been 0,07 percent higher.[4] Jorgenson and Wilcoxen used a more sophisticated model and found that the impact on annual GNP growth to be 0.191 percentage points between 1973 and 1985: real GNP in 1985 would have been 2.59 percent (or about $150 billion) higher.[5] They contend that new regulations, particularly from the 1990 Clean Air Act Amendments, will slow annual GNP growth

[1] If regulations precede a sound scientific foundation (as indeed, they sometimes must), the benefits may not be truly ascertainable, even though the costs may be.

[2] Ger Klaassen and Andries Nentjes, ' 'Macroeconomic Impacts of an EEC Policy to Control Air Pollution, " *Journal of Policy Modeling*, vol. 1 3,No. 3, 1991, pp. 347-366.

[3] Measures of gross national product (GNP) or gross domestic product (GDP) are not very different. While some studies have used GNP as a measure, recently, government has adopted the convention of using GDP. GDP plus net receipts of factor income from the rest of the world (e.g., receipts and payments of dividends and interests of foreign affiliates of U.S. corporations and U.S. affiliates of foreign corporations) equals GNP.

[4] E.F. Denison, *Trends in American Economic Growth, 1929-1982* (Washington, DC: The Brookings Institution, 1985), p. 34.

[5] In other words, if GNP grew 2.5 percent a year with environmental regulations, it would grow 2.691 percent a year without them. Dale W. Jorgenson and Peter J. Wilcoxen, "Environmental Regulation and U.S. Economic Growth, ' discussion paper, Harvard University, Energy and Environmental Policy Center, November 1989.

by another 0.04 percent by the year 2005 and 0.05 percent by 2020.[6]

However, due to simplified assumptions made in modeling the direct effects of environmental regulation on the economy, the results of econometric studies have to be interpreted with caution, First, some studies that measure only compliance costs to business are underreporting the true costs of regulation, since they are not based on a full equilibrium model of how the costs work their way through the economy in the long run. Using these methods, costs are normally higher than simple measurement of compliance costs.[7] Both Jorgenson and Wilcoxen and Hazilla and Kopp use such full equilibrium models to measure costs.

However, a second and more serious limitation of all the studies is that while they include the costs of environmental regulations, they do not include the benefits, by definition assuring that their models will find that regulation lowers GDP. There are a number of benefits of regulation, both to the polluting firm and to the rest of society, that if measured might increase GDP. The polluting firm may benefit from pollution control, particularly if it involves production process changes that lead to increased productivity, lower energy and materials use, and increased worker welfare. While the extent of the benefits to the industry is not clear (they are probably not large), not including them overestimates economic losses.

More sizable benefits occur outside the firm. For example, increased natural resource productivity from lower levels of pollution (e.g., increased agricultural and fisheries yield), reduced health care costs, maintenance costs, and capital expenditures on environmental controls (e.g., public water treatment plants) would all increase GDP, in part through increased productivity.[8]

Moreover, some benefits are nonmonetary and not included in GDP measures. For example, enjoyment of natural resources, reduced nuisance (e.g., odor) from pollution, and even species diversity might result from a cleaner environment but would not necessarily be measured in GDP. Also, there are important flaws in how national wealth is calculated with respect to natural resources. While depreciation of man-made capital assets (plant, equipment, buildings) is subtracted from GNP to calculate net national product (NNP), depreciation of natural capita-l (soil, forests, fisheries, minerals), or human capital (illness due to pollution) is not subtracted as these natural and human resources are depleted.[9] Thus, not all of the results of defensive activities that slow down the degradation of natural and human resources would be measured in GDP, even though they would raise societal welfare.

While it is important to include these benefits in any assessment of the relationship between regulation and economic growth, accurate and comprehensive measures of the benefits of environmental regulation have not been fully developed.[10] Some argue that the U.S. spends significant resources regulating some pollutants that cause little damage to health or environment, while spending little on abating other pollutants that cause greater damage (e.g., indoor air pollution) and that, as a result, regulation lowers GDP.[11] In contrast, others argue that on net, the benefits of environmental regulations outweigh the costs.[12] It remains unclear whether environmental regulations impose more costs

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6 Dale W. Jorgenson and Peter J. Wilcoxen, ''The Impact of Environmental Legislation on U.S. Economic Growth, Investment, and Capital Costs,' U.S. *Environmental Policy and Economic Growth: How Do We Fare?* Monograph Series on Tax and Environmental Policies and U.S. Capital Costs (Washington DC: American Council for Capital Formation, 1992), pp. 1-39.

7 Michael Hazilla and Raymond J. Kopp, "The Social Cost of Environmental Quality Regulations: A General Equilibrium Analysis, " *Journal of Political Economy,* vol. 98, No. 4, pp. 853-873.

8 For example, lower health care costs could lead to reduced work absences and would also allow revenues formerly going to health care to go to other economic activities. See Organization for Economic Co-operation and Development, *Environmental Policy Benefits: Monetary Valuation* (Paris: OECD, 1989).

9 Robert Repetto, ''Accounting for Environmental Assets, *Scientific American,* vol. 266, No, 6, June 1992.

10 Under the 1990 Clean Air Act, EPA was required to prepare a report assessing the benefits of the Federal clean air regulations. The report is scheduled for release in late 1993. Moreover, EPA is considering doing more detailed work to measure the benefits of regulations in all media.

11 Paul R. Portney, ''Policy Watch: Economics and the Clean Air Act,'' *The Journal of Economic Perspectives,* vol. 4, No. 4, fall 1990; also, Robert Crandall, "Why is the Cost of Environmental Regulation So High,'' policy paper, Center for the Study of American Business, Washington University, St. Louis.

12 Alvin L. Alm, ''Competitiveness and Environmental Quality,' *Environmental Science and Technology,* **vol.** 25, No. 12, **December, 1991, p. 1993.**

Table A-l—Estimates of the Share of Total Factor Productivity y Decline From Environmental Regulation

Study	Percent share	Period	Industry scope
Gray[1]	12%	1973-78	240 manufacturing sectors
Denison[2]	16%	1972-75	Business sector
Christainsen and Haveman[3]	8-12%*	1973-78	Manufacturing
Norsworthy, Harper, & Kunze[4]	12%*	1973-78	Manufacturing
Barbera and McConnell[5]	10-12%	1970-80	Chemicals; stone, clay, and glass; iron and steel
Barbera and McConnell[6]	30%	1970-80	Paper
Gallop and Roberts[7]	44%	1973-79	Electric utilities

* contribution to decline in labor productivity

1 Wayne B. Gray, "The Cost of Regulation: OSHA, EPA and the Productivity Slowdown," *The American Economic Review*, vol. 77, No. 5, December 1987 pp. 998-1006.

2 Edward P. Denison, *Accounting for Slower Economic Growth: The U.S. in the 1970s* (Washington, DC: The Brookings Institution, 1979).

3 Robert H. Haveman and Gregory B. Christainsen, "Environmental Regulations and Productivity Growth," in *Environmental Regulation and the U.S. Economy*, edited by Henry M. Peskin, Paul R. Portney, and Allen V. Kneese (Baltimore, MD: Johns Hopkins University Press/Resources for the Future, 1981).

4 J.R. Norsworthy, Michael J. Harper, and Kent Kunze, "The Slowdown in Productivity Growth: Analysis of Some Contributing Factors," *Brookings Papers on Economic Activity*, No. 2, 1979, p. 387-421.

5 Anthony J. Barbera and Virginia D. McConnell, "The Impact of Environmental Regulations on Industry Productivity: Direct and Indirect Effects," *Journal of Environmental Economics and Management*, vol. 18, 1990, pp. 50-65.

6 Ibid.

7 Frank M. Gallop and Mark J. Roberts, "Environmental Regulations and Productivity Growth: The Case of Fossil-fueled Electric Power Generation," *Journal of Political Economy*, vol. 91, No. 4, August 1983, pp. 654-674.

than benefits, and until this question is answered, it is not possible to accurately measure the impact of regulations on productivity or GDP.

Finally, even if net benefits from regulations do exceed costs, those costs 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 can also be translated into a long-term advantage. Also costs may be concentrated, affecting certain industries, workers, and communities, while the benefits may be diffuse.

Productivity and Environmental Regulation

A number of studies were done to explain the slowdown in manufacturing productivity gains in the 1970s. Virtually all the studies found that environmental regulations contributed a small share to the slowdown in productivity.[13] Manufacturing productivity growth rates in the 1980s, however, regained pre-1970 levels.[14]

There are several reasons why environmental regulations could lower productivity.[15] First, because pollution abatement inputs (e.g., capital, labor, energy) produces pollution reduction, which is not included as an output in conventional productivity measures, by definition compliance costs lower total factor productivity. Conventional output indicators measure only the value of the saleable product and not the negative value of the environmental damage caused by the pollution. Therefore, studies find that environmental compliance expenditures reduce productivity because their outputs (a cleaner environment than otherwise) are not included as part of the firms' outputs.

13 Productivity is generally measured in two ways, total factor (or multifactor) productivity, which relates outputs (value of the products the plant or firm produces) to all inputs to the firm, including capital, labor, purchased inputs, energy and raw materials, and single factor productivity (e.g., labor productivity), which relates outputs to the amount of a single factor (e.g., labor).

14 William Gullickson, "Multifactor Productivity in Manufacturing Industries," *Monthly Labor Review*, October 1992, pp. 20-29.

15 For example, see Wayne Gray and Ronald J. Shadbegian, "Environmental Regulation and Manufacturing Productivity at the Plant Level," Center for Economic Studies DiscussIon Paper (Washington, DC: U.S. Bureau of the Census, March 1993).

Gallop and Roberts found that almost half (44 percent) of the productivity slowdown in the electric power industry in the 1970s was attributable to environmental regulations.[16] Repetto has developed a measure to include pollution in productivity measures for the electric power industry,[17] which includes both electricity and economic damages from pollutants (e.g., crop losses, morbidity) as outputs from utilities. Using this expanded measure, Repetto found that between 1970 and 1985 environmental productivity (kilowatt hours per unit of emissions) increased more rapidly than labor, capital, or energy productivity y. 18 As a result, while electric power productivity declined by 0.38 percent a year between 1971 and 1985 when measured in conventional terms, Repetto estimates that it increased by between 0.33 and 0.62 percent a year when the benefits of a cleaner environment are included as outputs.

Second, environmental regulation could lower the productivity of nonabatement resources in producing measured outputs, if it reduces the efficiency of existing inputs into production. For example, firms use large amounts of energy to run smokestack scrubbers and also must expend substantial effort to maintain these devices.

Third, if firms change production practices in response to regulatory demands, these new practices may be less efficient than the old ones. For example, companies may switch from cleaning with solvents to less productive mechanical cleaning. In addition, to avoid liability and present an image as a clean company, larger firms may subcontract out some of their dirtier production processes to smaller firms, even though it may be more efficient to produce in-house.[19]

Fourth, if firms divert funds from spending on productive investments (e.g., new capital equipment) to pay for environmental expenditures, then productivity growth may lag since less new equipment is bought. It is not clear the extent to which this crowding out takes place; in fact, at least one study[20] found that among pulp and paper mills, firms that spent more on productive investments as a share of the plant capital stock also spent more on environmental investments.[21]

Fifth, if regulations have a new-source bias, this may discourage investment in new, more efficient technologies and encourage holding on to older facilities. Finally, regulations may divert management time and effort away from issues of production toward issues of compliance and hence might reduce productivity.

However, there are some reasons why regulations might increase productivity. First, as discussed in chapter 8, new production practices developed to comply with regulations might be more productive than old. For example, Barbera and McConnell found that regulations may have resulted in lower production costs in the non-ferrous metals industry because of the introduction of new lower polluting production practices that were also more efficient.[22] However, even though aggressive pollution prevention efforts can reduce compliance costs, particularly when compared to the current end-of-pipe approach, in most cases they are not cost effective in the absence of regulation.

Second, regulations could provide a shock to outdated management practices and encourage management to devote increased attention to production processes and work practices. Finally, if regulation

16 Frank M. Gallop and Mark J. Roberts, "Environmental Regulations and Productivity Growth: The Case of Fossil-fueled Electric Power Generation," *Journal of Political Economy,* vol. 91, No, 4, August 1983, pp. 654-674.

17 Robert Repetto, "Environmental Productivity and Why It Is So Important," Challenge, vol. 33, No. 5, September-October 1990, pp. 33-38.

18 Environmental productivity is defined as output per unit Of emissions.

19 F.A. Steward Consulting, "Environment and Competitiveness in the Metal Finishing Industry," contractor report prepared for the Office of Technology Assessment, February 1992.

20 Wayne Gray and Ronald J. Shadbegian, "Environmental Regulation and Manufacturing Productivity at the Plant Level," op. cit.

21 Many analysts assume that this crowding out occurs on a one-to-one basis, that is, that for every dollar Spent on pollution control, firms spend one dollar less on productive investments. While the empirical evidence of this is slim, it does seem to suggest that this is not the case, that instead, it crowds out only between 33 and 50 percent. Adam Rose, "Modeling the Macroeconomic Impact of Air Pollution Abatement," *Journal of Regional Science,* vol. *23, No. 4,* 1983, p. *449.*

22 Anthony J. Barbera and Virginia D. McConnell, "The Impact of Environmental Regulations on Industry Productivity: Direct and Indirect Effects," *Journal of Environmental Economics and Management,* winter, 1990, pp. 50-65.

imposes substantial costs on some sectors and forces some plants to close, it is likely that the plants that close will be those with the lowest productivity and profits.[23] To the extent that the remaining production takes place in U.S. plants with higher productivity, then industrywide productivity will have increased. For example, OTA found that environmental regulations accelerated steel industry modernization.[24]

On balance though, environmental regulations appear to have dampened productivity (narrowly defined to not include environmental outputs). Most studies suggest that environmental regulation contributed to around 10 to 15 percent of the productivity growth slowdown during the 1970s. Even among industries bearing the highest pollution abatement costs, environmental regulation did not account for the majority share of the slowdown in productivity growth in the 1970s. In other words, while spending on environment has been responsible for some of the deceleration in productivity growth, other factors (such as technology changes, investment, and training) were more important. There is some consensus that the impacts of regulation on productivity in the early 1980s were somewhat less.[25] In addition, productivity growth rebounded somewhat in the 1980s.[26] However, one study examining regulation from 1979 to 1985 found that among industries with the highest compliance costs (pulp and paper mills, steel mills, and oil refineries), environmental costs were associated with lower productivity. On average, environmental regulations in these high compliance cost sectors caused a 3 to 7 percent decline in total factor productivity.[27]

It is not clear how future environmental regulations will affect productivity. On the one hand, the expected increase in environmental compliance costs could inhibit productivity. On the other hand, firms are much more experienced with implementation of environmental regulations than they were in the 1970s, and new approaches (such as pollution prevention) could reduce compliance costs and lower negative productivity effects.

23 Kathryn Harrigan, *Strategies for Declining Businesses* (Lexington, MA: Lexington Books, 1980).

24 U.S. Congress, Office of Technology Assessment, *Technology and Steel Industry Competitiveness*, OTA-M-122 (Washington, DC: U.S. Government Printing Office, June 1980), p. 83.

25 U.S. Congress, Confessional Budget Office, *Environmental Regulation and Economic Efficiency Washington,* DC: CBO, March 1985).

26 William Gullickson, "Multifactor Productivity in Manufacturing Industries," *Monthly Labor Review,* October, 1992. pp. 20-29.

27 For every additional dollar in environmental operating costs, total factor productivity would drop by $3 to $4. Wayne B. Gray and Ronald J. Shadbegian, "Environmental Regulation and Manufacturing Productivity at the Plant Level," op. cit.

Appendix B: List of Acronyms

ABC —Advanced Battery Consortium
AFBC —atmospheric fluidized bed combustion
ARPA —Advanced Research Projects Agency (formerly DARPA)
ASEAN —Association of Southeast Asian Nations (members are: Brunei, Indonesia, Malaysia, Philippines, Singapore, and Thailand)
BAT —best available technology
BEA —Bureau of Economic Analysis (DOC)
BMFT —Federal Ministry for Research and Technology (Germany)
BOD —biological oxygen demand
BOTB —British Overseas Trade Board
CAAA -Clean Air Act Amendments
CCTP ---Clean Coal Technology Program
CERCLA -Comprehensive Environmental Response Compensation and Liability Act
CFCs -Chlorofluorocarbons
CMA --Chemical Manufacturers Association
COD -chemical oxygen demand
CORECT -Committee on Renewable Energy Commerce and Trade
CRADA -Cooperative Research and Development Agreement
CTAC --Customer Technology Applications Center
DERP —Defense Environmental Restoration Program
DOC —Department of Commerce
DOD —Department of Defense
DOE —Department of Energy
DSM -demand side management
EC —European Community
EGS environmental goods and services
EOP -end-of-pipe
EPA —Environmental Protection Agency
EPACT —Energy Policy Act of 1992
EPRI —Electric Power Research Institute
ERCs -engineering research centers
ESCOs -energy service companies
Eximbank —Export-Import Bank of the United States
FBC —fluidized bed combustion
FCCSET —Federal Coordinating Council on Science, Engineering and Technology
FGD —flue gas desulfurization
GAO —U.S. General Accounting Office
GATT -General Agreement on Tariffs and Trade
GDP —gross domestic product
GNP -gross national product
GRI --Gas Research Institute
HC -harmonized code
ICETT —International Center for Environmental Technology Transfer (Japan)
IGCC —integrated gasification combined cycle
JETRO —Japan External Trade Organization
JICA —Japanese International Cooperation Agency
MACT —maximum achievable control standards
MITE —Municipal Innovative Technology Evaluation Program

MITI —Ministry of International Trade and Industry (Japan)
MNCs —multinational corporations
MTCs —Manufacturing Technology Centers
NAFTA —North American Free Trade Agreement
NASA —National Aeronautics and Space Administration
NASDA —National Association of State Development Agencies
NCMs —National Center for Manufacturing Sciences
NEDO —New Energy and Industrial Development Organization (Japan)
NEPA —National Environmental Policy Act of 1969
NETAC —National Environmental Technology Applications Corporation
NGOs —non-governmental organizations
NICs —newly industrialized countries
MST —National Institute for Standards and Technology
NOAA —National Oceanic and Atmospheric Administration
NO_x —nitrogen oxides
NSF —National Science Foundation
NTDB —National Trade Data Bank
OECD -Organisation for Economic Co-operation and Development
OIT -Office of Industrial Technologies (part of DoE)
OPIC -Overseas Private Investment Corporation
OSHA ----Occupational Safety and Health Administration
OSTP -Office of Science and Technology Policy
PCBs —polychlorinated biphenyls
PERF —Petroleum Environmental Research Forum
PFBC —pressurized fluidized bed combustion
POTW —publicly-owned treatment works
PV —photovoltaic cell
PVUSA —Photovaltaics for Utility Scale Applications
RCRA —Resource Conservation and Recovery Act
R&D —research and development
RITE —Research Institute of Innovative Technologies for the Earth (Japan)
SARA -Superfund Amendments and Reauthorization Act
SBA -Small Business Administration
SCORE -Service Corps of Retired Executives
SCR —selective catalytic reduction
SEMATECH --Semiconductor Manufacturing Technology Consortium
SERDP -Strategic Environmental Research and Development Program
SIC —standardized industrial code
SITE --Superfund Innovative Technology Evaluation Program
SMEs —small and medium sized enterprises
SNCR —selective non-catalytic reduction
SO_2 —sulfur dioxide
SRRP -Source Reduction Review Project
TCA —total cost accounting
TDA —Trade and Development Agency
TPCC —Trade Promotion Coordinating Committee
TQM —total quality management
TRI —Toxic Release Inventory
UNCED —United Nations Conference on Environment and Development
US-AEP —United States - Asia Environmental Partnership
USAID —U.S. Agency for International Development
USCAR —United States Council for Automotive Research
USETI —United States Environmental Training Institute
US&FCS —U.S. and Foreign Commercial Service
USTR —United States Trade Representative
VOCs —volatile organic compounds

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