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 transforming 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

[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 I-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.

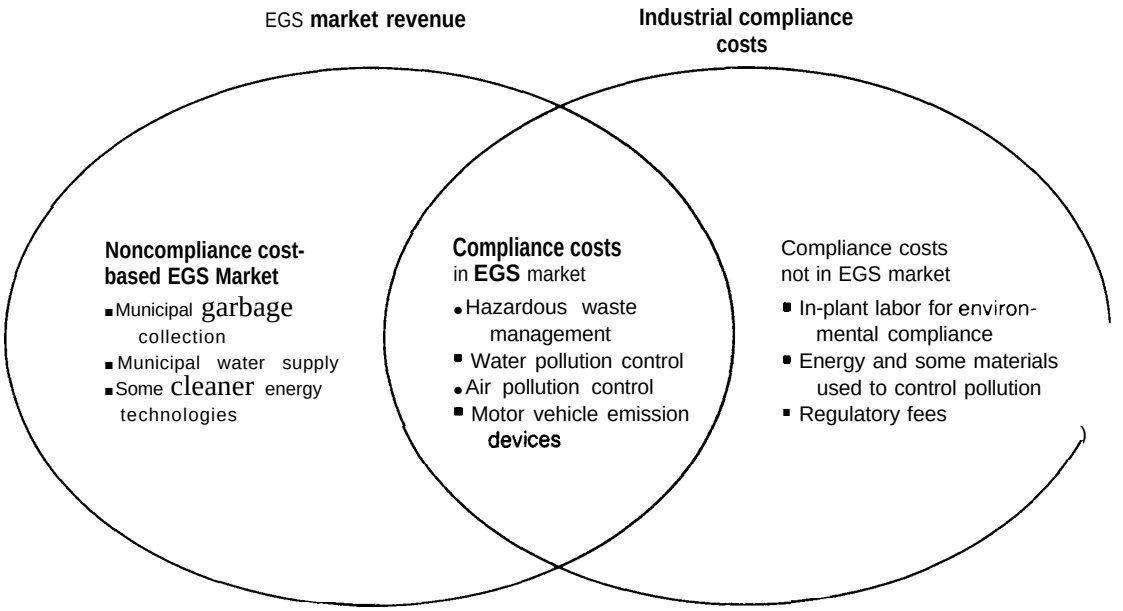
and royalties are difficult to compare with employment and export earnings. For instance, some environmental companies in the United States are subsidiaries of foreign firms but export goods and services from the United States. At the same time, a number of American companies have foreign operations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

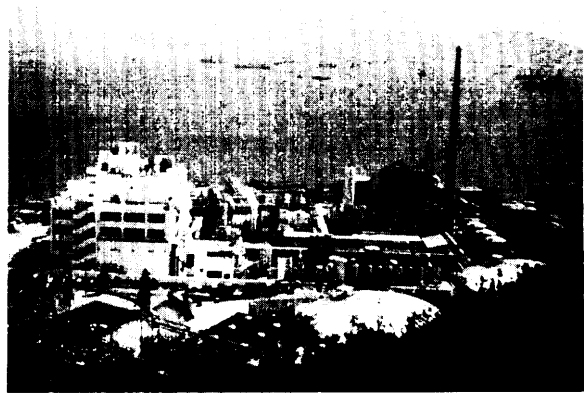
The U.S. environmental industry is the world's largest, estimated at over 34,000 firms employing over 900,000 people and earning $112 billion in revenues (not including private water utilities or

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 l-l).

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.

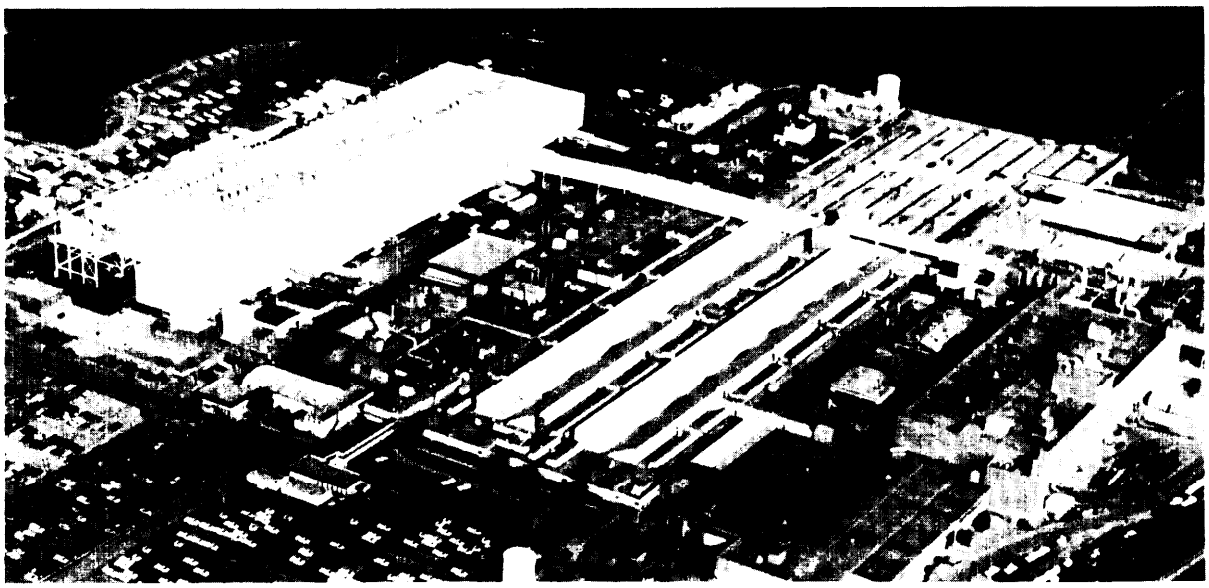
Compliance costs are not a major share of total costs for any industry, and are only one of many factors determining competitive advantage. For example, of the high compliance cost sectors mentioned above, chemicals and wood pulp are highly competitive internationally, with significant trade surpluses. 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-



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 million on environmental R&D, including an estimated $50 million 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 commercial 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.

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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 fo, 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

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16 Also, EPA could fund census-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.

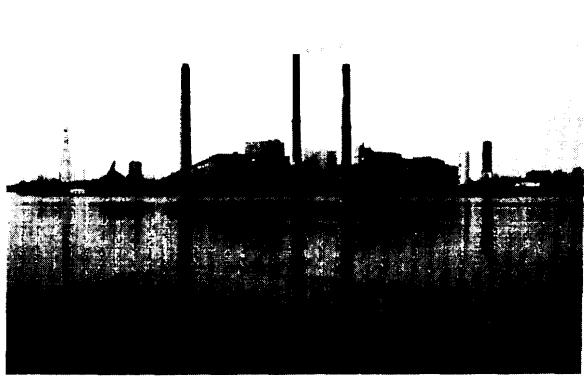
One option for addressing developing country needs while still facilitating U.S. exports would be for the U.S. Government to work with other countries to set up an expanded technical information capability through the United Nations Environment Program or another international agency to provide objective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


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.

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).