Global Competitiveness of U.S. Environmental Technology Industries: Air Pollution Prevention and Control

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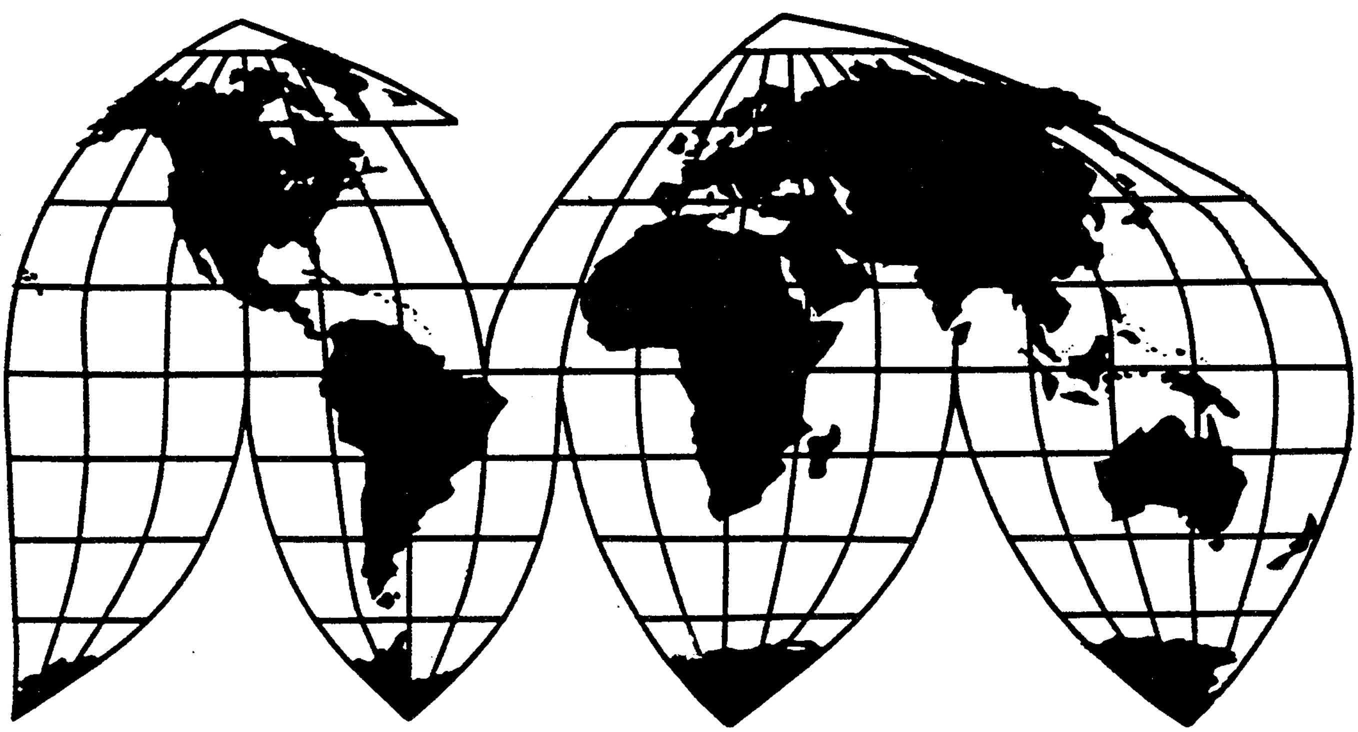

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NOTE

The information and analysis in this report are for the purpose of this report only. Nothing in this report should be construed to indicate how the Commission would find in an investigation conducted under statutory authority covering the same or similar matters.

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EXECUTIVE SUMMARY

Background

On October 14, 1993, the Senate Committee on Finance requested that the U.S. International Trade Commission (USITC) collect and analyze information on the competitiveness of U.S. industries producing environmental goods and services, in part by comparing the export promotion/technical assistance policies of the United States in the environmental technology field with those of its principal competitors. The Committee requested two reports, one focusing on the industries providing goods and services for municipal and industrial water and wastewater treatment, and another focusing on the industries providing goods and services for air pollution and abatement. The USITC completed its investigation on water and wastewater treatment in March 1995, and instituted its investigation on air pollution and abatement in April 1995.

The Committee's request letter defined environmental technology as goods and services for pollution abatement, pollution prevention, or environmental remediation; or goods and services that have as a central component the reduction of energy or materials consumption, or the reduction of environmental impact during use or upon disposal.

In this study, the goods used for air pollution prevention and control (APC) have been grouped into three categories: (1) stationary source equipment and its component parts; (2) mobile source equipment and its component parts; and (3) instruments used for monitoring and analysis. The APC services sector may be grouped into two broad categories similar to those for water and wastewater treatment: (1) engineering and construction, and (2) environmental monitoring and testing. As in water and wastewater treatment services, the firms providing goods and services overlap in each of the categories.

Information in this report has been compiled from written submissions, responses to the USITC questionnaire, reviews of existing literature, meetings with government and industry officials, telephone interviews, domestic and foreign fieldwork, and other sources. The questionnaire developed for this investigation requested data and information about each firm's operations and its opinion of the competition in U.S. and foreign APC markets.

Findings

Overview of the Global Market

According to the Organisation for Economic Co-operation and Development (OECD), the world market for environmental technologies was $200 billion in 1990, and is forecast to reach $300 billion by 2000. Of this $200 billion, approximately $40 billion is reportedly air related. Estimates made by other groups are similar, with differences in definition appearing to account for much of their variation. For example, the OECD estimated that the United States ran a trade surplus of $4 billion in 1990 in environmental goods and services (EGS), with exports of $8 billion and imports of $4 billion. However, the Environmental Protection Agency (EPA) estimated the U.S. trade surplus for 1990 for environmental equipment at only $800 million, with a trade surplus in APC equipment of about $420 million. EPA did not include services in its estimate and included only equipment that was unambiguously environmental.

- The principal consumers of environmental goods and services are OECD countries. An OECD estimate had North America with 48 percent, Western Europe with 29 percent, and Japan with 14 percent of world consumption in 1992. Most of the remaining 9 percent of consumption was in Eastern Europe and Asia. The market in developing countries is growing faster than that in developed countries, but given the much smaller base in the developing countries, the absolute growth in the market will remain in the developed countries for the near future.

- Japan and Germany are the principal competitors of the United States in the global APC market.

- Currently, definitional complexities make analysis of APC industries and markets difficult. The OECD and the U.S. Department of Commerce have both undertaken initiatives to develop common definitions of environmental technologies to assist in the collection of comparable production, consumption and trade data. Such data would aid the preparation of more current and accurate estimates of the size of global, regional, and national markets.

The Industry and Market in the United States

The United States is the world's largest producer and consumer of EGS. The U.S. market for APC equipment and services increased from about $27 billion in 1991 to nearly $32 billion in 1993, of which approximately 95 percent is believed to be supplied by domestic sources. This amount is about equally split between expenditures on stationary sources (e.g., power plants) and expenditures on mobile sources (automobiles). The market is expected to continue growing because (1) consuming industries are still installing equipment to meet the environmental requirements of the Clean Air Act Amendments of 1990, and (2) consuming industries need to replace APC systems that were put in place during the 1970s and earlier. U.S. APC markets for stationary sources are electrical utilities and firms producing petroleum and coal products, chemicals, paper and allied products, and primary metals. Estimates of the U.S. APC industry range from 1,000 to 3,000 firms, of which approximately 80 percent concentrates on equipment and 20 percent focuses primarily on services. The industry is dominated by several large multinational companies, both in the United States and abroad.

- Estimates of U.S. production/shipments of APC equipment range from $11 billion to $15 billion. Stationary and mobile source equipment each account for about half of the total. Some industry sources estimate U.S. production of mobile source equipment to be between $2.8 billion and $3.9 billion. Estimates of the value of U.S. APC services are not readily available, however some of the equipment estimates probably include the value of some APC services.

- Market demand for U.S. APC equipment and services is driven by environmental regulations. For some segments of the market, the increased use of market trading of emission rights has led industry to incorporate technological changes to reduce emissions below regulatory levels. The excess emission rights may be saved for future expansion of production or may be sold in the market.

- The services segment of the APC industry is relatively concentrated. The top five services firms responding to the Commission questionnaire accounted for approximately 40 percent domestic APC service revenues during 1992-94, and accounted for about 80 percent of worldwide gross revenues of all firms reporting. The top 25 percent of services firms accounted for nearly 55 percent of APC service revenues, and accounted for more than 90 percent of the gross revenues reported by all APC service firms for 1994.

- The equipment segment of the APC industry does not appear to be as concentrated as the services segment within the U.S. market or internationally. The five largest domestic APC equipment suppliers responding to the questionnaire accounted for 30 percent of domestic APC equipment revenues in 1994 and accounted for about 70 percent of worldwide gross revenues of all firms reporting. The top 25 percent of the reporting firms accounted for 70 percent of domestic APC equipment sales and 96 percent of worldwide gross revenues.

- U.S. trade statistics for APC equipment show a positive trade balance. U.S. exports have fluctuated within a narrow range of approximately $800 million to $860 million during 1992-95, with the major export markets being Canada and Japan. U.S. imports, primarily from Canada, Japan, Germany and China, have risen steadily during 1990-95 to a value of $204 million.

- U.S. Government policy and programs are being coordinated into a national strategy for environmental technology policy. Key components include a national program for environmental technology research and development, and a program of training and technology transfer. In addition, export promotion and development assistance programs are becoming more focused.

The Industry and Market in Germany

Germany is a major competitor in providing services and producing equipment for international APC markets. Estimates of the overall environmental market in Germany range from $17 billion to $36 billion annually during 1990-1992. Estimates of the overall APC market in Germany are not available, however one estimate placed the APC equipment market at $835 million annually in the early 1990s. The reunification of Germany has increased the demand for such equipment, and such demand is projected to continue to increase through the 1990s. The former East Germany generates a relatively higher level of air emissions than the former West Germany, owing in part, to its historical dependence on high-sulfur coal.

- The EGS equipment industry in Germany is estimated to be comprised of 250 to 1300 firms. One estimate placed the number of APC firms at 94. As in the United States and Japan, large diversified firms are believed to dominate the industry.

- The "green movement" in Europe originated in Germany, which has some of the strictest environmental laws and standards in the European Union (EU). German regulations for air pollution emissions are developed by the Federal Government and are required to be consistent with the directives of the EU. The implementation and enforcement of the regulations is the responsibility of the states, or lander.

- German regulations require a broader range of stationary sources to acquire emissions permits than do those of the United States or Japan.

- The German industry producing APC equipment is a major supplier to international consumers, and the largest supplier to most EU markets. Exports of APC equipment increased to $1.2 billion in 1995, with trade surpluses ranging from $444 million to $808 million annually during 1990-1995.

The Industry and Market in Japan

Japan is a major U.S. competitor in providing equipment and services to APC markets. Estimates of the APC market in Japan range from $4.4 billion in 1995 to $6 billion in 1990. The Japanese APC market accounts for about 15 percent of the global APC market. Consumption of APC equipment appears to be rising due to the tightening of air quality standards at the national level which resulted from the 1993 update of Japan's Basic Environmental Law. The Government of Japan is currently evaluating new regulations for hazardous air pollutants.

- Thermal electric power producers, petroleum refineries, steel and chemical manufacturers are the largest consumers of APC equipment in Japan. Although it is not an industrial market, the single fastest growing market for APC equipment and services in Japan is for incinerators of municipal solid waste. Incineration as a form of waste disposal is increasing as space for landfill becomes scarce.

- Although Japan's Environment Agency coordinates the administration of environmental regulation, the Ministry of International Trade and Industry (MITI) is influential in establishing regulations that directly affect industry. The Ministry of Construction and Ministry of Transportation also help formulate regulations that affect construction machinery and motor vehicles.

- Local governments in Japan have a stronger role than the National Government in setting air emissions standards and in enforcing compliance. "Administrative guidance" is a form of negotiation between local government officials and individual plant managers for to achieve agreement on how and when standards will be met.

- The APC equipment industry in Japan is dominated by five large, diversified companies, who hold 50 percent of the domestic market share. Another 100 or so firms produce the remainder of the equipment. Industry officials claim that more small specialized companies are entering the market.

- The number of firms supplying APC services in Japan is less clear, although it is believed that Japan has fewer independent consulting firms than the United States. Many electric power producers in Japan use service organizations to operate and maintain large desulfurization facilities.

- Japan's APC imports increased 75 percent during 1990-95. In 1995, 60 percent of Japan's APC equipment imports came from the United States, and 9 percent came from Germany. Japan's imports of APC equipment from the developing countries of Southeast Asia and China are growing and currently account for about 12 percent of total imports.

- Total Japanese APC exports were $878 million in 1995. The United States and South Korea are Japan's largest individual APC export markets. Although, it is estimated that 45 to 74 percent of all APC exports are sent to Southeast Asia and China. Exports to the region increased 202 percent, and exports to China alone increased 343 percent between 1990 and 1995.

- Several MITI organizations implement Japan's industrial technology development policy. With regard to environmental technology, the New Energy and Industrial Development Organization, the Research Institute for Innovative Technology for the Earth, the International Center for Environmental Technology Transfer, and the Clean Coal Utilization Center of Japan are organizations whose missions include international cooperation in technology development, the dissemination of environmental technology to developing countries, training of foreign government officials, or some combination of each.

- As of 1993, the Government of Japan was the world's largest provider of overseas development assistance (ODA), according to the OECD. At the 1992 Earth Summit, the Government of Japan announced that it would provide a total of $7.5 billion in environmental ODA for developing countries between 1993 and 2000. Reportedly, Japan is on target to contribute that amount.

- Japan's Green Aid Program, 20 percent of which is ODA funding, supports the transfer of environmental technology to developing countries. Under this program, Japanese firms and industry associations are constructing several environmental projects in Asia, three of which are air-related.

Comparative Analysis of U.S. and Major Foreign Competitors

- The United States has the largest APC industry of the three countries, primarily because the U.S. market is significantly larger than the markets in Japan and Germany. Each industry dominates its home market.

- The ranking of export performance of the three countries' APC industries in the global market is unclear. Differences in definition and data sources yield contrasting pictures of the three countries' trade balances in APC equipment and thus different views of the three industries' relative performance.

- While multinational companies dominate the industries in all three countries, the largest companies in Japan have revenues from APC equipment and services that are significantly greater than their largest competitors in either Germany or the United States.

- The three countries have similar national ambient air quality standards and emission standards. However, the form and method of setting emission standards and ensuring compliance with the emission standards are significantly different between the countries.

- Government support for export sales in all three countries includes export education, market information services, trade missions and fairs, financing, and technology research, development and demonstration programs. Japan appears to have the strongest support for environmental technology exports and research and development.

- All three countries have programs for environmental technology export promotion. Efforts are underway by both the public and private sector in the United States to expand the availability of information on the benefits and procedures of exporting and on the availability of potential overseas business partners. Specific, emerging markets have been the focus of such efforts by the U.S. Government.

- Each country's export finance program differs in emphasis and approach. For example, Germany's export financing is largely handled by its commercial banking system, whereas Japan finances approximately 40 percent of total exports through its official program. The share of official government financing in the United States falls in between the two. The level of export support through programs like export credits is declining in the United States.

- Export credit agencies of the three countries do not generally have special programs for environmental technology. Preferential treatment is unusual, and most agencies treat applications for export credit as a strictly commercial decision, based on returns and risk. Environmental considerations in project selection, if any, address the potential environmental impact of the project, not the use of environmental technology.

- Most R&D for air pollution environmental technology appears to be associated with energy programs. The Department of Energy in the United States, the Ministry of International Trade and Industry in Japan, and the Federal Ministry for Research and Development in Germany have active programs to increase energy efficiency, energy substitution, and energy conservation.

CHAPTER 1
Introduction

Many of the world's governments have come to the conclusion that air pollution is a significant, growing global problem. Scientists generally agree that emissions of some chemicals, such as chlorofluorocarbons (CFCs), threaten the earth's protective layer of stratospheric ozone. Air pollutants, such as carbon dioxide and the other green house gases that are believed to contribute to global warming, are primarily the product of the combustion of fossil fuels. Some of these gases, such as sulfur dioxide, also contribute to the problems of smog and acid rain. Other air pollutants, termed toxics, are hazardous to human health.

Both governments and industries have responded to the growing body of scientific evidence about air pollution as well as to populations and consumers more protective of their environment. The governments of many nations have responded by raising air quality standards for industrial producers, by requiring new and cleaner production technologies, and by requiring lower air pollutant emissions from major products such as automobiles. Industries have responded by developing new technologies to reduce air pollution emissions from their production processes and by developing more environmentally friendly consumer products.

The U.S. environmental technology industry, which includes firms in the air sector, is increasingly focused on the expanding export market for environmental goods and services (EGS).[1] Pressures on the U.S. economy to create technology-related jobs and to reduce costs associated with environmental regulation have increased the emphasis on research, development, and commercialization of environmental technologies. Exports offer additional opportunities for EGS and as a means to help foreign countries protect their own environments.[2]

Purpose of the Report

On October 15, 1993, the U.S. International Trade Commission (USITC) received a letter from the Senate Committee on Finance requesting that the USITC provide two reports on the competitiveness of U.S. industries producing EGS. The Committee requested that the USITC follow up the recent research into environmental technology by the Office of Technology Assessment (OTA) with an examination of two specific areas of environmental

[1] The acronym EGS will be used here when referring to overall environmental goods and services, as opposed to just those dedicated to air pollution prevention and control.

[2] U.S. Department of Commerce, International Trade Administration, statement by Secretary Ronald H. Brown quoted in *The National Export Strategy, Second Annual Report* reprinted in *Business America*, vol. 115, No. 9, special issue (Oct. 1994), p. 119.

technology.[3] Specifically, the Finance Committee asked the USITC to compare U.S. programs and policies, such as export promotion and technical assistance, with those of nations whose industries are the primary competitors in these areas of environmental technology. The first USITC report considered the industries providing goods and services for municipal and industrial water and wastewater treatment.[4] This second report considers the industries that provide air pollution prevention and control (APC) equipment and services.[5]

This report describes the production and trade of those EGS used for air pollution prevention and control. Most experts agree that more detailed information is needed to more precisely define environmental technology, to develop better production and trade data, and to develop export policies and strategies. Other efforts are underway in the United States[6] and abroad, most notably by the Organisation for Economic Co-operation and Development (OECD),[7] to define environmental technology and to determine the structure and character of the market.

Definition of Environmental Technology

The Finance Committee letter requesting this report defined environmental technology as goods and services for pollution abatement, pollution prevention, or environmental remediation; or goods and services that have as a central component the reduction of energy or materials consumption or the reduction of environmental impact during use or upon disposal.[8] This comprehensive definition of environmental technology makes challenging any attempt to measure the value of the goods and services covered. However, this

[3] The Office of Technology Assessment (OTA) of the U.S. Congress, at the request of the Senate Committee on Finance, conducted a series of studies examining emerging market opportunities for U.S. exporters of environmental goods and services. These reports identified a number of factors relevant to the global competitiveness of U.S. environmental technology in general. See OTA, *Industry, Technology, and the Environment: Competitive Challenges and Business Opportunities*, OTA-ITE-586 (Washington, DC: GPO, Jan. 1994); *Trade and Environment: Conflicts and Opportunities*, OTA-BP-ITE-94 (Washington, DC: GPO, May 1992); and *Development Assistance, Export Promotion, and Environmental Technology--Background Paper*, OTA-BP-ITE-107 (Washington, DC: GPO, Aug. 1993). OTA was abolished on September 30, 1995.

[4] USITC, *Global Competitiveness of U.S. Environmental Technology Industries: Municipal and Industrial Water and Wastewater*, Investigation No. 332-347, March 1995, Publication 2867.

[5] A copy of the request from the Committee on Finance of the U.S. Senate for the two reports is included as appendix A.

[6] EPA, Office of Policy, Planning, and Evaluation, *The U.S. Environmental Protection Industry: A Proposed Framework for Assessment*, EPA 230-R-95-001 (Washington, DC, Sept. 1995).

[7] OECD, *Forum Discussion on the Environment Industry: Background Paper*, OCDE/DSTI/IND(94)20 (Paris: OECD, Nov. 1994) and OECD, *The Global Environmental Goods and Services Industry* (Paris: OECD, 1996).

[8] This definition appears in the letter of request for the investigation (see appendix A) and in S. 978, the National Environmental Technologies Act, which was introduced in 1993.

definition is no less broad than others that have been developed.[9] Environmental goods and services include those used to change production processes to prevent air pollution, as well as those used for "end-of-pipe" pollution treatment or control. Exclusive identification of a technology is often impossible and the challenge is compounded by the fact that many of the APC goods and services have multiple end uses.

Scope of the Report

This report focuses on two major market segments for APC goods and services: (1) industrial stationary sources, including electric power facilities and (2) mobile sources, including automobiles, buses, trucks, and other vehicles (table 1-1). These sources account for the bulk of air pollution control expenditures worldwide.

Industrial facilities and thermal electric power plants[10] are the two categories of stationary sources. The combustion of fossil fuels releases primarily oxides of sulfur and nitrogen, along with hydrocarbons and particulates. The amounts of these pollutants differ with the type of fuel (coal, oil, or gas) and the quality of the fuel. Most sources report that electric power plants are the largest consumers of APC equipment, owing largely to the quantities of fuel consumed, particularly coal. The industrial sources with the largest expenditures for air pollution prevention and control include petroleum refining, and the industries producing pulp and paper, chemicals, and primary metals.

Mobile sources, especially the automobile, are the major contributors to certain kinds of air pollution throughout the world, particularly in the major cities. Motor vehicles are significant emitters of carbon monoxide, nitrogen oxides (NO_X), sulfur oxides (SO_X), hydrocarbons, lead, and particulates.[11] The world automobile fleet has risen from 53 million in 1950 to more than 430 million in 1990.[12] The truck and bus fleet was about 145 million in 1990. If the estimated 100 million 2-wheelers (i.e., motorcycles) are added, there are about 675 million vehicles worldwide contributing to air pollution and providing a vast potential market for APC equipment. Estimates of the numbers of vehicles without adequate emission controls range from 20 percent in the developed countries to nearly 100 percent in the developing countries.[13]

Industries that produce and export APC goods and services range from small engineering and manufacturing operations to large multinational engineering and construction firms or manufacturers. Products and services range from individual components, chemicals, or pieces of equipment and scientific instruments, to the design, construction, and operation of

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[9] See National Science and Technology Council, *Technology for a Sustainable Future*, (Washington, DC, July 1994), p. 9 and OECD, 1996, p. 8.

[10] Power plants included here are those that burn fossil fuels, such as coal, petroleum, or natural gas.

[11] Boubel, *Fundamentals of Air Pollution*, p. 91.

[12] Walsh, Michael, *Motor Vehicle Pollution Control, The Global Market*, July 1993.

[13] OECD, *Air Pollution from Motor Vehicles*, 1996, p. 93.

Table 1-1
Major market segments and major industries

SIC codes	Stationary sources
20	Food and kindred products
21	Tobacco products
22	Textile mill products
23	Apparel and other finished products made from fabrics and similar materials
24	Lumber and wood products, except furniture
25	Furniture and fixtures
26	Paper and allied products
27	Printing, publishing, and allied products
28	Chemicals and allied products
29	Petroleum refining and related industries
30	Rubber and miscellaneous plastic products
31	Leather and leather products
32	Stone, clay, glass, and concrete products
33	Primary metal industries
34	Fabricated metal products, except machinery and transportation equipment
35	Industrial and commercial machinery and computer equipment
36	Electronic and other electrical equipment and components, except computer equipment
37	Transportation equipment
38	Measuring, analyzing, and controlling instruments; photographic, medical and optical goods; watches and clocks
39	Miscellaneous manufacturing industries
49	Electrical power[1]
	Mobile sources
37	Transportation equipment

[1] This report addresses SIC 4911, Electric Services, of this major group, which also includes gas and sanitary services.

Source: Office of Management and Budget, *Standard Industrial Classification Manual 1987*.

facilities. While some firms produce only one or two APC products or services, many firms produce a wide range of both goods and services, making precise classification of the segments of the APC industry difficult. In addition, most firms produce similar goods and services that are not used for air pollution prevention and control.

The most easily defined groups of firms are those that produce and market the equipment used to directly remove pollutants from smokestack emissions. The major products of this segment include equipment that collects pollutants (i.e., electrostatic precipitators, scrubbers, and filters) and equipment that destroys or breaks down the pollutants into a nonpolluting entity (i.e., incinerators or other oxidation systems) (table 1-2).

Table 1-2
Market-oriented product categories

Particulate air pollution control equipment
Electrostatic precipitators Fabric filters Wet scrubbers Mechanical collectors Flue gas conditioning
Gaseous volatile organic compounds (VOC) controls
Catalytic oxidizers Thermal oxidizers Adsorbers (carbon, etc.) Absorbers (scrubbers) Chillers Others (membrane, biofilters, etc.)
Gaseous - acid gas (e.g., SO_2, HCl) controls
Wet flue gas desulfurization Dry scrubbing (spray dryers, dry injection, etc.)
Gaseous - nitrogen oxides (NO_x) controls
Selective catalytic reduction (SCR) Selective non-catalytic reduction (SNCR) Non-selective catalytic reduction (NSCR)
Mobile source controls
Catalytic controls (e.g., catalytic converters for HC, CO, NO_x) Non-catalytic controls (e.g., trap oxidizers for diesel particulate control) On-board diagnostic systems
Emissions monitoring systems (e.g., continuous emission monitors)

Source: Institute of Clean Air Companies, written communication of Nov. 3, 1994.

A second group of equipment firms produces the instrumentation used for monitoring and testing both ambient air quality and emissions for various pollutants. Much of the equipment included in this area is not unique to the APC industry (i.e., chemical analysis equipment, particulate monitoring and analysis systems), but extends across various other industrial and laboratory applications.

A third group, generally comprising smaller, more singular product-oriented firms, manufactures specific components or systems that allow the process equipment and the monitoring instrumentation to function efficiently. The products of these firms are generally items such as specific filters or filtration systems, entire absorption or adsorption systems as well as specific components, or products such as conveyance devices, i.e., fans, ducts, and pumps.

The second major segment of the APC industry consists of firms that provide a wide range of services to the industrial consumers of APC equipment to help these consumers meet air quality regulations. These firms range from small companies with technological expertise in air pollution prevention and control for specific industrial processes to large multinational firms that offer the complete range of environmental, technical, and management services. The services offered by these firms include design, engineering, construction and equipment installation, operation and maintenance, monitoring and testing, computer modeling, and media reactivation.

Approach of the Report

The approach of this report is to examine the competitive factors in APC markets and the relative strengths and weaknesses of the United States and its major rivals with respect to these various factors. These factors include those internal to the industries such as price, quality, and research and development, as well as those external to the industries such as government policies regarding environmental regulation, export promotion and market development, technology transfer, and technical and economic development assistance.

The report also examines recent supply and demand conditions prevalent in the domestic and selected foreign markets for APC goods and services. Given the definitional difficulties, the diversity of the goods and services covered, the lack of statistical information, and the number of firms involved, the assessment of competitive factors is largely qualitative. The report focuses chiefly on 1994 data on production and trade by U.S. industry, but presents other data when helpful for descriptive purposes and analysis.

Information in this report has been compiled from written submissions, responses to the USITC questionnaire, review of existing literature, meetings with government and industry officials, telephone interviews, domestic and foreign fieldwork, and other sources. The questionnaire developed for this investigation requested data and information about each firm's overall operations, operations in support of industrial APC, and revenues from U.S. and foreign markets. The usable response rate was 35 percent of the questionnaires mailed. Appendix B describes the questionnaire sample and response rate.

Organization of the Report

The remainder of chapter 1 provides an overview of the global market for EGS and APC goods and services. Chapter 2 describes the U.S. industries and market in terms of structure, production, consumption, trade, and other factors such as government programs and policies affecting production and trade of these goods and services and the performance of the APC industries. Chapters 3 and 4 discuss similar issues for the industries and markets of the major U.S. foreign competitors: Germany and Japan. Chapter 5 analyzes the factors that affect the competitive position of the APC goods and services industries of the United States and its major rivals in the global market. Chapter 5 also presents case studies for two industries, electric power, and pulp and paper, that are significant purchasers of APC equipment and services.

The Global Market

Several studies estimate that the global market for EGS in the early 1990s, of which APC is a part, was $200 billion to $300 billion annually and is forecast to grow steadily over the next decade (see table 1-3).[14] The OECD estimate of $200 billion in 1990, with growth to $300 billion by 2000, has been widely quoted since its original publication in 1992 and has stimulated interest in increased promotion of U.S. environmental exports.[15] OECD estimates that $30 billion of the environmental market in 1990 was represented by APC equipment, and that this figure will increase to $42 billion by 2000.[16] The other estimates of the global EGS market for 1990 (1992 in the case of Environmental Business International (EBI) and ECOTEC), are similar[17] but differ significantly in their forecasts. In all four estimates in table 1-3, the United States represents about 40 percent of the global environmental market.

A more recent study done by EBI for EPA estimated the global EGS market for 1994 at $408 billion (table 1-4).[18] This study reports that approximately 41 percent of the EGS market is in the United States, 31 percent is in Western Europe,[19] and 16 percent is in Japan. This study estimates the global APC equipment market for 1994 to be nearly $26 billion, 45 percent of which is in the United States, 27 percent is in Western Europe, and 17 percent is in Japan. The EBI study did not provide estimates of the global market for APC services.

While the EGS market, including APC goods and services, remains concentrated in the developed countries, future growth is expected to be most rapid in developing countries, particularly in Asia and South America.[20] The APC market in both developed and developing countries is being driven by environmental protection and economic growth. For example, demands are growing for electric power, automobiles, and other internal combustion vehicles at the same time that many of the major cities in the world are recognizing the need to address their severe air pollution problems.

Developed country markets tend to be relatively mature, having invested in APC for more than 20 years. However, as the industrial base in these countries ages, APC equipment becomes outdated and in need of modernizing and upgrading. These countries are expected to continue to account for the vast majority of the market into the next century.

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[14] Interagency Environmental Technologies Exports Working Group, *Environmental Technologies Exports: Strategic Framework for U.S. Leadership* (Nov. 1993), p. 11.

[15] OECD, *Forum Discussion on the Environment Industry*, p. 3.

[16] OECD, *The OECD Environment Industry*, p. 13. The OECD breaks out environmental equipment into four different sectors, but combines services from all sectors in one estimate.

[17] Differences in definition appear to account for much of the variation in the estimates.

[18] EBI, *The Global Environmental Industry: A Market and Needs Assessment* (San Diego, CA: EBI, 1996), p. 6.

[19] The study did not separately estimate the market for Germany.

[20] DOC, *Big Emerging Markets*, (Washington, DC: DOC, Nov. 1995).

Table 1-3
Global environmental market

(Billion U.S. dollars)

Market	OECD		ECOTEC			EBI		ETCDC2	
	1990	2000	1992	2000	2010	1992	1998	1990	2000
North America	85	125	100	147	240	145	199	125	217
United States	78	113	85	125	200	134	180	115	185
Canada	7	12	14	18	30	10	17	7	14
Mexico	-	-	1	5	10	1	2	3	18
Other Latin America	-	-	2	4-5	15	6	10	-	-
Europe	68	99	65	98	167	108	159	78	213
United Kingdom	7	11	-	-	-	-	-	11	28
France	10	15	-	-	-	-	-	10	30
Germany	17	23	-	-	-	-	-	21	65
Other European Union	-	-	[1]60	[1]89	[1]144	[1]94	[1]132	15	48
Other Western Europe	19	28	-	-	-	-	-	6	17
Eastern Europe/NIS	15	21	5	9	23	14	27	15	25
Asia/Pacific	26	42	38	63	149	30	49	46	138
Japan	24	39	30	44	72	21	31	24	65
Austrailia/NZ	2	3	-	-	-	3	5	2	4
Taiwan	-	-	-	-	-	-	-	5	30
Hong Kong	-	-	-	-	-	-	-	-	3
South Korea	-	-	[2]5	[2]12	[2]50	-	-	1	8
China	-	-	2	5	20	-	-	-	-
India	-	-	1	2	7	-	-	-	-
Other Asia Pacific	-	-	-	-	-	6	13	14	28
Rest of World	21	34	-	-	-	6	9	6	12
Total World	200	300	210	320	570	295	426	255	580

[1] All Western Europe.
[2] East and South-East Asia.
Note.—Since figures are estimates, sums may not equal totals shown.

Source: Compiled from OECD, Meeting of Experts on the Environment Industry, *Background Paper*, Oct. 13-14, 1994, p. 6; OECD, *The OECD Environment Industry*, p. 15, not including "clean" technologies; ECOTEC, *The UK Environment Industry*, not including "clean" technologies; EBI (Environmental Business International), in OTA, *Industry, Technology, and the Environment*, p. 98, including some "clean" technologies, such as alternative energy sources; ETCD2 (Environmental Technologies Development Corporation), James Higgins, "Global Environmental Industry," *Ecodecision* (Jan. 1994), p. 22, including replacement "clean" technologies only, excluding entirely new "clean" processes, "clean" and alternative energy generation, and "clean" products.

Table 1-4
The global environmental market, 1994

(Billion dollars)

Markets	USA	West Europe	Japan	Asia	Latin Amer.	Canada	Aus/ NZ	Eastern Europe	Middle East	Africa	Total dollars	Total percent
Equipment												
Water Equipment and Chemicals	13.2	10.0	4.8	2.0	1.0	1.1	0.6	0.7	0.4	0.3	34.0	8.3
Air Pollution Control	11.6	7.0	4.4	0.7	0.3	0.5	0.2	0.4	0.3	0.0	25.6	6.3
Instruments and Information Systems	1.9	1.5	0.7	0.1	0.1	0.1	0.1	0.1	0.1	0.0	4.6	1.1
Waste Management Equipment	11.0	8.7	3.8	1.0	0.4	0.8	0.4	0.4	0.2	0.1	26.7	6.5
Process and Prevention Technology	0.8	0.5	0.5	0.1	0.0	0.1	0.0	0.0	0.0	0.0	2.0	0.5
Services												
Solid Waste Management	31.0	28.1	20.2	2.6	1.2	2.1	1.2	1.0	0.7	0.3	88.3	21.6
Hazardous Waste Management	6.4	5.0	3.6	0.4	0.3	0.4	0.2	0.3	0.2	0.0	16.7	4.1
Consulting and Engineering	14.7	8.0	1.0	0.6	0.3	0.9	0.5	0.3	0.2	0.1	26.5	6.5
Remediation/Industrial Services	8.5	3.5	1.1	0.3	0.1	0.4	0.2	0.2	0.3	0.0	14.7	3.6
Analytical Services	1.6	1.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	3.1	0.8
Water Treatment Works	25.8	20.8	8.8	2.0	0.8	1.8	1.1	0.6	0.3	0.1	62.1	15.2
Resources												
Water Utilities	24.3	18.8	10,1	3.3	1.6	1.8	1.2	2.1	1.0	0.6	64.9	15.9
Resource Recovery	13.1	13.0	5.8	0.9	0.3	0.6	0.3	0.3	0.1	0.1	34.6	8.5
Environmental Energy	1.6	1.5	0.5	0.3	0.1	0.1	0.1	0.1	0.0	0.1	4.4	1.1
Total dollars	165.5	127.4	65.3	14.2	6.6	10.8	6.2	6.4	3.8	1.8	408.0	
Total percent	40.6	31.4	16.0	3.5	1.6	2.6	1.5	1.6	0.9	0.4		100.0

Source: Environmental Business International, Inc., San Diego, CA.

Developing country environmental technology markets have vast potential for sales. However, these markets tend to be immature, and developing countries are often more reliant on outside financing to pay for many environmental investments. Since older and less efficient technologies can generally be purchased at a lower initial cost, the availability of financing may be crucial in encouraging investment in environmentally sound industrial development, including APC technologies.

OECD states that international trade[21] in EGS products is growing rapidly. OECD also notes that estimates of this trade vary widely, but that recent trends suggest that international trade will continue to increase, particularly in the developing countries.

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[21] OECD, 1996.

CHAPTER 2
The Industry and Market in the United States

The U.S. air pollution prevention and control (APC) industry is composed of service and equipment firms, ranging from large multinational engineering and construction firms to small firms with fewer than 10 employees whose output falls within a very specific range of services or equipment. Most of the domestic demand for APC equipment and services in the U.S. market, the largest in the world, is satisfied by domestic firms. Although the U.S. industry is among the most technologically competitive, Germany and Japan compete effectively in many export markets. U.S. Government activities relating to domestic APC industry and to exports of both goods and services include a number of APC research and development programs, training programs, Department of Commerce (DOC) export promotion trade missions and the Department of State (DOS) policy of adding an environmental protection component to export promotion of all industrial goods.

Structure and Dynamics of the Market

The U.S. market for environmental technology has grown steadily since the early 1970s. Estimates of the size of the U.S. environmental technology market ranged from $59 billion to as much as $171 billion during 1990-94.[1] Estimated expenditures within the APC market ranged from $14 billion to $32 billion during 1990-94.[2] APC expenditures are estimated to have accounted for 29 to 31 percent of all domestic pollution abatement and control expenditures during 1991-93.[3] Expenditures are expected to increase moderately through the year 2000.[4]

Market Description

Expenditures by U.S. industry for air pollution control and abatement increased from $27.2 billion in 1991 to $31.9 billion in 1993 (table 2-1). One estimate of the U.S. market for APC equipment for 1994 was $12.4 billion,[5] about 95 percent is believed to have originated from domestic sources.[6] The domestic APC equipment market is estimated to

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[1] Environmental Business International (EBI), *The Global Environmental Industry: A Market and Needs Assessment* (San Diego, CA: EBI, 1996).

[2] EBI, *The Global Environmental Industry*. The wide range of estimated values results from the definitional differences among the sources of the estimated.

[3] Based on data in U.S. Department of Commerce, *Survey of Current Business*, May 1995.

[4] Organisation for Economic Co-operation and Development (OECD), *The OECD Environment Industry: Situation, Prospects, and Government Policies* (Paris: 1992).

[5] EBI, *The Global Environmental Industry*.

[6] Based on data compiled from official statistics of the U.S. Department of Commerce.

Table 2-1
Total expenditures on pollution abatement and control, by type, 1991-93
(Billion dollars)

Category	1991	1992	1993
Mobile Source	14.3	14.6	15.8
Stationary Source	12.9	14.7	16.1
Total	27.2	29.3	31.9

Source: Compiled from data in U.S. Department of Commerce, "Pollution Abatement and Control Expenditure, 1993," *Survey of Current Business*, May 1995.

have been $11 billion to $15 billion in 1990, much of which is related to mobile source control, which is estimated to have been about $8 billion, while estimates of the stationary source control market range from $2 billion to $5 billion.[7]

Capital expenditures for pollution abatement and control by U.S. industrial consumers increased rapidly during 1991-94, owing primarily to the phasing in of increasingly more stringent air pollution regulations (table 2-2).[8] Such requirements have effectively lowered the levels of allowable emissions on an annual basis, prompting a demand for new equipment and technologies to meet the new standards. In particular, the 1990 Clean Air Act Amendments (CAAA) contributed to an expansion of the market for SO_2 and NO_x reduction technologies, particularly reflected in the expenditures of electric utilities.

Capital expenditures by manufacturing industries for APC increased by 16 percent during 1991-94, primarily related to a doubling of such expenditures by the petroleum industry. Capital expenditures for APC account for a uniformly large share of all pollution abatement and control capital expenditures across most of the consuming industries (figure 2-1). For all manufacturing industries, APC accounted for 57 percent of all such expenditures in 1993 and 1994; for electric utilities APC accounted for nearly 73 percent of all such expenditures in 1993, and 75 percent in 1994.

The major industrial consumers of pollution abatement and control equipment and services for 1994, as reported by those domestic firms responding to the Commission questionnaire are shown in table 2-3. The major industrial markets (not including utilities and mobile source controls) served by respondents[9] to the Commission questionnaire, are clearly the

[7] Congressional Research Service (CRS), *The Pollution Control Industry: An Emerging Economic Presence*, Sept. 13, 1993, p. CRS-16. Estimates of total APC market may include some instrumentation that is not necessarily included in either the mobile or stationary source figures.

[8] "Continued Growth Expected in Environmental Market," *Pollution Engineering*, Oct. 15, 1994, p. 12.

[9] Manufacturers and marketers of pollution prevention and control equipment and services.

Table 2-2
Pollution abatement and control capital expenditures for all manufacturing industries and electric utilities, by industry, 1991-93

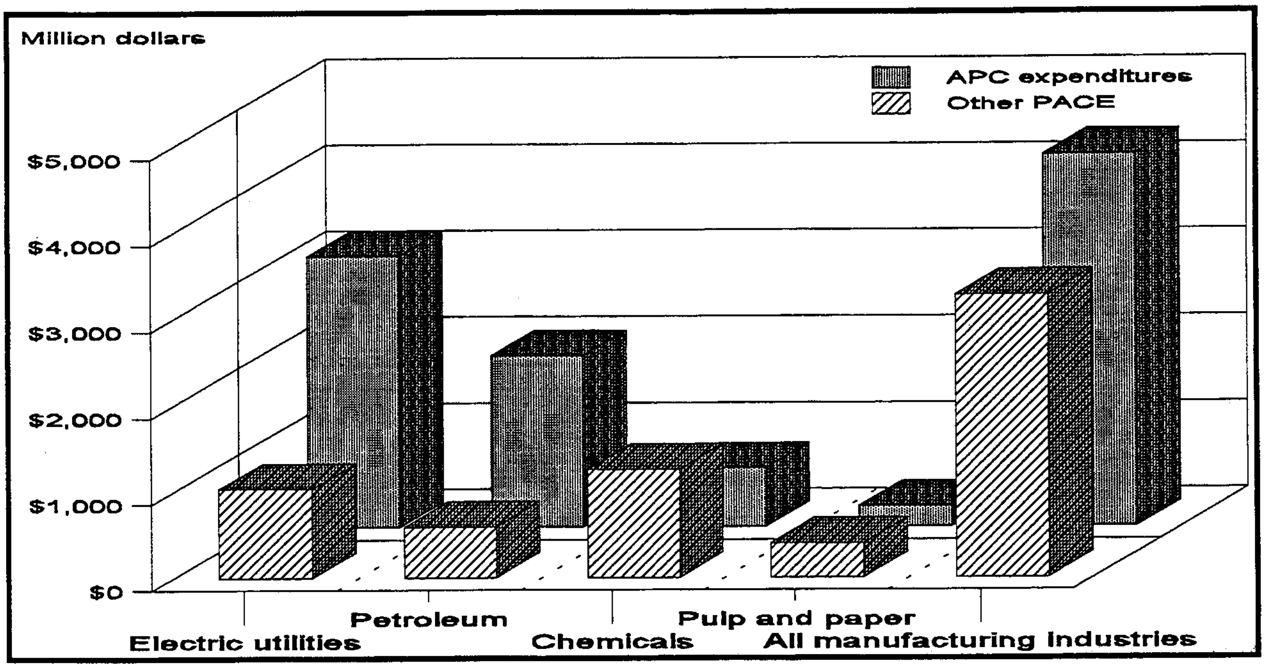
(Million dollars)

SIC Code	Industry	Pollution Abatement and Control Capital Expenditures for Air				Pollution Abatement and Control Capital Expenditures for all Media[1]			
		1991	1992	1993	1994	1991	1992	1993	1994
26	Paper	481	397	307	241	1,233	1,005	716	636
28	Chemicals	816	775	768	677	2,066	2,121	1,958	1,931
29	Petroleum	997	2,080	1,975	1,982	1,463	2,685	2,649	2,572
33	Primary metals	499	343	281	290	673	526	442	428
All other		913	808	791	1,120	1,955	1,530	1,413	2,011
Total for all manufacturing industries[2]		3,706	4,403	4,122	4,310	7,390	7,867	7,178	7,578
49	Electric utilities	1,055	1,948	2,929	3,145	1,943	2,887	4,032	4,179
Total including electric utilities		4,761	6,351	7,051	7,455	9,333	10,754	11,210	11,757

[1] Includes air, water, and solid/contained waste.
[2] Total does not include electric utilities data.

Source: Derived from official statistics of the U.S. Department of Commerce.

Figure 2-1
Pollution abatement and control expenditures, by major industrial consumers, 1994



Source: U.S. Department of Commerce, *Current Industrial Reports, Pollution Abatement Costs and Expenditures, 1994,* May 1996.

Table 2-3
Shares of revenues of U.S. producers of APC equipment and services, 1994

SIC codes	SIC industry classification	Shares of APC equipment revenues (percent)		Shares of APC services revenues (percent)	
		U.S.	Non-U.S.	U.S.	Non-U.S.
26	Paper	4	1	9	3
28	Chemicals	10	5	12	8
29	Petroleum	8	8	16	39
33	Primary metals	2	([1])	2	8
37	Transportation [2]	17	28	2	([1])
49	Electric power	24	37	22	28
All other		35	21	39	16
Total		100	100	100	100

[1] Less than 0.5 percent.
[2] May include a significant amount of mobile source equipment.

Source: U.S.I.T.C. questionnaire data.

petroleum and chemical industries, followed closely by the pulp and paper industry. Utility markets were far larger in terms of the demand for both APC equipment and services.

Regulation in the United States

Clean air legislation was first enacted at the federal level in 1955.[10] More comprehensive legislation was enacted in the Clean Air Act[11] (the Act, or CAA) in 1963.[12] The CAA has been amended several times, most notably in 1970[13] and 1977,[14] and was substantially amended and expanded in 1990.[15] It imposes emission standards on almost all stationary sources that are based in part on available emission control technology and in part on the regional ambient air quality.[16] The Act's mobile source controls contain both clean fuel requirements as well as tailpipe and evaporative emission standards for various pollutants. The CAA contains a variety of compliance and enforcement mechanisms, including permit requirements, market incentives such as emissions trading, and a range of civil and criminal sanctions. A principal, underlying policy of the CAA has been described as the adoption of a "technology-forcing" strategy, which requires polluters to develop the necessary technology to meet the Act's emission standards.[17] An emerging policy is the trend away

[10] *The Air Pollution Control, Research and Technical Assistance Act of 1955*, Pub. L. No. 80-159 69 Stat. 322.
[11] 42 U.S.C. § 7401 et seq.
[12] Pub. L. No. 88-206, 77 Stat. 392 (1963).
[13] Pub. L. No. 91-604, 84 Stat. 1676 (1970).
[14] Pub. L. No. 95-95, 91 Stat. 685 (1977).
[15] Pub. L. No. 101-549 104 Stat. 2399 (1990) (1990 Amendments).
[16] CAA § 110, 42 U.S.C. § 7410 (1994).
[17] Timothy A. Vanderer, Jr., ed., *Clean Air Law and Regulation* (1992), p. 6. One example of this strategy is the "prevention of significant deterioration" requirements, which reportedly employ technology forcing by making industrial expansion contingent upon the development of improved emission controls, and requiring new sources to adopt the most recent technological improvements. Ibid., p. 7.

from traditional "command and control" methods of pollution control toward market incentives.[18]

Implementation, compliance and enforcement

The Environmental Protection Agency (EPA) has the role of promulgating regulations pursuant to the CAA through the formal rulemaking process. The notice and comment features of formal rulemaking allow interested parties to participate, and historically the process, as it pertains to the CAA, has been slow and adversarial, with the majority of regulations challenged in court.[19] The emerging trend toward "negotiated rulemaking," where regulators and interested groups informally negotiate an agreement which forms the basis of the rule, may make regulation promulgation less cumbersome.[20] Once regulations have been adopted, the CAA gives the states the role of implementing air pollution standards through "state implementation plan" (SIP), with close supervision and assistance from the federal government. The states in turn delegate much of the regulatory and enforcement responsibility to local government.[21] The 1990 Amendments also provide for interstate air pollution control commissions, which develop regional strategies.[22]

State implementation plans

Under section 110 of the CAA, states are required to implement a plan to meet national ambient air quality standards (NAAQS) through the imposition of emission controls. The SIP is subject to EPA approval, and must provide for the implementation, attainment, maintenance and enforcement of the NAAQS.[23] The states must ensure that the NAAQS are attained no later than three years after the approval of the SIP,[24] and are directed to include a broad set of requirements in each SIP as well as to enact certain programs. Among the requirements are emissions limitations for stationary pollution sources, controls or techniques such as market incentives and schedules for compliance; pollution monitoring programs; enforcement and regulation of emission limitations and stationary sources, as well as a permit program; provisions to prevent interstate pollution that will preclude another state from attaining or maintaining national standard; and limitations on the construction of new or modified sources pursuant to the "nonattainment" and "prevention of significant deterioration" programs, and compliance with the consultation and public notification requirements of the CAA.[25]

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[18] See infra.

[19] Office of Technology Assessment (OTA), *Industry, Technology, and the Environment: Competitive Challenges and Business Opportunities* (1994), p. 266.

[20] Ibid., p. 267.

[21] OECD, *OECD Environmental Performance Reviews: United States*, 1996, p. 112.

[22] CAA § 176A, 42 U.S.C. § 7506a (1994).

[23] CAA § 110(a)(1), 42 U.S.C. § 7410(a)(1) (1994).

[24] Ibid.

[25] CAA § 110(a)(2), 42 U.S.C. § 7410(a)(2) (1994). In the event that a state fails to devise an adequate SIP, EPA must impose a "Federal Implementation Plan" ("FIP") and impose sanctions on the state. CAA § 110(c)(1), 42 U.S.C. § 7410(c)(1) (1994).

Permits

The 1990 Amendments require states to establish a comprehensive new permit program for several categories of significant air emissions sources. Under section 502,[26] and the definitions in section 501,[27] the following source categories require permits:

> "Major" sources, defined as those that emit or have the potential to emit in excess of 100 tons per year of any air pollutant;[28]
>
> New or modified sources subject to new source performance standards in section 111, prevention of significant deterioration standards in Subtitle C of Title I, and nonattainment provisions of Subtitle D of Title I;
>
> Sources of hazardous air pollutants subject to section 112;
>
> Power plants covered by the acid deposition control provisions in Title IV; and
>
> Any other sources which EPA decides require a permit.

A central feature of this program is annual emission fees for permit holders and applicants for permits.[29] The Act also provides the public with the opportunity to participate in the permit process, from the initial permitting to compliance, because the state must make available to the public any permit application, compliance plan, permit or compliance report.[30] States may also have permit requirements in addition to the federally mandated requirements.[31]

Market incentives

The CAA has historically developed as "command and control" regulation, meaning that EPA prescribes standards and then compels compliance with those standards.[32] There has been a continuing effort to include market incentives in the regulatory scheme on the theory that such a method of regulation is often not the most cost-effective form of pollution control.[33] An example from the 1990 Amendments is the marketable SO_2 emission allowance program that is part of the acid rain provisions.[34] Another example is EPA's "bubble" policy, which allows facilities to average emissions from multiple sources within the facility, rather than adhere to imposed emission limits for each point source.[35] This policy allows facility owners to offset emission reductions from one point source with an

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[26] 42 U.S.C. § 7651o (1994).
[27] Ibid.
[28] CAA §§ 302(j),502(a), 19 U.S.C. §§ 7602(j), 7651o(a) (1994).
[29] CAA § 502(b)(3), 42 U.S.C. 7651o(b)(3) (1994).
[30] CAA § 503(e), 42 U.S.C. § 7651o(e) (1994).
[31] CAA § 506(a), 42 U.S.C. 7651o(a) (1994).
[32] Vanderer, *Clean Air Law and Regulation*, p. 10.
[33] Ibid.
[34] CAA §§ 401-406, 42 U.S.C. §§ 7651-7651e (1994).
[35] Vanderer, *Clean Air Law and Regulation*, p. 206.

increase at another point source, thereby giving the facility owner latitude to determine the most efficient way to keep the total facility emissions at the required level.[36]

Enforcement and liability provisions

The Act contains a broad array of civil enforcement instruments as well as criminal sanctions. Civil enforcement can be sought either through administrative order, administrative penalty, or judicial action.[37] The 1990 Amendments significantly increased this enforcement authority by giving EPA the power to swiftly levy substantial fines without a court proceeding.[38] EPA may impose administrative penalties of up to $25,000 a day for any violation of a CAA requirement, permit or order.[39] EPA also has field citation authority for violations discovered in on site investigations.[40] Another enforcement pressure on pollution sources is the provision for citizen suits. Citizens, typically environmental groups, may file suit against EPA to compel performance of a statutory obligation, against violators of an "emission standard or limitation" set forth in the Act, and against any person who violates the permit provisions of the Act.[41] Since the enactment of the citizen suit provision in 1970, citizen suits have played an active role in the development of environmental regulation.[42] The Act provides criminal sanctions for five different categories of violations. The criminal penalties vary depending on the seriousness of the crime. The most serious crime, "knowing endangerment," carries a maximum penalty of $1,000,000 for each violation and a potential jail sentence of 15 years.[43]

Structure of the Industry

The domestic industry supplying APC services and equipment is typical of many major U.S. industries that primarily serve industrial markets. There are a few large, dominant multinational companies, but also a great number of smaller firms that have carved out specific areas of expertise, creating market niches for their equipment or services. Of the estimated 1,000 to 3,000 firms that compose the U.S. APC industry, approximately 80 percent provide primarily equipment and 20 percent provide primarily services.[44]

The largest providers of APC equipment to industrial customers are primarily large multinational firms that have developed equipment to deal with a wide range of air emissions. However, there are specific types of equipment in which certain firms dominate, and few, if any, firms produce all types of APC equipment. The small-to-medium U.S. equipment firms are generally more specialized than the larger firms.

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[36] Ibid.

[37] CAA § 113(a), 42 U.S.C. 7413(a) (1994).

[38] CAA § 113(b), 42 U.S.C. 7413(b) (1994).

[39] Ibid.

[40] 59 Fed. Reg. 22,776 (1994).

[41] CAA § 304(a), 42 U.S.C. § 7604(a) (1994).

[42] Harold Feld, "Saving the Citizen Suit: the Effect of *Lujan v. Defenders of Wildlife* and the Role of Citizen Suits in Environmental Enforcement," 19 *Columbia Journal of Environmental Law* 141, 1994, p. 144.

[43] CAA § 113(c)(5), 42 U.S.C. § 7413(c)(5) (1994).

[44] Based on U.S.I.T.C. questionnaire data.

The largest providers of APC services to industrial customers are typically large, multinational firms that have developed significant skills and experience to provide a complete integrated APC control package. Services may include any or all of the following: design, engineering, construction, maintenance, and operation of the APC system.

Estimates of the APC equipment segment are more readily available than are estimates for services. One study places the value of production of APC equipment by 800 firms at $11.7 billion in 1994.[45] This figure includes both stationary and mobile source equipment, but does not include the value of APC instruments. That study did not break out the value of APC services. The value of U.S. production of mobile source equipment is estimated by industry sources to be between $2.8 and $3.9 billion.[46]

In response to the Commission questionnaire, suppliers of APC equipment and services reported worldwide revenues of $2.4 billion in 1994 for both equipment and services, with slightly less than three-quarters of this figure coming from the sales of equipment (table 2-4).[47] Growth in worldwide equipment revenues at 27 percent annually from 1992 to 1994 exceeded growth in both overall revenues (23 percent) and APC service revenues (13 percent).

Table 2-4
Worldwide revenues of U.S. producers of APC equipment and services, 1992-94[1]

	1992	1993	1994
Gross Revenues (Million dollars)	29,976	32,939	35,139
U.S. (Percent)	63	62	60
Non-U.S. (Percent)	37	38	40
Revenues from sales of APC equipment and services (Million dollars)	1,617	2,268	2,432
Revenues from sales of APC equipment (Million dollars)	1,113	1,649	1,794
U.S. (Percent)	76	66	70
Non-U.S. (Percent)	24	34	30
Revenues from sales of APC services (Million dollars)	504	619	638
U.S. (Percent)	82	78	81
Non-U.S. (Percent)	18	22	19

[1] These figures are the totals for 212 firms responding to the Commission questionnaire and do not represent the entire industry. Staff believes that the data may represent about one-third of the revenues of the U.S. APC industry.

Source: U.S.I.T.C. questionnaire data.

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[45] EBI, *The Global Environmental Industry*, p. 7. The EBI survey reports analytical instruments for all media in one category and does not separately account for APC instruments.

[46] EBI, *The Global Environmental Industry* and other industry sources.

[47] See appendix B for more information on the Commission survey.

Total APC equipment shipments from the firms responding to the Commission questionnaire were valued at $1,690 million[48] (table 2-5).[49] Questionnaire respondents were asked to report the value of shipments for specific types of equipment, as listed directly in the questionnaire, that could be used for APC purposes,[50] and also to report the value of equipment that they knew were directed toward use for APC purposes. In certain cases, almost all of the equipment reported was geared toward APC (i.e., electrostatic precipitators); while other equipment had multiple uses and only a share of the reported shipments were known to be destined for APC (i.e., adsorption equipment and monitoring and analysis equipment). Respondents' shipments of instrumentation and mobile source equipment were valued at $563 million, leaving approximately $1,127 million for stationary equipment.

The value of shipments of selected industrial air pollution equipment for 1994 was reported by the Bureau of the Census to be $711 million (table 2-6).[51] The equipment that is being counted in the census survey is a group of specific, selected stationary source control equipment, and also excludes equipment that may be in use by electricity-generating utilities. The Census survey included 110 companies that have reported involvement in the production of such APC process equipment. Table 2-7 compares the data derived from the Commission questionnaire and the information compiled by the Bureau of the Census for selected APC equipment. The data in the tabulation represents only those specific segments from both sources that are comparable.[52]

One indicator of the relationship between the shipment data collected in the two surveys is found in the category in which the surveys coincide, electrostatic precipitators. There were nine respondents to the Commission questionnaire that reported shipments of these items, and nineteen firms noted in the Census report. However, the Census survey reported shipments of $137 million, while respondents to the Commission questionnaire reported shipments of $95 million, about 69 percent of the total. This indicates that the Commission questionnaire respondents probably represent the larger-end producers/marketers of APC equipment in the U.S. industry. Similarly, the Commission respondents for fabric filters and mechanical filters numbered 28, or about 29 percent of the number of Census survey

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[48] Although equipment shipment data were requested for both U.S. and non-U.S. facilities, there were instances in which the respondents could not supply all of the non-U.S. information that was requested. The revenue data in table 2-4 probably more closely reflect the total value of shipments of the APC equipment.

[49] For 1994, a total of 167 companies reported production of APC equipment in response to the Commission questionnaire, 67 companies reported at least some production of stationary source equipment, while 56 of these responses were limited to production of instrumentation and/or mobile source equipment. See appendix B for an explanation of the methodology employed in the survey.

[50] The specific list of equipment used in the Commission questionnaire can be found in Appendix D. A significant share of the shipments of equipment reported by respondents fit into the specific categories but was known not to be destined for use as APC functions.

[51] U.S. Department of Commerce, *MA35J–Selected Industrial Air Pollution Equipment Annual, 1994*, Sept. 1995.

[52] The differences in the primary data according to the two sources derives from the organization of the two surveys. The questions relating to shipments of specific APC equipment in the Commission questionnaire were organized primarily according to the type of equipment; while the Census survey collected information based primarily on the type of pollutant that was being collected, and then secondarily by the types of equipment. See tables 2-5 and 2-6.

Table 2-5
Firms producing APC equipment: Revenues from equipment shipments, domestic and foreign, 1994

Description	Total equipment shipments		Total equipment exports		Ratio of total exports to total shipments (Percent)	APC equipment shipments		APC equipment exports		Ratio of APC exports to APC shipments (Percent)	Ratio of APC shipments to total shipments (Percent)	Ratio of APC exports to total shipments (Percent)
	Number of firms reporting	Value (Million dollars)	Number of firms reporting	Value (Million dollars)		Number of firms reporting	Value (Million dollars)	Number of firms reporting	Value (Million dollars)			
Absorption equipment	37	193	25	32	17	37	169	25	27	16	88	14
NOx combustion control equipment	9	80	5	15	19	9	64	5	13	21	80	16
NOx post-combustion control equipment	8	10	([1])	([1])	([1])	8	10	([1])	([1])	([1])	100	([1])
Adsorption equipment	19	221	8	38	17	19	80	7	17	21	36	8
Electrostatic precipitators	9	95	6	10	10	9	95	6	10	11	100	11
Combustion equipment	27	180	13	44	25	27	155	12	26	17	86	14
Fabric filtration equipment:												
Baghouses	18	66	8	12	18	18	49	8	9	18	74	13
Parts of baghouses and other fabric filtration equipment	20	265	11	45	17	20	160	11	24	15	60	9
Auxiliary equipment and parts, and other APC equipment, nes.	39	847	16	471	17	39	345	16	202	59	41	24
Monitoring and analysis equipment	71	628	56	153	24	71	311	55	66	21	50	11
Mobile source PC equipment and instruments	8	257	6	57	22	8	252	6	57	23	98	22
Total	166	2,842	123	877	31	166	1,690	120	450	27	59	16

[1] Combined with auxiliary equipment and parts to avoid disclosure of confidential business information.

Source: U.S.I.T.C. questionnaire data.

Table 2-6
Shipments for selected industrial air pollution control equipment, 1994

Description		Number of companies	Number of units	Value (Million dollars)
Industrial air pollution control equipment		110	67,927	711
Particulate emissions collectors		90	54,744	453
35646 51	Electrostatic precipitators	19	552	137
35646 54	Fabric filters	59	47,213	211
35646 55	Mechanical collectors	39	5,692	68
35646 58	Wet scrubbers	31	1,287	37
Gaseous emissions control devices		38	1,169	207
35646 70	Catalytic oxidation systems	10		28
35646 71	Nitric oxide (NO) control systems	3		
35646 72	Thermal and direct oxidation systems	14	272	31
35646 73	Scrubbers (gas absorber non-FGD*)	11	658	14
35646 74	Wet flue gas desulfurization systems	5		106
35646 75	Dry flue gas desulfurization systems	4	14	12
35646 76	Gas adsorbers	9		
Other		19	12,014	52
35646 79	Other types of industrial air pollution control equipment	19	12,014	52

Source: Compiled from data collected and reported by Bureau of the Census in *MA35J--Selected Industrial Air Pollution Equipment Annual, 1994,* issued September 1995.

Table 2-7
Comparison of questionnaire and Census shipment data

Description	Commission Questionnaire Data[1]		Census Data	
	Number of Companies	Value ($ million)	Number of Companies	Value ($ million)
Electrostatic precipitators	9	95	19	137
Fabric filters			59	211
Mechanical filters	28	209	39	68
Wet Scrubbers			31	37
Wet FGD's	6	59	5	106
Other APC equipment reported		764		152
Total APC equipment reported[2]		1,127		711
Instrumentation	71	311		
Total PAC equipment, including instruments[2]		1,438		

[1] Equipment for APC use.
[2] Stationary source only.

Source: Compiled from U.S.I.T.C. questionnaire data and data collected and reported by Bureau of the Census in *MA35J--Selected Industrial Air Pollution Equipment Annual, 1994,* issued September 1995.

respondents in roughly the same categories, but Commission respondents accounted for 75 percent of reported shipments.

The top five domestic APC equipment firms (by gross worldwide revenue for 1994), responding to the Commission questionnaire reported production of about 71 percent of all worldwide gross revenues in 1994, but they accounted for only about 31 percent of worldwide APC equipment revenues (table 2-8). The top quartile (25 percent) accounted for more than 95 percent of reported gross worldwide revenues; and nearly 75 percent of worldwide APC equipment revenues in 1994.[53] This is because the larger firms are producing a wider range of EGS (or non-EGS) products, and the smaller firms that make up much of the rest of the U.S. industry are more oriented toward production of APC equipment.

Further, the larger firms dominate the export market to the extent that the top five equipment firms accounted for more than 86 percent of non-U.S. gross revenues and 60 percent of non-U.S. APC equipment revenues. The top quartile of these firms accounted for 98 percent of non-U.S. gross revenues and 87 percent of non-U.S. APC equipment revenues.[54]

Provision of all types of environmental consulting and engineering services and analytical services to the domestic market by U.S. firms was estimated to have been approximately $15 billion in 1994.[55] Respondents to the Commission questionnaire reported APC service revenues of $638 million, of which 28 percent was attributed to design, engineering, and consulting services, 27 percent to construction services, and 11 percent to design and installation services.

Estimated revenues attributable to all domestic environmental engineering and consulting services to the domestic market were $15.3 billion for 1994,[56] with approximately 9 percent attributable to non-U.S. sources.[57] The five largest services firms responding to the Commission questionnaire[58] (by gross worldwide revenues) accounted for 40 percent of worldwide APC service revenues; the top quartile of firms accounted for 55 percent; and the second quartile accounted for a 30-percent share of the worldwide APC service revenues (table 2-9). However, the same top five firms accounted for more than 82 percent of the total worldwide revenues from these service firms, and the top quartile of firms accounted for 92 percent of the 1994 total worldwide revenues. This relates to the size, expertise, and general acceptance of these firms as the world's experts in most all industrial engineering and construction areas, not for just the APC, or more general EGS area.

The industry's top five domestic APC service firms accounted for about 80 percent of reported gross worldwide revenues for the reporting firms during 1992-94 (table 2-9). But these same five firms did not dominate the domestic APC service market to the same extent,

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[53] U.S.I.T.C. questionnaire data.

[54] Ibid.

[55] EBI, *The Global Environmental Industry*, p. 7.

[56] EBI, *The Global Environmental Industry*, p. 6.

[57] Services related to APC represent only a small share of the total reported here, possibly between 10 and 15 percent.

[58] See appendix B for methodology. There were 97 firms reporting revenues from APC services out of 212 firms overall reporting revenues from the APC industry.

Table 2-8
Share of revenues of firms classified as APC equipment firms[1], by quartiles, sorted by gross revenues

(Percent)

Revenues derived from:	Top 5	First Quartile	Second Quartile	Third Quartile	Fourth Quartile
Worldwide gross, 1992	67%	91%	3%	1%	5%
Worldwide gross, 1993	70%	96%	3%	1%	(2)
Worldwide gross, 1994	71%	96%	3%	1%	(2)
U.S. gross, 1992	46%	82%	5%	2%	12%
U.S. gross, 1993	52%	92%	5%	2%	(2)
U.S. gross, 1994	53%	92%	5%	2%	(2)
Non-U.S. gross, 1992	85%	98%	1%	(2)	(2)
Non-U.S. gross, 1993	86%	98%	1%	(2)	(2)
Non-U.S. gross, 1994	86%	98%	1%	(2)	(2)
Worldwide gross equipment, 1992	11%	39%	11%	5%	45%
Worldwide gross equipment, 1993	33%	75%	16%	7%	2%
Worldwide gross equipment, 1994	31%	75%	16%	7%	2%
U.S. gross equipment, 1992	7%	34%	10%	5%	52%
U.S. gross equipment, 1993	20%	69%	20%	9%	2%
U.S. gross equipment, 1994	18%	70%	19%	9%	2%
Non-U.S. gross equipment, 1992	38%	76%	17%	6%	2%
Non-U.S. gross equipment, 1993	59%	87%	8%	4%	1%
Non-U.S. gross equipment, 1994	60%	87%	9%	3%	1%
Worldwide gross services, 1992	(2)	80%	15%	4%	2%
Worldwide gross services, 1993	26%	88%	10%	1%	1%
Worldwide gross services, 1994	23%	86%	12%	1%	1%
U.S. gross services, 1992	(2)	79%	15%	4%	2%
U.S. gross services, 1993	11%	83%	14%	1%	1%
U.S. gross services, 1994	9%	82%	15%	1%	2%
Non-U.S. gross services, 1992	1%	84%	16%	(2)	(2)
Non-U.S. gross services, 1993	57%	98%	2%	(2)	(2)
Non-U.S. gross services, 1994	60%	97%	3%	(2)	(2)

[1] There were 212 respondents to the Commission questionnaire. Of these respondents, 45 reported only APC service revenues; 115 reported only APC equipment revenues; and 52 reported revenues derived from both services and equipment. However, of the 52 respondents reporting both services and equipment revenues, 2 firms were determined to be primarily providers of APC services and 50 firms were determined to be primarily marketers of APC equipment. The data in this table relates to the 165 respondents that were classified as primarily APC equipment firms.

[2] Less than 0.5 percent.

Source: U.S.I.T.C. questionnaire data.

Table 2-9
Share of revenues of firms classified as APC service firms[1], by quartiles, sorted by gross revenues

(Percent)

Revenues derived from:	Top 5	First Quartile	Second Quartile	Third Quartile	Fourth Quartile
Worldwide gross, 1992	82%	92%	7%	1%	([2])
Worldwide gross, 1993	83%	92%	6%	1%	([2])
Worldwide gross, 1994	82%	92%	6%	1%	([2])
U.S. gross, 1992	80%	90%	8%	1%	([2])
U.S. gross, 1993	80%	90%	8%	1%	([2])
U.S. gross, 1994	79%	90%	8%	2%	([2])
Non-U.S. gross, 1992	93%	99%	([2])	1%	([2])
Non-U.S. gross, 1993	93%	99%	1%	([2])	([2])
Non-U.S. gross, 1994	92%	99%	1%	([2])	([2])
Worldwide gross equipment, 1992	([2])	29%	([2])	53%	18%
Worldwide gross equipment, 1993	([2])	29%	([2])	63%	9%
Worldwide gross equipment, 1994	([2])	34%	([2])	64%	3%
U.S. gross equipment, 1992	([2])	15%	([2])	67%	19%
U.S. gross equipment, 1993	([2])	27%	([2])	66%	7%
U.S. gross equipment, 1994	([2])	34%	([2])	65%	1%
Non-U.S. gross equipment, 1992	([2])	86%	([2])	([2])	14%
Non-U.S. gross equipment, 1993	([2])	36%	([2])	45%	18%
Non-U.S. gross equipment, 1994	([2])	33%	([2])	60%	7%
Worldwide gross services, 1992	43%	62%	25%	12%	2%
Worldwide gross services, 1993	42%	60%	26%	12%	1%
Worldwide gross services, 1994	40%	55%	30%	13%	1%
U.S. gross services, 1992	30%	54%	30%	14%	2%
U.S. gross services, 1993	31%	52%	31%	14%	1%
U.S. gross services, 1994	34%	51%	32%	15%	2%
Non-U.S. gross services, 1992	93%	95%	4%	1%	([2])
Non-U.S. gross services, 1993	89%	94%	3%	2%	1%
Non-U.S. gross services, 1994	69%	75%	20%	4%	1%

[1] There were 212 respondents to the Commission questionnaire. Of these respondents, 45 reported only APC service revenues; 115 reported only APC equipment revenues; and 52 reported revenues derived from both services and equipment. However, of the 52 respondents reporting both services and equipment revenues, 2 firms were determined to be primarily providers of APC services, and 50 firms wee determined to be primarily markets of APC equuipment. The data in this table relates to the 47 respondents that were classified as primarily APC service firms.

[2] Less than 0.5 percent.

Source: U.S.I.T.C. questionnaire data.

accounting for 30 to 34 percent of domestic APC revenues over the same 3-year period. The top quartile accounted for 51 to 54 percent of domestic APC service revenues during 1992-94.

A number of the U.S. APC industry participants are also fairly well integrated, incorporating the provision of both services and equipment in their marketing plan. These firms account for a significant share of APC equipment revenues, as indicated by responses to the Commission questionnaire. Of the total of 163 respondents that are classified as APC equipment firms, 48 also offer services to some extent, while of the 49 APC services firms, two firms also report revenues from production and sales of APC equipment.

Respondents reported total service revenues for 1994 of more than $9 billion, of which less than 7 percent, or approximately $636 million, was attributable to APC customers (Table 2-10). The ten largest service providers (by gross revenues) accounted for 87 percent of the gross service revenues, but accounted for only 43 percent of APC service revenues in 1994. This highlights the importance of the smaller services firms in the domestic industry. The firms with the largest overall revenues are construction and engineering firms that also do design and engineering, and installation services; while the smaller firms provide primarily design and engineering services, and monitoring and testing services. Two categories of APC services, design, engineering, and consulting services, along with design and installation services accounted for 46 percent of revenues earned by the top ten firms. However, the smaller firms' division of revenues by task was much more evenly distributed among the services described, with significant revenues derived also from repair and maintenance services and environmental monitoring and testing services.

Respondents to the Commission questionnaire reported shipments of equipment[59] in 1994 of $2.8 billion, with those shipments specifically attributable to APC uses valued at $1.7 billion (table 2-5). The difference between these shipment values relates to the production of multiple-use equipment. Such equipment may be designed for APC uses, but users may also have identified other functions for which it may be employed. Shipments of instruments for monitoring and analysis were valued at $628 million, with nearly 50 percent estimated to have gone into APC markets.[60] More detailed information on domestic APC equipment shipments involved directly in the process of removal of air pollutants indicates that the value of these shipments was approximately $711 million in 1994. The majority of the shipments were related to particulate emission collection, accounting for 64 percent of shipments of equipment used directly for removal of pollutants.[61] Respondents to the Commission questionnaire reported particulate emission collection accounted for approximately 54 percent of their shipments of APC process equipment.

In the future, the specific equipment segments in which demand growth is expected include those markets for electrostatic precipitators, fabric filters, mechanical collectors, and wet scrubbers, all of which are used to remove particulates from smokestack emissions. Much

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[59] Equipment typically used in APC applications. For example, certain equipment, such as centrifuges, may or may not be used in an APC application.

[60] U.S.I.T.C. questionnaire data.

[61] Process equipment as requested in on the Commission questionnaire was defined as absorption and adsorption equipment, NO_X combustion and post-combustion equipment, electrostatic precipitators, baghouses and their component parts, gravity settling chambers and cyclones.

Table 2-10
Revenue by type of environmental service, 1994

Description	Total Revenues	APC revenues	Total non-U.S. revenues	Non-U.S. APC revenues
All reporting firms, value (Million dollars)				
Construction	2,558	49	599	11
Design, engineering, and consulting	2,617	157	289	13
Design and installation	1,025	112	830	15
Repair and maintenance	43	37	10	10
Environmental monitoring and testing	240	55	16	3
Environmental modeling	253	28	102	1
Media reactivation	23	6	([1])	([1])
Other[3]	2,631	192	175	69
Total	9,390	636	2,022	123
All reporting firms, share of total (Percent)				
Construction	27	8	30	9
Design, engineering, and consulting	28	25	14	11
Design and installation	11	18	41	12
Repair and maintenance	([2])	6	([2])	8
Environmental monitoring and testing	3	9	1	2
Environmental modeling	3	4	5	1
Media reactivation	([2])	1	([2])	([2])
Other[3]	28	30	9	56
Total	100	100	100	100
Top ten reporting firms, by total service revenue (Million dollars)				
Construction	2,428	15	593	10
Design, engineering, and consulting	2,044	83	268	5
Design and installation	945	43	817	2
Repair and maintenance	5	([1])	0	0
Environmental monitoring and testing	60	11	4	1
Environmental modeling	196	13	102	1
Media reactivation	0	0	0	0
Other[3]	2,473	110	150	45
Total	8,151	276	1,933	65
Top ten reporting firms (by total service revenue), share of total (Percent)				
Construction	30	5	31	15
Design, engineering, and consulting	25	30	14	8
Design and installation	12	16	42	3
Repair and maintenance	([2])	([2])	0	0
Environmental monitoring and testing	1	4	([2])	2
Environmental reactivation	2	5	5	2
Media reactivation	0	0	0	0
Other[3]	30	40	8	69
Total	100	100	100	100

[1] Less than $500,000
[2] Less than 0.5 percent.
[3] This category reflects the services that the respondent firms could not classify. It is believed that most of these revenues are design, engineering, and construction.

Source: U.S.I.T.C. questionnaire data.

of this equipment currently serving the industry is expected to require replacement during the next decade, as much original equipment was initially installed during the 1950s and 1960s and emission standards are changing enough that new equipment may be required to meet these standards.[62]

Exports/Imports

U.S. trade in APC equipment indicates that the value of exports of domestically produced APC equipment remained fairly stable during 1991-95, declining about 5 percent.[63] During this period the value of exports ranged from a low of $805 million in 1993 to a high of $889 million in 1991 (table 2-11).[64] The value of imports of APC equipment increased each year between 1990-93, and increased again significantly during 1994-95.[65] The average annual growth rate for imports for 1991-95 was approximately 11 percent. According to Census data for APC equipment, the United States shows an overall trade surplus of $644 million, in 1995, and trade surpluses with almost all of its major trading partners, particularly Canada and Japan. However, industry estimates[66] for U.S. exports of APC equipment for 1994 were approximately $600 million and for U.S. imports $900 million, leading to a trade deficit in APC equipment of about $300 million (table 2-12).

Respondents to the Commission questionnaire reported APC equipment exports of $450 million, which was approximately 27 percent of their total APC shipments. According to revenue data supplied by questionnaire respondents for 1994, the largest non-U.S. market for APC equipment was Western Europe, which accounted for 33 percent of both equipment and services' foreign markets (table 2-13). The next largest foreign markets for equipment reported were Canada, Central and South America, and Mexico. Also, questionnaire respondents were asked to report on the future importance of various foreign markets to their production (table 2-14). Producers of both equipment and services stated that the most important foreign market for the next 3 years would be the Pacific Rim nations other than Japan and Canada.

Marketing Practices

The U.S. APC industry reports that the most common purchasers in 1994 were local industry end-users, which accounted for 45 percent of domestic sales, while multinational U.S. purchasers accounted for 19 percent. The 5 largest firms, by world wide gross revenues, have a much higher share of domestic sales to multinational clients (24 percent) than all other reporting firms (15 percent). Comparative data for foreign market purchases show a similar pattern. Again, local industry end-users account for the largest share of U.S. sales

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[62] EBI, *A Report for the Office of Energy and Infrastructure*, p. 80.

[63] Several trade subheadings for APC equipment in the HTS changed between 1990 and 1991; with possible inconsistencies in the series.

[64] Compiled from official statistics of the U.S. Department of Commerce. There is no HTS that allows for the complete tabulation of APC equipment trade. Therefore, although the categories selected represent much of the equipment that is characteristic of APC trade, the data do not purport to be absolute or all-inclusive. The categories are those used by EPA, 1993.

[65] Compiled from official statistics of the USDOC.

[66] EBI, *The Global Environmental Industry*. These data were based on responses to an EBI survey.

Table 2-11
Air pollution control equipment: U.S. Imports and exports, 1990-95

(Million dollars)

Partner	1990	1991[1]	1992	1993	1994	1995
Exports						
World	543.6	888.7	828.7	805.1	859.7	848.1
Canada	229.9	277.7	252.7	270.6	312.6	346.6
Japan	67.5	236.8	166.6	149.9	165.6	100.7
South Korea	20.6	24.8	27.2	19.7	40.4	42.9
Germany	14.7	66.2	84.1	62.0	51.2	32.5
United Kingdom	18.2	46.9	23.0	28.7	21.4	27.3
Mexico	34.6	43.9	53.7	54.8	57.9	26.6
Taiwan	20.7	34.1	37.1	17.7	17.1	24.2
Thailand	1.8	4.4	7.6	6.6	6.4	23.9
France	14.9	28.4	17.3	16.6	10.4	15.9
China	4.1	5.2	7.3	27.1	17.7	15.0
Total other	116.5	120.5	152.1	151.3	159.0	192.5
Imports						
World	123.4	130.6	133.9	171.7	167.8	204.2
Canada	34.3	31.8	35.0	41.5	48.2	62.1
Japan	21.4	19.3	27.1	33.3	26.5	28.9
Germany	15.3	14.7	15.2	25.3	21.7	21.5
China	7.2	4.1	4.9	8.3	15.8	20.7
Mexico	8.7	10.4	11.8	22.0	16.0	16.6
United Kingdom	5.0	5.7	6.6	8.9	10.9	12.3
Taiwan	11.2	6.8	10.1	7.5	7.2	10.2
Israel	5.6	8.7	5.2	5.3	2.7	8.0
Italy	3.3	2.0	1.4	2.4	4.7	5.9
France	1.9	6.0	2.0	1.9	2.4	2.4
Total other	9.5	21.1	14.7	15.2	11.8	15.7

[1] Several of the trade subheadings attributable to APC equipment in the HTS changed several times during 1990-95, with possible inconsistencies reflected in the resulting statistics for 1990-93.

Note.—Top 10 partners sorted by imports for consumption (customs value in 1995).

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table 2-12
U.S. environmental trade balance, 1994

(Billion dollars)

	U.S. industry	U.S. market	Surplus	Export	Import	Percent of exports
Equipment						
Water Equipment and Chemicals	13.5	12.7	0.8	2.1	1.3	16
Air Pollution Control	11.7	12.0	-0.3	0.6	0.9	5
Instruments and Information Systems	2.9	1.9	1.0	1.2	0.2	42
Waste Management Equipment	11.2	10.5	0.7	0.9	0.2	8
Process and Prevention Technology	0.8	0.8	0.0	0.0	0.0	1
Services						
Solid Waste Management	31.0	30.6	0.4	0.8	0.4	3
Hazardous Waste Management	6.4	6.3	0.1	0.2	0.1	3
Consulting and Engineering	15.3	14.6	0.7	0.9	0.2	6
Remediation/Industrial Services	8.6	8.4	0.2	0.2	0.0	2
Analytical Services	1.6	1.6	0.0	0.0	0.0	2
Water Treatment Works	25.7	26.3	-0.6	0.2	0.8	1
Resources						
Water Utilities	24.2	24.7	-0.5	0.1	0.6	0
Resource Recovery	15.4	13.6	1.8	2.0	0.2	13
Environmental Energy	2.2	1.5	0.7	0.9	0.2	41
Totals	170.5	165.5	5.0	10.1	5.1	6

Note. U.S. industries is revenues generated by U.S. companies, U.S. market is revenues generated from U.S. customers. Exports do not include ownership of overseas companies but do include repatriated profits.

Source: Environmental Business International, Inc., San Diego, Calif.

Table 2-13
Revenues from non-U.S. markets for certain U.S. APC industry participants, 1994

Market	Equipment		Services	
	Value of non-U.S. revenues (Million dollars)	Share of non-U.S. markets (Percent)	Value of non-U.S. revenues (Million dollars)	Share of non-U.S. markets (Percent)
Canada	76	14	23	19
Mexico	52	10	14	11
Central America, Caribbean, and South America	52	10	5	4
Western Europe	178	33	40	33
Eastern Europe, including the NIS[1]	22	4	11	9
Japan	34	6	1	1
China	16	3	2	2
India	10	2	2	1
Other Pacific Rim	36	7	9	7
Other Asia	15	3	1	1
Australia & New Zealand	17	3	6	5
Middle East & Northern Africa	20	4	8	7
Saharan & Subsaharan Africa	19	3	2	1
Total	545		123	

[1] Newly Independent States of the Former U.S.S.R.

Source: U.S.I.T.C questionnaire data.

Table 2-14
Importance of foreign markets to domestic industry (1 meaning most important)

Markets	Equipment	Services
Canada	2	2
Mexico	4	4
Central America, Caribbean, and South America	5	3
Western Europe	3	5
Eastern Europe, including the NIS[1]	7	9
Japan	10	10
China	6	6
India	9	8
Other Pacific Rim	1	1
Other Asia	8	7
Australia & New Zealand	11	12
Middle East & Northern Africa	12	11
Saharan & Subsaharan Africa	13	13

[1] Newly Independent States of the Former U.S.S.R.

Source: U.S.I.T.C. questionnaire data.

abroad, 20 percent, and multinational clients account for 18 percent. National governments, however, account for almost 12 percent of foreign sales, a far greater share than U.S. Government purchases in the domestic market.[67] This is primarily due to greater government ownership of electrical utilities in many foreign markets.

The techniques used to market U.S. APC equipment and services abroad are also reportedly somewhat different for the larger and smaller domestic firms. Overall, foreign sales offices accounted for approximately 24 percent of foreign revenues and export sales accounted for another 22 percent. Foreign joint ventures accounted for only about 10 percent of foreign revenues. The five largest firms accounted for 28 percent and the first quartile accounted for 24 percent of their sales through foreign sales offices, whereas the smaller firms primarily marketed their product from their U.S. facilities, as their export sales accounted for 32 to 52 percent of their foreign revenues.

The competitive nature of the domestic market is reflected in the factors that domestic producers believe affect their ability to complete sales (table 2-15). The primary factor cited was quality of the product, followed by the ability to meet specific needs of the customers; both are factors typically found to be most important when there are a number of choices available and there is little difference in price from one competitor to another. Price was the third factor cited, followed by the reputation of the firm, another factor generally associated with quality rather than price. In the foreign market, price competition was cited as the most important competitive factor, closely followed by quality and the ability to meet specific needs.

Firms responding to the Commission questionnaire provided certain anecdotal information relating to competition in foreign markets. Advantages of U.S. firms most often cited involved the current exchange rate, particularly relating to competition in Asian markets vis-a-vis Japanese firms, and the reputation and name recognition associated with firms being U.S.-based. Among the disadvantages cited was difficulty in financing for smaller projects. Respondents noted that financing for such projects was rarely available from major sources that tended to favor larger scale projects.

Particular problems cited by questionnaire respondents for the services segment in foreign markets involved competition against local firms for projects controlled by government entities with significant interests in using local contractors. Also, for the equipment segment, requirements in developing countries are generally less stringent and do not require the technology employed to be state-of-the-art. As such, firms in these countries with less effective, but lower cost systems, are at a competitive advantage in relation to most U.S. firms.

U.S. firms responding to the Commission questionnaire also reported their perceptions specifically concerning the assistance rendered to Japanese and German firms through general Government assistance programs (figure 2-2).[68] In general, U.S. firms regarded Japanese Government involvement in the APC industry as fairly uniform across all types of programs. Although there was little knowledge of specific programs reported, about two-thirds of the respondents mentioned that Japanese Government programs have assisted Japanese exports of APC equipment and services. However, respondents noted an emphasis of the German Government with assistance on market information programs, specifically

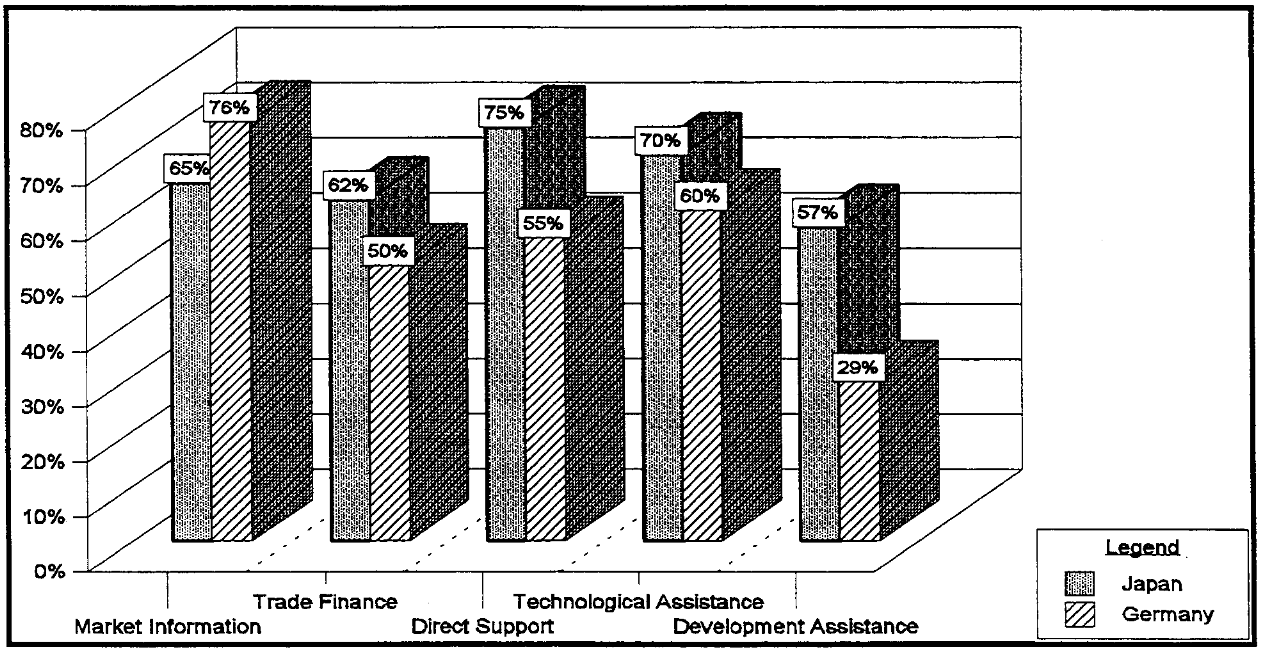
[67] U.S.I.T.C. questionnaire data.
[68] U.S.I.T.C. questionnaire data.

Table 2-15
Competitiveness factors for the U.S. and non-U.S. markets

Description	Rating	Rank
Factors affecting competitiveness in U.S. market:		
Price	4.03	3
Quality	4.39	1
Firm size and financial strength	2.98	10
Ability to offer complete package	3.28	8
Ability to meet specific needs	4.22	2
Availability to perform work/scheduling	3.45	6
Company reputation/name recognition	3.82	4
Ability to offer training	2.77	12
Form of environmental regulation	3.33	7
Enforcement of environmental regulation	3.73	5
Availability of market information	2.78	11
Availability of project financing	2.58	13
Procurement practices of public sector	2.46	14
Procurement practices of private sector	3.02	9
Factors affecting competitiveness in non-U.S. markets:		
Price	3.51	1
Quality	3.42	2
Firm size and financial strength	2.62	12
Ability to offer complete package	2.98	7
Ability to meet specific needs	3.38	3
Availability to perform work/scheduling	2.77	8
Company reputation/name recognition	3.09	4
Ability to offer training	2.47	20
Form of environmental regulation	2.75	9
Enforcement of environmental regulation	3.01	6
Availability of market information	2.55	17
Availability of project financing	2.49	19
Procurement practices of public sector	2.32	22
Procurement practices of private sector	2.62	13
Knowledge regarding exporting	2.58	16
Tariffs or duties	2.45	21
Technical standards and licensing	2.61	14
Lack of metrification in the United States	1.58	26
Availability of protection for intellectual property	2.32	23
Exchange rates	2.59	15
Availability of suitable foreign partners or foreign JV's	2.55	18
Existence of foreign sales offices/representatives	3.07	5
Risk of non-payment	2.75	10
Local technical capacity to use and support your technology	2.71	11
Lack of information on U.S. government programs	2.02	25
Foreign tax laws	2.13	24

Source: U.S.I.T.C. questionnaire data.

Figure 2-2
U.S. firms' perception of benefits to foreign firms' exports through Government assistance programs



Source: U.S.I.T.C. questionnaire data.

trade missions and trade fairs, training and demonstrations, and overseas assistance by government and technical personnel. Respondents believe that the German Government does not provide their domestic industry with a level of assistance comparable to the Japanese Government's co-financing with multilateral development banks.

Most respondents also reported that their major sources of competition for sales and contracts in foreign markets outside Germany and Japan were other U.S. firms. Several firms described situations in which associations and business arrangements with U.S. firms were regarded as preferable to Japanese and German competitors, in most cases related to political and social issues rather than traditional competitive factors.

Government Programs and Policy

Government policy and programs can affect exports of environmental technology. In the case of the United States, a concerted effort to develop a coordinated program culminated in the formulation of a national strategy for environmental policy in 1995.[69] The new strategy sought a more effective national program for research and development, enhanced efforts to transfer the results of this technology to both domestic and foreign producers with appropriate protections for intellectual property, better focused export promotion programs to capture the economic benefits, and a development assistance program to make the benefits

[69] National Science and Technology Council (NSTC), *Bridge to A Sustainable Future: National Environmental Technology Strategy* (Washington, DC, Apr. 1995), pp. 1-5.

of environmental technology available to as many other countries as possible. The following discusses these efforts and provides as much detail as possible on how the new strategy affected air pollution control equipment and services.

Environmental Technology Policy

U.S. Government involvement in environmental technological development generally includes one or more of the following broad categories: (1) direct support of officially mandated Federal Government responsibility for environmental programs; (2) indirect support of environmental objectives by fostering more effective abatement and control of pollution; (3) support of general environmental objectives by promoting "environmentally preferred technologies;" and (4) promotion of environmental technology exports.[70]

Research and Development

Total U.S. government spending for environmental technology research and development (R&D) is substantially less than total R&D. Estimates of U.S. Government spending on environmental technology in FY 1994 range between $2.3-3.5 billion (table 2-16), whereas total government spending for all government-funded R&D in 1994 exceeded $70 billion.[71] Spending on air pollution technology R&D represents a substantial, but difficult to define, portion of this expenditure. The following discussion highlights some of the attempts to estimate government spending on environmental R&D programs.

There have been two recent interagency data collection efforts coordinated by the White House Office of Science and Technology Policy (OSTP) in an effort to estimate federal environmental R&D expenditures. The study conducted by the Committee on Environment and Natural Resources (CENR) was wide in scope; it asked federal agencies with primary missions for environment and natural resources to report all their environmental research activities from basic scientific research to technology development.[72] CENR estimated that federal agencies spent more than $5 billion on environmental R&D in FY 1994, but the CENR estimate did not break out environmental "technology" expenditures. The second study conducted by the National Science and Technology Council (NSTC) specifically sought data on R&D for environmental technology.[73] It estimated that major Federal agencies spent $2.8 billion on this R&D in FY 1994.[74] If demonstration, scaleup, and commercialization are included, total spending is $3.7 billion.

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[70] OTA, *Environmental Technology: Analysis of Selected Federal R&D Programs*, OTA-ITC-155 (Washington, DC, July 1995), pp. 1-4.

[71] Ibid., p. iii.

[72] This approach did not include the Department of Defense, which does have significant expenditures for development of environmental technology.

[73] NSTC, *Bridge to A Sustainable Future*, p. 6 and National Science Foundation, *Federal Funds for Research and Development: Fiscal Year 1994*, vol. 42, NSF 94-328 (Arlington, VA, 1993).

[74] NSTC did include the Department of Defense in its survey. Data are from OTA, *Environmental Technology: Analysis of Selected Federal R&D Programs*, pp. 7-9. NSTC did not publish its data, except for calculated expenditure shares in NSTC, Technology for a Sustainable Future.

Table 2-16
Environmental technology R&D programs covered in the report[1], FY 1994

(Million dollars)

Program	Environmental technology
Department of Energy[2]	
Clean Coal Demonstration	222
R&D pertinent to cleaner fossil fuels	314
Solar and Renewable Energies	219
Environmental Management Technology Development Program	215
Energy Efficiency	[3]334
Subtotal	1,304
Department of Defense[4]	
Strategic Environmental R&D Program	154
Environmental Security Certification Program	-
Advanced Research Projects Agency	[5]68
Individual Services (total)	178
Subtotal	400
Other departments/agencies	
Environmental Protection Agency	94
Department of Commerce	[6]43
National Aeronautics and Space Administration	[6]153
Department of Health and Human Services	11
Department of Interior	44
National Science Foundation (environmental technology R&D)	34
U.S. Department of Agriculture	240
Subtotal	714
Total	2,419

[1] Funding estimates cited above may differ from other estimates for specific agencies in FY 1994 due to differences in methodologies, definitions, and jurisdictions covered in data collection. Totals may not add due to rounding.
[2] Figures do not include activities carried out through the Office of Energy Research (such as global change research), the Office of Assistant Secretary for Environment, Safety, and Health, the Bonneville Power Administration, and some other programs.
[3] Figure includes funding related to the Partnership for a New Generation of Vehicles and for building technologies.
[4] Information provided by the Department of Defense.
[5] Figure does not include $10 million in appropriated but unreleased funds.
[6] Figure does not include monitoring and assessment technology.

Source: Office of Technology Assessment, 1995; based on information provided by Federal agencies and data collected by the National Science and Technology Council.

The two studies are similar, but not entirely comparable. The CENR survey covers all environmental R&D, excluding the Department of Defense (DOD). The NSTC survey focused on technology, but includes other items, such as more than $1 billion for monitoring and assessment technology. This other expenditure is largely for development of space, aircraft, and ground observation technology by the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA) for monitoring general global environmental conditions, not just air quality.

The Office of Technology Assessment (OTA) of the U.S. Congress prepared an analysis of selected R&D expenditures on environmental technology, mostly for energy efficiency, cleaner energy, and remediation technologies. It estimated that a total of $2.3 billion was spent in FY 1994 by nine Federal agencies.

While the major agencies conduct their own environmental technology programs, several efforts are multi-agency based and are coordinated by a lead agency. For example, EPA coordinates the agencies participating in the Environmental Technology Initiative (ETI), the Department of Commerce sponsors the Advanced Technology Program (ATP), and the DOD has several projects involving its Technology Reinvestment Program (TRP). However, a frequent criticism of the federal effort was that it lacked a common strategy.[75] The Administration responded by encouraging agencies to formulate their individual strategies,[76] and an overall strategy was coordinated by the NSTC.[77] As part of this process, NSTC formulated a strategy for environmental technology R&D, which identified four steps: (1) shift from control and waste management technologies to avoidance and conservation technologies; (2) use regulatory and fiscal policies to stimulate development of these technologies; (3) use export and aid policies to increase exports of environmental technologies; and (4) use education, training, and information dissemination to influence the market for these technologies.

Two subgroups of NSTC, CENR and the Committee on Civilian Industrial Technology (CCIT) are responsible for environmental technology. Specific programs and activities include an information system, the Global Network for Environmental Technology (GNET), an effort to promote commercialization of these technologies by supporting demonstration and verification, and by obtaining permits; the Rapid Commercialization Initiative (RCI), and an outreach program to promote interaction between private and government research interests, the Private Enterprise-Government Interaction Task Force (PEGI). Another technology initiative coordinated through NSTC is the Partnership for a New Generation of Vehicles (PNGV), a program for pollution avoidance.[78]

OTA estimated that the Department of Energy (DOE) budget for total environmental technology research, development, and demonstration in FY 1994 was $1.3 billion. This consisted of direct efforts to reduce air pollution, such as the clean coal demonstration program and R&D for cleaner fossil fuels, and indirect efforts, such as solar and renewable

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[75] See discussion in U.S.I.T.C., *Global Competitiveness of U.S. Environmental Technology Industries: Municipal and Industrial Water and Wastewater*, Publication No. 2867 (Mar. 1995), p. 5-2.

[76] Department of Commerce (DOC), *Environmental Technology Exports: Strategic Framework* (Market Research Report), June 29, 1994.

[77] NSTC, *Bridge to A Sustainable Future*, pp. 1-5.

[78] According to OTA, federal agencies budgeted $246 million for PNGV in FY 1995.

energies and energy efficiency (table 2-16). Environmental management expenditures are largely for nuclear and hazardous waste management.

Direct efforts, such as DOE's Clean Coal Technology Program, have been operational for 10 years as the government and private industry have cost-shared 45 demonstration projects with total combined spending of $6.9 billion over the period, $2.3 billion in federal funds.[79] If there are successful commercial applications of these projects, the government funds can be recovered from the private industry.

R&D for cleaner fossil fuels, i.e., natural gas, oil, coal, is an attempt to develop cleaner fuels or reduce their impact, whether in fuel use, supply, conversion, or delivery. Examples are gas turbine and fuel cell development.[80] In an effort to strengthen the fossil fuel industry's technological base this R&D is also conducted through cost sharing efforts with industry, and through university grants. Total R&D of the fossil fuel program was $426 million in FY 1994 and $442 million in 1995.[81]

DOE's energy efficiency programs reduce pollution through energy conservation. One of the principal goals of such programs has been increasing energy efficiency in the transportation sector, especially clean-car and electric vehicle programs through increased fuel efficiency, hybrid propulsion and battery systems, and advanced fuel cell technologies. Another focus has been on improved building construction technology, including more energy efficient buildings and in finding alternatives for certain chemicals, such as chlorofluorocarbons (CFCs) used in building materials and refrigeration and air-conditioning systems. DOE's efforts toward industrial technology efficiency have focused particularly on polluting process industries, such as pulp and paper, oil refining, chemicals, steel, aluminum, foundries, and glass. DOE's Office of Industrial Technologies (OIT) operates the Industrial Waste Reduction Program, which spent approximately $90 million in FY 1994 on waste characterization technology R&D, and technology and information transfer.[82] DOE reported that technology commercialized by OIT has produced a cumulative energy savings of $2.2 billion.

Solar and renewable energy programs also have implications for pollution reduction through reduction of use of fossil fuels. Alternative power sources include solar, wind, geothermal, ocean-based, hydroelectric, biomass, hydrogen, and photovoltaic-produced power. Total DOE funding for solar and renewable programs was $324 million in FY 1994.[83] This included basic research, development and demonstrations, field testing and evaluations, and programs for foreign technical assistance and export promotion. NSTC identified $219 million of this spending as environmental technology R&D (table 2-16).

One of the programs of DOE and a number of other agencies is the Cooperative Research and Development Agreement (CRADA). DOE provides personnel, services, facilities, equipment, or other resources of one or more of its national laboratories, and a non-Federal entity provides funds, personnel, services, facilities, equipment, or other resources for a

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[79] OTA, *Environmental Technology,* p. 20.
[80] Ibid., p. 19.
[81] Ibid.
[82] Ibid., p. 22.
[83] Ibid., p. 23.

specific research or development effort. As of January 1995, DOE had 1,157 CRADAs, including 152 specifically identified as environmental technology projects.[84]

OTA estimated that DOD spent at least $400 million on environmental technology in FY 1994. Much of what DOD does parallels what other agencies are pursuing: technology to improve compliance, more efficient use of resources and reduction of use, and cost-effective pollution prevention. The Strategic Environmental Research and Development Program (SERDP), mandated by Congress in 1990, is a joint effort that includes DOD, DOE, EPA, NOAA, and NASA; more than $150 million was spent in FY 1994 on identifying technologies and research developed within the government that would be useful in the private sector and vice versa. Approximately $55 million was budgeted for FY 1995. Another DOD program, the Advanced Research Projects Agency (ARPA) does not do its own research, but supports military and government laboratories, defense contractors, and universities. In addition to research on fuel cells, battery, and photovoltaics, ARPA reported $68 million in support of environmental technology in FY 1994.

As a regulatory agency, the EPA focuses more on regulatory procedures than on direct support of new environmental technology research.[85] In an effort to support its regulatory function, EPA formulated an Environmental Technology Strategy (ETS) with four objectives: (1) adapt EPA's framework to promote innovation; (2) help technology developers to succeed; (3) invest EPA funds in the development and commercialization of promising new technologies; and (4) accelerate the diffusion of innovative technologies at home and abroad.

The EPA total R&D spending in 1994 was $535 million, while its budget for support of environmental technology increased from $79 million in FY 1993, to $94 million in FY 1994, and to $101 million in FY 1995.[86] EPA is the lead agency in the ETI, which had received $36 million in FY 1994 and $68 million in FY 1995. In FY 1994, EPA had planned 73 activities in four categories for the ETI: (1) research, development, demonstration, testing, and evaluation of monitoring, pollution prevention, control, and remediation technologies; (2) clean technology for use by small business in pollution prevention; (3) promotion of technology abroad through technical assistance; and (4) identification of gaps and barriers to environmental technology.[87] EPA was also very active in the CRADA program with private industry with 57 CRADAs and 12 patent licensing agreements as of July 1994.[88]

Other Federal agencies also support environmental technology. The Department of Agriculture (USDA) reported large expenditures, of almost $250 million in FY 1994, on such research. However, OTA was not able to estimate how much funding went to technologies to prevent, control, and repair environmental damage.[89] NASA had a budget of $791 million in 1994 and more than $800 million in FY 1995 for basic environmental technology research into the major biological, chemical, and physical processes of earth

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[84] Ibid., p. 26.
[85] Ibid., p. 41.
[86] Ibid., p. 42.
[87] Ibid., p. 43.
[88] Ibid., p. 46.
[89] Ibid., p. 52.

science. It spent $153 million in FY 1994 on pollution avoidance and control and $181 million in FY 1995.[90]

The DOC also supports basic environmental technology research through NOAA and the National Institute of Standards and Technology (NIST), but these organizations are also mostly oriented to basic research or to issues like climate change. NOAA spent approximately $34 million in FY 1994 on environmental technology R&D and $35 million in FY 1995; NIST spent $8.5 million in FY 1994 and $15.5 million in FY 1995.[91]

Export Promotion

The U.S. Government's national strategy for environmental policy envisioned an active program of export promotion. Selected U.S. Government programs affecting environmental exports are presented in table 2-17. While budget constraints are curtailing many activities, there is still a concerted effort to continue the Government strategy to promote environmental exports.

Export education, market information, and trade fairs

The DOC, the Small Business Administration (SBA), and the Agency for International Development (USAID) offer programs to introduce businesses to the export market. In addition to these agencies, DOE, EPA, the Overseas Private Investment Corporation (OPIC), and the Trade and Development Agency (TDA) provide market information and sponsor trade missions. State agencies, local trade associations, chambers of commerce, and other private entities, such as bar associations, institutes, and congresses also conduct export activities.

The DOC has been the most active U.S. Government agency in export promotion generally, and has played a major role in promoting environmental technology exports and focusing the administration's environmental technology strategy.[92] These developments and much of the current effort on export promotion of environmental technology were discussed in the Commission's report on water.[93]

The International Trade Administration of the DOC has several export promotion initiatives. Its matchmaker program recently conducted a trade mission for environmental technologies in South Korea, Singapore, and Indonesia. The Environmental Technologies Office of DOC has been working with state export promotion organizations to formulate a more coordinated approach. There are approximately 70 district offices of DOC around the United States and two abroad, Beijing and Mexico City, which also promote environmental technologies. USAID recently announced a new program, the Latin American Initiative for Environmental Technology. Similar to USAID's program in the Asia-Pacific, this program will provide approximately $100 million in two funds. Grants will be given to U.S. firms exploring projects in Latin America and there will also be a venture capital fund to finance renewable energy and pollution abatement.

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[90] Ibid., p. 55.

[91] Ibid., pp. 50-51.

[92] NSTC, *Bridge to A Sustainable Future*, pp. 1-5 and OTA, *Environmental Technology*, p. 26.

[93] U.S.I.T.C., *Global Competitiveness of U.S. Environmental Technology Industries*, pp. 111-222.

Table 2-17
Selected U.S. Government agency programs affecting environmental exports

(Million dollars)

Agency/program	1994 funding	1995 funding	1996 funding	Program description
Department of Commerce				
Office of Environmental Technology Exports	1.0	4.1	([1])	Facilitates the increase of U.S. environmental technology exports.
Department of Energy				
Export Assistance Program	1.5	1.6	([1])	Provides studies and analysis in support of the National Export Strategy.
International Market Development, Energy Conservation	3.1	7.8	([1])	Promotes energy conservation, establishes data base for energy efficient products.
Coal Technology Export Program	1.6	0.8	0.8	Supports coal technology exports.
Committee on Renewable Energy Commerce and Trade	0.9	1.9	([1])	Promotes U.S. exports of renewable energy products and services.
Committee on Energy Efficiency Commerce and Trade	0.7	1.1	([1])	Promotes U.S. exports of energy efficient products and services.
Environmental Protection Agency				
U.S. Technology for International Environmental Solutions	11.0	11.0	1.0	Promotes the use of U.S. technologies and expertise in solving international environmental problems.
Trade and Development Agency	6.1	6.2	([1])	Funds export promotion activities for water and environment.
Export-Import Bank	1,095.0	1,370.0	([1])	Provides direct loans and guarantees with an environmental purpose.
Overseas Private Investment Corporation				
Environmental Enterprise Development Initiative	1.0	([2])	–	Gives pre-investment assistance to U.S. companies planning to establish environmental operations in eligible Asian countries.
Global Environment Fund	70.0	100.0	([1])	An investment partnership created to realize long-term capital appreciation through investments that promote environmental improvement.
Multi-funded Programs				
Environmental Training Institute	2.5	5.2	5.2	Provides training to foreign government officials to facilitate U.S. technology transfer.

[1] Program specific budget information is not available.
[2] Program ended.

Source: U.S.I.T.C. staff telephone survey.

Overseas presence and advocacy

The DOC has played a lead role in a coordinated government-wide effort to provide high-level government advocacy of commercial interests abroad. The Department of State (DOS) recently announced what it characterized as a new fundamental principle of U.S. foreign policy. Protection of the environment will now be treated on the same level as national security as a policy issue.[94] A new Under Secretary for Global Affairs position was created to integrate environmental issues into DOS's traditional framework. All bureaus and embassies were ordered to incorporate environmental issues into all diplomatic activity and planning and to prepare initiatives that will promote American interests.

Feasibility studies

The U.S. TDA is the lead agency in funding feasibility studies of overseas projects that can lead to exports of environmental technology. In FY 1994 TDA spent 11.4 percent of its budget, or $6.1 million, on 43 activities involving the environment. These included various clean coal projects, flue gas desulfurization in Poland, and ozone depleting industrial solvents in Russia.[95] In FY 1995 TDA spent $6.2 million on 45 activities, including studies of air emission sources in the Philippines, flue gas scrubbing in Estonia, wind power in Ecuador, air quality monitoring in Venezuela, and vehicle fuel conversion in Uzbekistan.[96]

Financing and insurance

Exporters usually require some means of expediting payment, whether with a letter of credit, a longer period of payment, or a guarantee or insurance. Even loans to pay for product development or production are included in broad definitions of export financing. Private sector banks are the customary source of these services, but there has always been some government involvement to assist or supplement these private sources. This government support has frequently been a source of contention between countries, and agreements have attempted to bring some order to this competition.[97]

The Export-Import Bank of the United States (Ex-Im Bank) has aggressively pursued an environmental agenda. In FY 1994 it funded more than $1 billion in support of such exports for 22 projects in 9 countries.[98] In FY 1995 it again funded more than $1 billion for 17 projects in 10 countries. These included rebuilding a coal-fired power plant in Poland, a steel mill expansion in China, and various other power plant projects in Argentina, China,

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[94] Secretary Christopher, American Diplomacy and the Global Environmental Challenges of the 21st Century, (Address and Question and Answer Session at Stanford University, Palo Alto, CA) Bureau of Public Affairs, U.S. Department of State, Apr. 9, 1996.

[95] U.S. Trade and Development Agency (TDA), *1994 Annual Report*.

[96] TDA, *1995 Annual Report*.

[97] An arrangement under the auspices of the OECD in 1992 is supposed to bring order to tied-aid financing, a special form of support where development assistance is tied to purchases from the donor country. OECD, *Export Promotion and Environmental Technologies*, p. 9.

[98] Compiled from Ex-Im Bank, *Transactions with an Environmental Effect*, Report No. ACMR610-2 (Sept. 30, 1994).

Mexico, Indonesia, and Turkey.[99] So far in FY 1996, over $300 million in direct loans and guarantees has been approved, including power plant projects in Pakistan and Panama.[100, 101]

The OPIC also takes the environmental aspect of overseas projects into account. While it does not compile data on what environmental exports may ultimately result from its insurance of overseas investments, several projects could be identified with strong environmental content. In FY 1995 these included various coal-, gas-, and oil-fired power plants in Columbia, Guatemala, Equatorial Guinea, Indonesia, Jamaica, and the Philippines; a geothermal- powered plant in the Philippines; and an auto emission catalysts plant in South Africa.[102]

Official Development Assistance

The United States has alternated with Japan as the leading source of Official Development Assistance (ODA). U.S. ODA policy has been the promotion of humanitarian interests and not overt support of exports, but that has been changing in recent years with the commercial advocacy by the DOC and a new emphasis on the environment. As the leading donor country, U.S. ODA exceeded $11 billion in 1990-92, and fell by 17 percent to $9.7 billion in 1993 (table 2-18). Its ODA share of GNP fell to 0.15 percent in 1993, the lowest ratio by far of the members of the OECD Development Committee.[103] The United States total net flow of financial resources to developing countries and multilateral organizations increased to $57.8 billion in 1993, a record high, up substantially in every year of the period 1990-93 (table 2-18).

Table 2-18
United States: The flow of financial resources to developing countries and multilateral organizations, 1990-93

(Million dollars)

Net disbursements	1990	1991	1992	1993
Official development assistance	11,394	11,262	11,709	9,721
Other official flows	(450)	(776)	1,305	140
Grants by private volunteer agencies	2,505	2,671	2,812	2,567
Private flows of market terms (long-term)	(2,356)	7,599	17,666	45,405
Total resource flows (long-term)	11,093	20,756	33,492	57,833

Source: OECD, *Development Co-operation 1994: Effects and Policies of the Members of the Development Assistance Committee* (1995), pp. C17, C18.

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[99] Ibid.

[100] Compiled from Ex-Im Bank, *Transactions with an Environmental Effect*, Report No. ACMR610-2 (Apr. 30, 1996).

[101] Because of environmental concerns, the Ex-Im Bank turned down loan requests for $500 million from Caterpillar, Voith Co., and Rotech to finance construction work on China's Three Gorges Dam. The Ex-Im Bank may consider financing loans in the future, but environmental questions will have to be addressed.

[102] Overseas Private Insurance Corporation (OPIC), *Annual Report, 1995*.

[103] OECD, *Development Co-operation 1994, Effects and Policies of the Members of the Development Assistance Committee*, (Paris: OECD, 1995), p. A9-10.

CHAPTER 3
The Industry and Market in Germany

Germany is Europe's largest producer of environmental goods and services (EGS) equipment,[1] and is the world's third largest national market after the United States and Japan.[2] The air pollution control and prevention (APC) industry and markets in Germany, home of Europe's "green movement," have been stimulated by the strict environmental laws and standards imposed on its manufacturing sector.[3] German Government activities relating to its APC industry include research and development programs, export promotion, and overseas development assistance.

Structure and Dynamics of the Market

Market Description

The OECD has estimated Germany's 1990 EGS market at $17.5 billion, a level that was projected to increase 4 percent annually to $23 billion by the year 2000.[4] Other estimates of Germany's EGS market range from Germany's Statistiches Bundesamt (i.e., Germany's Federal Statistics Office) estimate of $27.8 billion or 1.6 percent of gross domestic product in 1992[5] to a private sector estimate of $36 billion in 1991.[6] The EGS may be substantially higher as annual environmental protection needs in eastern Germany are estimated at an additional $30 billion until the year 2000.[7]

The OECD has estimated that the German APC subsector of the EGS market is expected to grow moderately, as compared with the high growth rate of the recycling subsector and the low growth rate of Germany's water treatment/waste management subsector.[8] The 1992 industrial APC equipment market in Germany was estimated at $835 million.[9]

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[1] R. K. Miller & Associates, "Germany," ch. in *International Environmental Markets* (1994), p. 152.

[2] Office of Technology Assessment (OTA). *Industry, Technology, and the Environment: Competitive Challenges and Business Opportunities* (1994), p. 97.

[3] R. K. Miller & Associates, "Germany," p. 153.

[4] Organization for Economic Co-operation and Development (OECD), *The Global Environmental Industry* (1996), p. 16.

[5] Statistiches Bundesamt, *Environmental Data, Germany, 1995.* (Wiesbaden, Germany: Federal Government of Germany, 1995), p. 6.

[6] R. K. Miller & Associates, "Germany," p. 152.

[7] Ibid.

[8] OECD, The Global Environmental Goods and Services Industry (Paris: OECD, 1996), p. 25.

[9] R. K. Miller & Associates, "Germany," pp. 152-153.

Stationary sources

The German EGS market expenditures are divided by Germany's Federal Statistics Office into current expenditures and investment (table 3-1). Over the 1989-92 period, Germany's EGS market expanded from $18.9 billion to $27.8 billion, or by an average 15.8 percent annually.[10] Over the same period in Germany, total current expenditures increased by an average 19.2 percent annually from about $10 billion to $15.7 billion, while total EGS-related investment rose 12 percent annually from $8.9 billion to $12.1 billion.[11] Table 3-1 suggests that during 1989-92, German industry's current expenditures have exceeded and grown faster than its EGS-related investment (which actually declined slightly). Industry's current expenditures exceeded government current expenditures during 1989-92, while government investment levels exceeded industry's investment. In fact, while industry's EGS investment levels fell slightly from $4.1 billion to $4 billion during 1989-92, government EGS investment expenditures surged ahead an average 22.6 percent annually from $4.8 billion to $8.1 billion over the same period.[12]

APC-related investment levels in Germany declined during 1989-91. During this period, the following APC-related investment levels declined by about 7 to 9 percent annually: total levels from $2.5 billion to $2.1 billion; government levels from $21 million to $18 million; and industry levels from $2.5 billion to $2.1 billion. As a percentage of Germany's total EGS investment, APC-related investment fell from 28.4 percent to approximately 19 percent during 1989-1991. For industry, APC investment as a percentage of EGS investment declined from 62 percent in 1989 to 53 percent in 1991. APC-related current expenditures by German industry and government were not available.

Mobile sources

Motor vehicles emissions account for a large proportion of the major air pollutants in Germany.[13] The volume of motor vehicles has increased since German unification. Emission controls have been required on vehicles since the mid-1980s. Since then, the percentage of low-emission cars has risen from 2 percent of the fleet to 18 percent.[14] Future increases in this percentage will most likely come from additions of new vehicles to the German automobile fleet. Given estimates that purchases of new vehicles will remain stable over the next few years, the market demand for mobile source equipment is expected to remain flat.[15]

Motor vehicles are subject to both German and EU emission standards and fuel requirements. EC directives 91/441/EEC and 91/542/EEC provide for phased-in NO_X

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[10] Statistiches Bundesamt, *Environmental Data, Germany, 1995*, p. 6.
[11] Ibid.
[12] Ibid.
[13] OECD, *OECD Environmental Performance Review, Germany* (1993), p. 135.
[14] Statistiches Bundesamt, *Environmental Data, Germany, 1995*, pp. 13-16.
[15] M. P. Walsh, *Motor Vehicle Pollution Control, the Global Market* (Consultant report) (Arlington, VA: July 1993).

Table 3-1
Germany's EGS expenditures, 1989-92

(Million U.S. dollars)

Description	1989	1990	1991	1992
Total investment, EGS	8,889	10,899	11,064	12,096
Government	4,830	6,424	7,135	8,100
Industry	4,059	4,475	3,929	3,996
Total current expenditures, EGS	9,979	12,707	13,914	15,720
Government	4,452	5,781	6,653	7,556
Industry	5,527	6,926	7,261	8,164
EGS Market, total expenditures	18,868	23,606	24,978	27,816
APC-related investment	2,526	2,575	2,084	n/a
Government	21	25	18	n/a
Industry	2,505	2,550	2,066	n/a
APC as a share of EGS investment (percent)	28.4	23.6	18.8	n/a

Note.—Mark-denominated data were converted into U.S. dollars using the "rf" exchange rate in IMF, *International Financial Statistics*, May 1996, p. 268.

Source: Statistiches Bundesamt, *Environmental Data, Germany, 1995.* (Wiesbaden, Germany: Federal Government of Germany, 1995), p. 6.

standards for motor vehicles and also establish hydrocarbon emission limits. German regulations set evaporative emissions standards. Other measures include economic incentives for the use of three-way catalytic converters, the banning of leaded gasoline and certain gasoline additives, the use of state-of-the-art control technology for automobiles, and emission standards for heavy-duty vehicles.

Regulation in Germany

The Federal Immissions Control Act (the Act or FICA),[16] originally enacted in 1974, provides the legislative framework for air pollution control in Germany. The federal government has promulgated administrative regulations pursuant to Article 48 of the Act, the most significant of which is "The Technical Instructions on Air Quality Control" (TA Luft).[17] TA Luft sets ambient air quality standards, and sets technology-based emission

[16] *Act on the Prevention of Harmful Effects on the Environment Caused by Air Pollution, Noise, Vibration and Similar Phenomena* (Federal Immissions Control Act - BimSchG) (Mar. 15, 1974), BGB1.I, p. 721.

[17] *First General Administrative Regulation Pertaining to the Federal Emission Control Law* (Technical Instructions on Air Quality Control [TA luft]) (Feb. 27, 1986), GMB1, pp. 95, 202.

controls for many pollutants for both new and existing stationary sources.[18] The federal government has also issued many ordinances implementing the requirements of the Act regulating specific pollutants and pollution sources.[19] The principal mechanisms of the Act are permit and licensing systems.

Implementation, compliance and enforcement

The role of developing environmental legislation and regulation is held principally by the federal government,[20] and to some extent by the European Union.[21] At the federal level, air pollution control is the responsibility of the Ministry for the Environment, Nature Protection and Reactor Safety, which oversees the more specialized Environmental Protection Agency.[22] Once regulations have been adopted, the lander (states of Germany) have responsibility for implementing air pollution standards, granting permits, monitoring ambient air standards, and enforcement.[23] The federal government's role in implementation and enforcement is limited to an advisory role.[24] Many organizational differences exist among the lander; as a result, methods of implementation and enforcement differ.[25] All lander are subject to the same administrative procedure, however, which apparently provides some uniformity in administration of the laws.[26]

Permits

The Act requires the lander to establish a permit, or licensing, program for all air emissions sources which "are particularly liable to cause harmful effects on the environment or otherwise endanger or cause considerable disadvantages or considerable nuisance to the general public or the neighborhood."[27] The Act provides the public the opportunity to participate in the permit process.[28] Environmental impact assessments are generally a precondition to obtaining a permit for a new or modified facility.[29] As part of the permitting process, regulators examine both the reliability and knowledge of the operator, as well as

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[18] Ibid., Articles 2.5, 3, and 4.

[19] E.g., "Ordinance on Large Firing Installations," *Thirteenth Ordinance Implementing the Federal Immission Control Law* (13th Ord.) (13th BImSchV) (June 22, 1983).

[20] Hans D. Jarass and Joseph DiMento, "Through Comparative Lawyers' Goggles: A Primer on German Environmental Law," 6 *The Georgetown Int'l Envtl. Law Review* 47, 52 (1993).

[21] Ibid., pp. 57-59. The EC has passed many directives in the area of environmental protection, many of which incorporate standards already present in German federal law. Many of these EC directives, however, which oblige the German government to harmonize its national laws in accordance with the content of the directive, address subject matter previously not present in German law, such as environmental impact assessment and public access to environmental files.

[22] Argonne National Laboratory, *Comparison of International Environmental Policies* (Draft) (1993), p. V-25.

[23] OECD, *OECD Environmental Performance Reviews: Germany*, p. 34.

[24] Jarrass and DiMento, "Through Comparative Lawyers' Goggles," p. 55.

[25] Ibid., p. 54. Differences arise, for example, depending on whether the air pollution control laws are administered by engineers or by lawyers.

[26] Ibid., p. 55.

[27] *Federal Immissions Control Act (FICA)*, Article 4.

[28] *FICA*, Article 10.

[29] Mark Brealey, ed., *Environmental Liabilities and Regulation in Europe* (1994), p. 217.

plant safety.[30] The permit will also contain specific operational instructions for the plant, and the granting of a permit may be followed by supplementary orders.[31]

Enforcement and liability provisions

The principal enforcement mechanism is the permitting system, which provides for compliance monitoring after the permit has been granted.[32] Acts which are damaging or dangerous to the environment are subject to the German Criminal Code, and its use has apparently become more common.[33] The Act also provides for penalties of up to DM 100,000 for negligent or willful violations of the Act or environmental ordinances.[34]

The German Courts reportedly play an important role in implementation, as well as policy-making, in the area of environmental protection.[35] Environmental protection cases are mostly handled in the administrative courts, which review administrative actions that impact individual rights; for example, an appeal from the granting of a permit by individuals living near the polluting source in question.[36] In the context of such cases, German courts have a more restrictive standing requirement than that in the United States. Standing is denied to plaintiffs who cannot demonstrate some form of injury or direct effect upon themselves, such as environmental groups.[37] Also, unlike in the United States, there is no provision for citizen suits.[38]

Structure of the Industry

Germany's EGS industry is estimated to be comprised of 250 to 1,300 firms.[39] The German Committee for the United Nations Environment Program (GCUNEP) reports that of 254 EGS-related firms operating in Germany in 1995, 94 were involved in APC activities.[40] The GCUNEP classifies the 94 firms by 18 types of APC activities grouped into 5 categories, as summarized in table 3-2.[41] The number of German firms involved in EGS-related activities declined by 4.9 percent to 254 entities over the 1990-95 period.[42] Over the same period, the number of firms involved with APC activities fell 9.6 percent from 104 to 94. Of the five categories of APC equipment listed in table 3-2 for 1990 and 1995, the number of firms supplying different flue gas cleaning equipment either remained the same or, in most cases, fell; the number of firms supplying equipment for separation of solid and liquid matter from waste air and waste gas increased for all subcategories except filtering separators; supplying equipment dealing with separation of gaseous matter increased in most cases; and the

[30] Ibid., p. 216.
[31] Ibid., pp. 218-219.
[32] *FICA*, Articles 16 and 17.
[33] Brealey, *Environmental Liabilities and Regulation in Europe*, p. 208.
[34] *FICA*, Article 62.
[35] Jarrass and DiMento, "Through Comparative Lawyers' Goggles," p. 49.
[36] Ibid., p. 56.
[37] Ibid., p. 56.
[38] Ibid., p. 57.
[39] The 250-firm estimate is from German Committee for the United Nations Environment Program (GCUNEP), *German Technology* (1995). The larger estimate is from the OECD, *The Environment Industry* (1996), p. 280.
[40] GCUNEP, *German Technology*, 1995.
[41] Ibid., pp. ix-xi.
[42] GCUNEP, *German Technology*, 1995.

number of firms supplying other appliances and accessories remained the same. The number of firms supplying mobile source (waste gas) detoxification equipment fell from 5 to 2 between 1990 and 1995.

According to Umweltbundesamt (hereafter, Germany's Federal Environmental Agency),[43] there were 680,000 jobs in Germany's EGS market in 1990, and this level is expected to grow to 1.1 million by the year 2000. Of the 1990 jobs, 546,000 or about 80 percent were in West Germany, and 134,000 or about a fifth were in the former German Democratic Republic (GDR).[44] Of the 1990 EGS-related jobs, 252,000 jobs or 37 percent were classified as in pollution abatement, and 429,000 or 63 percent were involved with the manufacture of EGS goods.

Exports/Imports

Data concerning German imports and exports of APC equipment were obtained for 1990-93 and for 1994 for some trading partners, as well as the first 10 months of 1995 (table 3-3). Germany's exports increased by 4 percent from \$1.04 billion to \$1.08 billion during 1990-1993, and then to \$1.23 billion for the first 10 months of 1995. German exports to the United States declined from \$78.1 million to \$75.1 million during 1990-1993, after which levels increased 16 percent to \$87.3 million in 1994. German exports of APC equipment to Japan varied within the range of \$7.7 million-\$10.9 million during 1990-1993, and thereafter increased to \$15.6 million in 1994 and to \$18.4 million for the first 10 months in 1995. German exports to the United States have significantly exceeded export levels to Japan.

German APC equipment imports fluctuated substantially during 1990-95. During 1990-92, German imports of APC equipment steadily increased from \$513.6 million to \$645.1 million or by 12.8 percent annually, before declining 21.6 percent to \$506 million in 1993. German imports of U.S. APC equipment increased steadily, from \$64.8 million to \$101.7 million during 1990-93, and then fell by nearly a third to \$65.8 million in 1994. During 1990-94, German imports of Japanese APC equipment increased erratically from \$23.7 million to \$35.1 million. German imports of U.S. APC equipment substantially exceeded imports of Japanese equipment. Through the first 10 months of 1995, German imports from Japan were 20 percent higher than for all of 1994.

Germany consistently maintained a trade surplus in APC equipment, and this surplus increased from \$526 million to \$791.7 million during 1990-95. Germany's trade balance in APC equipment with the United States greatly varied during 1990-95: from a surplus in 1990, to three consecutive deficits during 1991-93. During 1994 and through October 1995, Germany reported trade surpluses with the United States. Germany consistently ran deficits with Japan in the trade of APC equipment during 1990-95.

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[43] Umweltbundesamt, Federal Government of Germany, *Environmental Protection--An Economic Asset* (Berlin: Umweltbundesamt, 1993, 1994), pp. 39-49.

[44] Umweltbundesamt, *Environmental Protection*, p. 39.

Table 3-2
APC activities and numbers of related firms operating in Germany, 1990 and 1995

Industry in charge		Number of firms		Percent change 1990 to 1995
		1990	1995	
Firms involved with environmental protection		267	254	(4.9)
Firms involved in 18 APC activities		104	94	(9.6)
3.1	Firms involved in flue gas cleaning			
3.1.1	Desulfurization plants	36	28	(22.2)
3.1.2	Denitrification plants	27	22	(18.5)
3.1.3	Dust removal installations	37	37	0.0
3.1.4	Other	22	19	(13.6)
3.2	Firms involved in the separation of solid and liquid matter from waste air and gas			
3.2.1	Electrostatic precipitator	17	19	11.8
3.2.2	Mass force separators	16	25	56.3
3.2.3	Wet precipitators	21	24	14.3
3.2.4	Filtering separators	33	31	(6.1)
3.2.5	Other dust removers	13	14	7.7
3.3	Firms involved with the separation of gaseous matter including odors from waste air and gas			
3.3.1	Biological	17	26	52.9
3.3.2	Chemical	17	19	11.8
3.3.3	Thermal	19	18	(5.3)
3.3.4	Catalytic	18	27	50.0
3.3.5	Absorption process	26	27	3.8
3.3.6	Adsorption process	30	39	30.0
3.3.7	Wet scrubber	26	21	(19.2)
3.4	Waste gas detoxification plants, appliances for internal combustion motors	5	2	(60.0)
3.5	Other equipment appliances and accessories for air pollution control	15	15	0.0

Source: German Committee for the United Nations Environment Program (GCUNEP), *German Technology*, pp. ix-xi.

Table 3-3
Air pollution control equipment: German imports and exports, 1990-95

(Millions of dollars)

Partner	1990	1991	1992	1993	1994	1995
Exports						
World	1,040	1,050	1,089	1,084	n/a	1,233
United States	78.1	55.5	60.5	75.1	87.3	69.0
Japan	9.5	8.9	7.7	10.9	15.6	18.4
Imports						
World	513.6	562.4	645.1	506.0	n/a	441.4
United States	64.8	86.2	93.9	101.7	65.8	64.4
Japan	23.7	20.1	30.7	27.9	35.1	42.2

Note.—The 1995 data are only for Jan. through Oct.

Source: Data for 1989-1991, 1993, and 1995 were compiled from official statistics of the Government of Germany: Statistiches Bundesamt, *Aussenhandel. Reihe 2, Aussenhandel nach Waren und Landem,* various December and October issues. The 1992 data were from the Eurostat's COMTEXT database faxed to staff by the EU delegation to the U.S. Some of the 1994 data were not available from either source.

Government Programs and Policies

Research and Development

The German government has actively pursued a research and development (R&D) program on environmental technology.[45] To coordinate these activities the Federal Government established the Scientific Advisory Board on Global Environmental Change in April 1992. The Federal Ministry for Research and Technology is the lead agency, but other ministries also participate, including Environment, Nature Conservation and Nuclear Safety; Food, Agriculture and Forestry; Economic Cooperation and Development; Transport; and entities such as the Deutsche Forschungsgemeinschaft[46] and the German Federal Environment Foundation. Activities generally parallel efforts by the United States and Japan, i.e., pollution reduction through renewable energy sources and more efficient energy use.

The Federal Government spends in excess of DM 1 billion ($625 million) annually on environmental research and technology development. Table 3-4 presents funding support for the Energy Research and Energy Technologies Program from 1983-94. Funding on renewable energy sources has fluctuated, but exceeded DM 300 million ($190 million) annually in the 1990s. However, according to an OECD performance review, government

[45] Federal Environment Ministry, Environmental Policy, *First Report of the Government of the Federal Republic of Germany Pursuant to the United Nations Framework Convention on Climate Change* (Bonn, September 1994), p. 146.
[46] Translated: Research Society of Germany.

Table 3-4

Funding support for research into renewable energy sources and efficient energy use, 1983-94[1]

(Million DM)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Renewable energy sources and energy efficiency	271.5	238.5	221.2	189.4	196.4	210.5	239.6	277.1	322.6	357.5	360.9	333.3
Photovoltaic systems (project support)	54.0	59.1	53.3	57.8	60.1	70.9	82.5	91.9	104.0	111.0	112.7	88.0
Wind energy (direct project support)	16.0	8.9	10.2	12.1	17.8	16.0	12.4	18.1	9.8	9.3	7.4	9.0
Wind energy (indirect project support)	-	-	-	-	-	-	0.2	3.8	8.0	16.4	24.8	32.0
Geothermal energy and other activities	14.0	14.9	13.3	2.8	4.9	3.3	10.9	14.3	16.7	16.7	20.5	21.9
Contributions of major research establishments	20.3	21.3	23.5	25.8	22.4	24.2	30.2	32.6	46.6	71.2	57.9	69.0

[1] Includes 1994 planned funding, as of March 1993.

Source: Federal Ministry for Research and Technology (BMFT).

spending for energy-related R&D has declined in real terms since the 1980s.[47] Most of Germany's energy R&D goes to supply availability; just over 3 percent is devoted to energy conservation.[48] Approximately 60 percent of the energy R&D budget of the Federal Ministry of Research and Development is for nuclear power research; 15 percent goes to coal and renewable energy.[49]

Past policy primarily employed "end-of-pipe" measures.[50] Emphasis is increasingly on pollution prevention.[51] In order to promote this approach, the Federal Ministry for Research and Technology has developed a support concept called "production-integrated environment protection," which was introduced in January 1994.[52] Its objective is the prevention or reduction of particularly large material loads or of pollutants that are very resistant to degrading or elimination.[53] The emphasis has been on volatile organic compounds (VOCs), initially on halogenated carbons (CCs and CFCs), but more recently on non-halogenated organic compounds, which are used in large amounts in painting, printing, and gluing.[54]

To develop an overall strategy for reducing emissions, the Federal Government instituted the IKARUS project (Instrumente fur Klimagas-Reduktionsstrategien). This program uses instrumentation and modeling techniques to determine the optimal strategy in light of cost-minimization goals.[55]

The German government has an extensive program of research, demonstration, and development for helping to reduce CO_2 and other greenhouse gases.[56] Aspects of the program that involve research in environmental technology include urban traffic[57] (public transportation and clean modes of transportation) and aviation engine technology.[58] Research into controlling emissions from the thermal treatment of waste has a very active and extensive agenda.[59]

Research into new technologies is particularly active. A specialized program on environmental technology subsidizes research into identifying the linkage between causes and effects of pollutants,[60] for developing technologies for avoiding, reducing, and recycling pollutants, and for the development of cleaner waste-elimination techniques.[61] Subsidization is up to 50 percent; businesses, municipalities, and private individuals can apply.[62] New

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[47] OECD, *OECD Environmental Performance Review, Germany*, p. 126.

[48] Ibid., p. 48.

[49] Ibid.

[50] Federal Environment Ministry, Environmental Policy, *First Report of the Government of the Federal Republic of Germany Pursuant to the United Nations Framework Convention on Climate Change*, p. 149.

[51] Ibid.

[52] Ibid.

[53] Ibid.

[54] Ibid.

[55] Ibid.

[56] Ibid., The following is excerpted from table 5.1, Federal measures for helping reduce emissions of CO_2 and other greenhouse gases, pp. 101-128.

[57] Ibid., p. 105.

[58] Ibid., p. 106.

[59] Ibid., p. 115.

[60] Ibid., p. 110.

[61] Ibid., p. 115.

[62] Ibid., p. 110.

technologies being studied include power plant technology, especially cleaner coal-burning technology, as well as flue-gas desulfurization and denitrification techniques.[63]

The German Aerospace Research Establishment and various institutes of higher education are helping to develop processes using combined steam and gas turbines with modern technologies such as charged fluidized bed combustion, integrated coal gasification, and pressurized coal-dust combustion.[64] A combined technology lignite-fired power plant with a pressurized fluidized bed is being planned.[65]

Renewable energy technologies are being supported, including pure research. Private persons, law partnerships and legal entities, public authorities, and public-law institutions could apply for subsidization of 6-8 pfennig per kWh of generated power, with subsidies available up to 60 percent of the investment.[66] Research into controlling emissions from the thermal treatment of waste has a very active and extensive agenda.[67]

An environmental foundation, the Deutsche Bundesstiftujng Umwelt (DBU), was established by a resolution of Parliament in 1991 and supports a broad range of activities, including innovative processes of emissions reductions and applied environmental research.[68] There is a stipend program to support young scientists working in the environmental area, as well as funding for academic professorships to support environmental teaching and research.[69] The Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety has such a program, as well as the Creditanstalt fur Wiederaufbau,[70] the Deutsche Ausgleichsbank, and a joint Federal/Lander task force to improve regional economic structure.[71] The various Ministries have commissioned numerous studies on how to optimize a CO_2 reduction program.[72]

Export Promotion

The German Government's involvement in export promotion programs has traditionally been understated because it has relied on the international network of German chambers of commerce to provide support to its industries.[73] However, the German Government has now formulated an initiative to match the new era of economic cooperation and competition

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[63] Ibid.
[64] Ibid., p. 111.
[65] Ibid.
[66] Ibid., p. 112.
[67] Ibid., p. 115.
[68] Ibid., p. 119.
[69] Ibid.
[70] Ibid.
[71] Ibid., p. 120.
[72] Ibid., p. 122.
[73] See discussion in U.S.I.T.C., *Global Competitiveness of U.S. Environmental Technology Industries: Municipal and Industrial Water and Wastewater*, Publication No. 2867 (Mar. 1995), pp. 5-4 and 5, pp 5-7 and 8, and pp. 5-15 and 16.

following the end of the East-West conflict.[74] It is a policy of trade liberalization, elimination of subsidies, and unrestrained investment and currency flows.[75]

Export education, market information, and trade fairs

German private chambers of commerce are an integral part of the overseas program and have expanded rapidly to include the former state-trading countries. Delegate offices have opened in the Czech Republic, Hungary, Poland, and in some of the countries of the Confederation of Independent States (CIS). In the Asia-Pacific area there are presently 10 offices, including recently established offices in Hanoi, Shanghai, and Singapore. Five chambers have opened in India, more than any other country except the United States.[76] There will be enhanced efforts at cooperation between governments at the state level and chambers both at home and abroad, along with domestic industry associations.[77] Product presentations, purchasing fairs, and company matchmaking represent an increased effort to reach small- and medium-sized companies.[78]

The German Foreign Trade Information Office utilizes electronic data processing to provide customer-tailored and needs-oriented up-to-date information.[79] Various internet sites have been established and an international network of correspondents gather information with the objective of making the Information Office a central source of foreign trade information.[80]

German promotion of trade fairs is another feature of its external promotion system. Approximately 120 to 150 foreign fairs are included in the official foreign fair program.[81] In coordination with industry associations, the Federal Ministry of Economics picks those companies who will receive financial assistance and support. Official participation is believed to enhance sales opportunities and increase jobs in its foreign trade sector.[82]

Overseas presence and advocacy

The Ministry of Economics and the Foreign Office are attempting to expand economic services at embassies and consulates by employing staff with industry-related training and extending the length of staff tenure in their posts abroad.[83] The Asia-Pacific and Latin America areas have received special emphasis. The Asia-Pacific Conference was held in Bangkok in April 1994 and the German-Chinese conference of Small and Midsize Companies in June 1994 in Bonn. The Federal Minister of Economics visited India, Thailand, and Taiwan, among others, as well as met with the Prime Minister of Singapore. The President of the Federation of German Industries led one of the largest business

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[74] Federal Ministry of Economics, *Initiatives for Foreign Trade, Germany as a Business Location in an Open World Economy* Dokumentation Nr. 351, (Bonn, Germany: Press and Public Relations Office, January 1995), p. 5.

[75] Ibid., p. 7.

[76] Confederation of German Trade Fair and Exhibition Industries, *Trade Fairs Made in Germany '96/97* (Cologne, Oct. 1995), p. 89.

[77] Federal Ministry of Economics, *Initiatives for Foreign Trade, Germany as a Business Location in an Open World Economy*, p. 10.

[78] Ibid.

[79] Ibid., pp. 10-11.

[80] Ibid., p. 10.

[81] Ibid., p. 11.

[82] Ibid.

[83] Ibid., p. 9.

delegations ever to a major trade fair, which was held in February 1994 in Mexico as German interest in the region increased following the conclusion of the North American Free Trade Agreement.

Financing and insurance

The Federal Ministry of Economics is pressing for an absolute prohibition of interest rate subsidies for export financing.[84] The ministry regularly reviews its export guarantee instruments to make sure that these guarantees finance themselves in the long term by covering their costs through a system of fees.[85] Depending on the country involved, the fee varies according to the risk. There is a flexible policy of granting export guarantees according to the economic and financial situation of the export market. Thus, German government liabilities with some Asian countries, especially China, have increased sharply.[86] Alternate forms of export financing and insurance are pursued, especially project finance associated with the privatization of publicly-owned companies in Eastern Europe and the CIS countries.[87]

Official Development Assistance

German official development assistance (ODA) increased steadily from $6.3 billion in 1990 to $7.6 billion in 1992, but fell by 8 percent to $7.0 billion in 1993 (table 3-5). Its ODA share of GNP at current prices and exchange rates fell to 0.37 percent, continuing a decline begun in 1991.[88, 89] Germany's total net flow of financial resources to developing countries and multilateral organizations increased to $15.3 billion in 1993, a record high, up substantially from $8.9 billion in 1992 (table 3-5).

Germany seeks to assist developing countries in establishing their own environmental agenda and to encourage this agenda by incorporating its objectives in Germany's support of all development projects in the recipient country.[90] Thus, specific projects are evaluated according to an environmental assessment, taking into account special circumstances in the developing country. Support of development projects dealing specifically with environmental protection was budgeted at DM 850 million ($510 million) in 1991 and DM 1 billion ($640 million) in 1992. Education and training, technical advice, and research development of national environmental plans are key objectives of this effort.

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[84] Ibid., p. 12.
[85] Ibid.
[86] Ibid.
[87] Ibid.
[88] OECD, *Development Co-operation 1994, Effects and Policies of the Members of the Development Assistance Committee,* (Paris: OCED, 1995), pp. A9-10.
[89] According to the OECD Performance Review, Chancellor Kohl declared at the Rio Conference that 0.7 percent of GNP be earmarked for ODA, including assistance to central and eastern European states. Ibid., p. 200.
[90] Ibid., p. 200.

Table 3-5
Germany: The flow of financial resources to developing countries and multilateral organizations, 1990-93

(Million dollars)

Net disbursements	1990	1991	1992	1993
Official development assistance	6,320	6,890	7,583	6,954
Other official flows	2,110	1,868	463	1,834
Grants by private volunteer agencies	757	763	856	801
Private flows of market terms (long term)	4,374	3,578	18	5,712
Total resource flows (long term)	13,560	13,098	8,921	15,300

Note.--Because of rounding, figures may not add to the totals shown.

Source: OECD, *Development Co-operation 1994: Effects and Policies of the Members of the Development Assistance Committee* (1995), pp. C9-10.

Germany and France initiated the multilateral Global Environmental Facility (GEF) of the World Bank as a means of financing projects for global environmental protection. During its pilot phase from 1991-93, Germany contributed $147 million of the $1 billion of the GEF's initial financing. It has further pledged $240 million of the additional $2 billion in financing for the period from 1994-97.

Germany has aggressively pursued a pro-energy policy in several energy projects in China. Chancellor Kohl visited China in late 1995 in a concerted German effort to convince China to use German technology and financing to develop key infrastructure projects over the next five years.[91] China's infrastructure market is estimated to be $250 billion-$300 billion over this period.[92] While in China, he initialed a power-plant agreement for a "build-operate-transfer" project worth $625 million.[93] Many aspects of this arrangement suggest unusually cooperative arrangements in pledges and financing.[94]

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[91] Unclassified Beijing cable 051540, Dec. 21, 1995, p. 2.
[92] Ibid., p. 3.
[93] Unclassified Beijing cable 051029, Dec. 14, 1995, p. 1.
[94] Ibid., p. 5.

CHAPTER 4
The Industry and Market in Japan

The air pollution prevention and control (APC) industry in Japan serves the world's second largest domestic market and is a significant competitor in the growing global market. Japanese companies dominate their home market and are active in the global market. Japan's share of the global APC market appears to be growing. In 1990 the Organisation for Economic Development and Co-operation (OECD) estimated Japan's APC market at $6 billion.[1] Environmental Business International (EBI) estimated the global APC market to be $25.6 billion in 1994, with Japan's share amounting to 17 percent or $4.4 billion.[2]

Government support for industry participation in both the domestic and export markets includes tax incentives and loans for investment, support through research and development, standards guidance, and financing for official development assistance (ODA) projects. While the APC industry in Japan is maintaining modest yet steady growth domestically, it is poised to assume a greater share of the burgeoning markets of Southeast Asia and China in a concerted effort to exploit the market opportunities that coincide with the increasingly serious environmental problems in the Asia Pacific region.

Structure and Dynamics of the Market

The APC market in Japan developed in response to pollution associated with Japan's post-World War II industrial growth. Air pollution worsened significantly when industrial growth intensified, reaching double-digit annual increases through the 1960s and early 1970s.[3] Many of the manufacturing industries that prospered during this period, such as steel, chemicals, and petroleum refining, are heavy polluters. Moreover, the energy requirements for the rapid industrial expansion were enormous, and because fossil fuels are the main source of electricity generation in Japan, air pollution levels intensified with greater industrial production.

Investment in APC equipment first peaked in 1975, leveled off during the late 1970s to 80s, and began to rise again after 1988 (figure 4-1).[4] Largely in response to the oil price shocks, an investment surge followed the first energy crisis of the 1970s, when government officials

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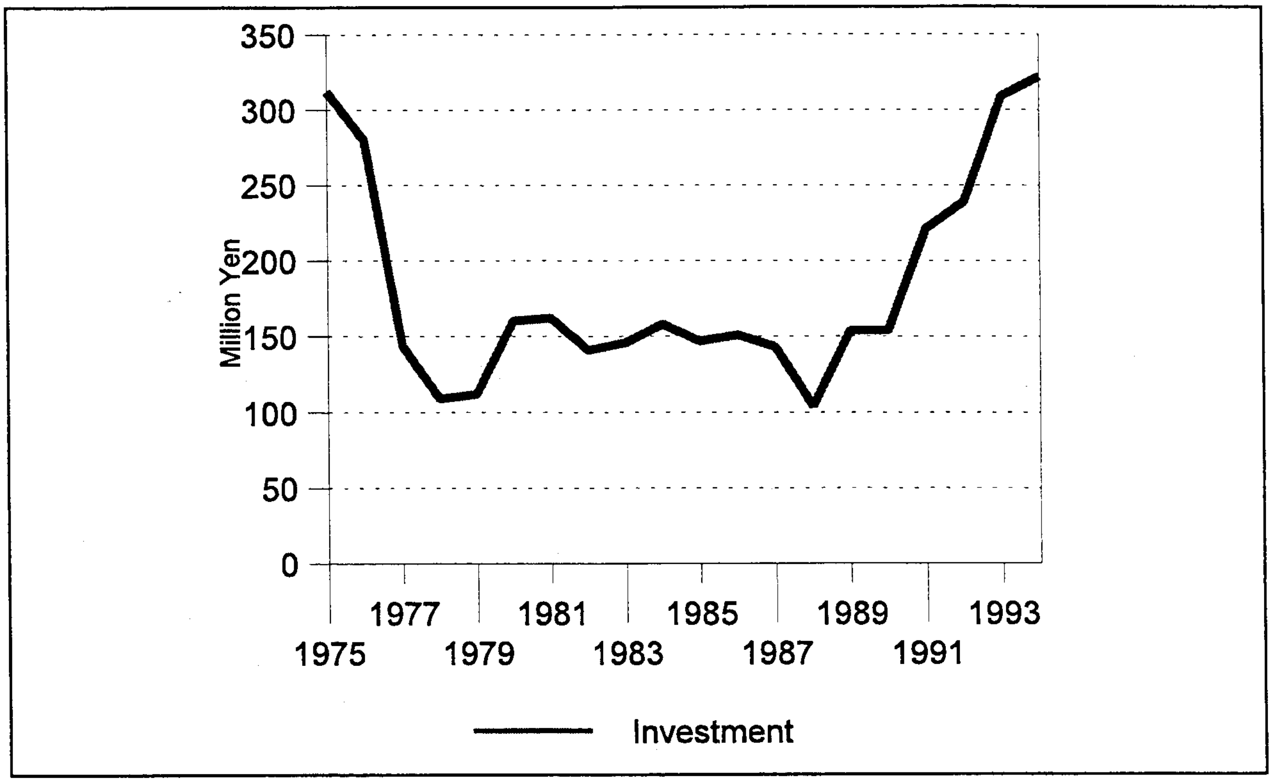
[1] Organisation for Economic Co-operation and Development (OECD), *The OECD Environment Industry: Situation, Prospects and Government Policies* (Paris: OECD, 1992).

[2] Environmental Business International (EBI), *The Global Environmental Market and United States Environmental Industry Competitiveness* (1995).

[3] OECD, *OECD Economic Survey, Japan, 1986 and 1970.*

[4] Office of Technology Assessment (OTA), *American Industry and the Environment, Competitive Challenges and Business Opportunities* (Jan. 1994).

Figure 4-1
Investment in air pollution control equipment in Japan, 1975-94



Source: Japan Society of Industrial Machinery Manufacturers, *Actual Production of Environment Equipment in Fiscal 1993 and 1994.*

were motivated to examine their dependence on foreign fossil fuels.[5] The Ministry of International Trade and Industry (MITI), in cooperation with local and municipal governments, promoted energy-saving activities and APC methods, and encouraged industry to reorganize industrial processes to achieve greater fuel efficiency. Most of the investment was to retrofit the "smokestack industries" and thermal electric power plants with desulfurization facilities. Between 1970 and 1975, the number of installed desulfurization units increased by nearly 60 percent a year.[6] Other explanations cited for the investment surge are new SO_x regulations implemented in 1975, the settlement of several court cases

[5] Fossil fuels generate more than 80 percent of the electricity in Japan. Keizai Koho Center, *Japan 1995, An International Comparison* (1995), p. 65.

[6] Japan Environmental Management Association for Industry (JEMAI), "Environmental Issues Information, Present Status Air Pollution Treatment Equipment," *Kankyo Mondai JOHO 6-3* (Mar. 1993), p. 2.

related to pollution incidents in the early 1970s, as well as the exhaustion of fuel substitution opportunities as a means to lower emissions.[7]

Investment remained low as shown in figure 4-1 from 1978 to 1988. The flat trend may have been due to the lower cost requirements that followed the initial installation costs incurred during the early 1970s by many industrial facilities. The sudden upturn in 1988 and the steady rise that continues into the mid-1990s may reflect renewed interest in the environment in Japan, as demonstrated by government programs focused on environmental technology (see Government Programs and Policies section). The passage of the Basic Environmental Law (see Regulation in Japan section) will have influenced investment as well. Finally, the upturn in investment may reflect the need to replace parts or entire facilities given the natural 15-20 year life cycle of the equipment.

Environmental investment fell from a high of 14 percent in 1977 to 3.1 percent of all capital investment in 1991.[8] The 15-year decrease may reflect the initial steep financial commitment required to install APC equipment and the more modest financial requirement to maintain and operate it. Environmental investment was 5.1 percent of total investment in 1995 and appears to be increasing.[9] Historically, manufacturers and electric power producers have placed most of the orders for APC.

Market Description

Estimates of the size of Japan's APC market range from $6 billion, or 25 percent of the Japanese EGS market in 1990,[10] to $4.4 billion in 1994, or 7 percent of Japan's total EGS market.[11] The OECD estimate accounts for equipment and related services, however, EBI accounts for equipment only. MITI estimated the 1994 environmental equipment market in Japan, which included air, water and noise pollution control, at $7.3 billion.[12] MITI's total environmental market estimate of $153 billion includes used cars and used furniture sales in the waste disposal and recycling sector and new tree planting in the environmental restoration sector. Non of the above estimates consider APC imports which may understate the size of the market.

Stationary sources

Electric utilities are by far the largest consumers of stationary APC equipment in Japan, as they are in the United States and Germany. Facilities to treat SO_X and NO_X are concentrated in the electric power industry (tables 4-1 and 4-2). In 1992 the electric power industry operated 5 percent of all desulfurization units, accounting for 42 percent of the installed

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[7] EX Corporation, *Japan's Experience in Urban Environmental Management* (Tokyo, Mar. 1994), pp. 87-90.

[8] Ibid., p 88.

[9] Ministry of International Trade and Industry (MITI), *Investment for equipment and facilities, MITI survey update, FY 1995.*

[10] OECD, *The OECD Environment Industry.*

[11] EBI, p. 10.

[12] Yoshio Nakamura, MITI, *Summary of "The Current Situation of Eco-business and Outlook" (1994).*

capacity of such units. For denitrification, the power industry operated 21 percent of the units accounting for more than 80 percent of installed capacity. Other industrial consumers, primarily steel plants, petroleum refineries, pulp and paper mills, food processing and primary metal processing facilities, accounted for the remainder of the desulfurization and denitrification units that are attached to boilers and incinerators (table 4-3). Municipal solid waste facilities are a growing market for desulfurization and denitrification equipment.[13]

Demand for electricity is expected to increase, and although more hydro and nuclear power stations are opening, 65.4 percent of electricity in Japan was generated with fossil fuels in 1992.[14] Construction on 59 new thermal power stations with a total generating capacity of over 17 million kilowatts is underway and expected to be completed by the year 2000.[15] It appears that the new power stations will be coal-fired plants as Japan reduces reliance on petroleum for electricity production (table 4-4).

Table 4-1
Desulfurization equipment, 1992

Industry	Percent of total units	Percent change from 1991	Percent of total capacity	Percent change from 1991
Electric power	4.7	0	42.0	- 2.7
Pulp and paper	12.5	- 3.3	11.5	- 1.4
Chemicals	15.2	+2.0	8.7	+1.0
Municipal solid waste	21.6	+18.0	7.1	+13.0
Total	100.0	+4.2	100.0	+2.5

Source: Japan Environmental Management Association for Industry (JEMAI), "Environmental Issues Information, Present Status Air Pollution Treatment Equipment," *Kankyo Mondai JOHO 6-3* (Mar. 1993), p. 2.

[13] JEMAI,"Environmental Issues Information, Present Status Air Pollution Treatment Equipment."

[14] Keizai Koho Center, *Japan 1995, An International Comparison*, p. 60.

[15] National Trade Data Bank, *Japan Power Generation Market* ISA9305 (1995, derived from 1993 report).

Table 4-2
Denitrification equipment, 1992

Industry	Percent of total units	Percent change from 1991	Percent of total capacity	Percent change from 1991
Electric power	21.0	+13.0	80.7	+12.7
Municipal solid waste	16.8	+22.0	3.3	+18.0
Chemicals	12.0	+7.6	1.7	+7.8
Total	100.0	+15.2	100.0	+12.3

Source: Japan Environmental Management Association for Industry (JEMAI), "Environmental Issues Information, Present Status Air Pollution Treatment Equipment," Kankyo Mondai JOHO 6-3 (Mar. 1993), p. 2.

Table 4-3
Desulfurization and dentrification equipment attached to boilers and waste incinerators, 1992

Equipment	Percent of total units	Percent change from 1991	Percent of total capacity	Percent change from 1991
Denitrification units attached to:				
Boilers	27.7	+6.5	60.1	+1.5
Waste incinerators	18.5	+20.4	3.5	+18.2
Desulfurization units attached to:				
Boilers	32.8	-2.5	70.6	-1.7
Waste incinerators	34.2	+77.0	11.5	+29.0

Source: Japan Environmental Management Association for Industry (JEMAI), "Environmental Issues Information, Present Status Air Pollution Treatment Equipment," Kankyo Mondai JOHO 6-3 (Mar. 1993), p. 2.

Mobile sources

Japan's market for catalytic converters is estimated to be 30-50 percent, or $1.3 billion-$3.5 billion of the global market.[16] Exhaust emission standards have been in place in Japan for light-duty vehicles fueled by gasoline since 1974 and for diesel-fueled vehicles since 1986.[17] The largest producers of mobile source pollution in Japan are diesel-powered vehicles, especially since their number has rapidly increased over the past several years and not all vehicles have the necessary APC equipment.[18] The Ministry of Construction and the Ministry of Transport are in the process of establishing higher emissions standards for trucks, buses, and construction equipment. Government funding is available for research on methanol powered and

[16] Market figures are not separately available for Japan, and the market for catalysts may be a subset of the automobile parts market.

[17] OECD, Motor Vehicle Pollution: Reduction Strategies Beyond 2010 (1995).

[18] Michael Walsh, *Motor Vehicle Pollution Control, The Global Market* (July 1993).

electric vehicles in cooperation with private automobile manufacturers, as are tax incentives for cars conforming to the most stringent exhaust gas regulations.

Regulation in Japan

The Basic Act for the Environment,[19] enacted in 1993, provides a comprehensive scheme of environmental goals and the institutional framework to implement those goals. The national air regulations and specific emissions are set forth in the Air Pollution Control Law.[20] Air pollution in Japan is also regulated by the local (prefectural and municipal) governments. The local governments play a more active role than the national government in air pollution control, both in terms of regulation, by setting progressively tighter controls as new technologies emerge (which are usually stricter than the national standards), and in the area of compliance. The twin goals of developing tighter emission standards and assuring compliance with those standards are accomplished at the local level through the pervasive use of "administrative guidance." Administrative guidance involves the negotiation of agreements between local government officials and individual plants which emit air pollutants. These agreements, which are the principal implementation and compliance mechanism of Japanese air pollution control, prescribe emissions limits and mandate the use of specific technologies.[21] Commentators credit these agreements with reducing the cost of implementing Japanese air pollution controls, as well as possibly stimulating the use of preventive, rather than remedial technology.[22] The reported lack of public information concerning the content of these agreements, however, apparently means that there is uncertainty as to the extent to which the agreements themselves are implemented.[23]

Implementation, compliance and enforcement

The Basic Act delineates the general responsibility of industry, national, and local government, and essentially empowers the central government to (1) establish and implement fundamental and comprehensive policies for the prevention of environmental pollution, (2) establish environmental quality standards, and (3) establish a dispute resolution system.[24] The Environmental Agency (EA), similar in many respects to the EPA of the United States, formulates and implements environmental policies of Japan at the national level. Federal activities in the area of air pollution prevention and control are regulated by the Air Quality Bureau (AQB) of EA. EA has been responsible for setting the national goals for air quality, as well as setting and implementing ambient air quality standards and emission standards to achieve those goals.

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[19] *The Basic Act for the Environment,* Law No. 91 of 1993. This act replaces the Basic Act for Environmental Pollution Prevention , Law No. 132 of 1967.

[20] *Air Pollution Control Law,* Law No. 97 of 1968, as amended by Law No. 18, No. 108, and No. 134 of 1970, No. 88 of 1971, No. 84 of 1972 and No. 65 of 1974.

[21] Staff meeting with Japan Environmental Agency (Aug. 22, 1995).

[22] OECD, *OECD Environmental Performance Reviews: Japan, 1994,* p. 104.

[23] Ibid.

[24] Shirwo Kawashima, "A Survey of Environmental Law and Policy in Japan", 20 N.C.J. Int'l L. & Com. Reg. 231, (1995, p. 245) citing the Basic Act for Environmental Pollution Prevention, Law No. 88 of 1971, at Article 4.

In name, EA is the principal administrative agency in charge of the national environmental policies of Japan, including those dealing with air pollution control. In reality, EA is merely a "coordinating agency," coordinating policies and measures in place of and in cooperation with other government ministries and agencies.[25] EA's limited role is also reflected in the limited budget allocated to EA each year.[26] EA also lacks jurisdiction over the settlement of pollution disputes and pollution crimes affecting human health, and some important enforcement mechanisms such as financial measures for pollution control also fall under the jurisdiction of other ministries.[27] Some commentators have suggested that MITI, which has jurisdiction over both finance and commerce, is the prime force in developing Japan's environmental policy.[28] MITI has reportedly always sought to ensure that companies affected by legislation may meet the standards without overwhelming burdens.[29] Primarily as a result of EA's limited power, it has reportedly become almost essential for local authorities to pick up the task of enforcing and implementing environmental regulations.[30]

Local government implementation

Since the 1960s, local governments have adopted their own environmental ordinances and measures to implement national environmental regulations.[31] Local governments may set and enforce stricter standards that are not in conflict with national laws, such as emission standards and fuel use standards.[32] The limited role of EA, as well as the relatively lax national environmental laws in some areas, have resulted in an overwhelming number of prefectures and municipalities setting and enforcing much stricter local standards.[33] For example, some large cities have banned cars in particularly polluted districts to combat NO_X pollution, in response to what were viewed as inadequate national standards.[34]

Administrative guidance is the preferred method of enforcement where the local government helps factories conform to the standards by informal negotiation, discussion, and consultation, without resorting to coercive adversarial proceedings.[35] For example, the pulp and paper plant, New Oji Paper Co., Inc., has negotiated its own, detailed agreement

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[25] Staff meeting with Japan Environmental Agency (Aug. 22, 1995).

[26] Kawashima, "A Survey of Environmental Law and Policy in Japan," p. 256. (citing Tsunao Imamura, *Environmental Responsibilities at the National Level: The Environment Agency in Environmental Policy*).

[27] Brendan F.D. Barrett, et al. "Environmental Policy and Impact Assessment in Japan" (1991) p. 72.

[28] J. William Futrell, "Future Directions in Clean Air: Lessons From The Japanese Experience", C661 ALI-ABA 361, 364 (1991) and Staff meeting with Japan Environmental Agency (Aug. 22, 1995).

[29] "A Green Tinge to Corporate Japan," *The Economist*, Dec. 11, 1993.

[30] Interview with embassy official, Washington, DC (July 25, 1995).

[31] Japan Environment Agency (EA), *Outline of Air Pollution Control in Japan* (1993), p. 3.

[32] Kawashima, "A Survey of Environmental Law and Policy in Japan," pp. 259-261.

[33] Interview with embassy official, Washington, DC (July 25, 1995).

[34] Barrett, "Environmental Policy and Impact Assessment in Japan," p. 73.

[35] Kawashima, "A Survey of Environmental Law and Policy in Japan," p. 257.

specifying emission levels and the use of specific technology.[36] In these agreements, local authorities outline required environmental procedures specific to the individual plant, and may require such measures as an environmental impact assessment (EIA) or a permit prior to construction, which are not mandatory under the Basic Act.[37] These agreements also may prescribe standards stricter than those mandated by the Basic Act.[38]

The agreements entered into by both the officials and the businesses resulting from the administrative guidance process become binding regulations between the two parties.[39] Japanese officials have relied heavily on administrative guidance, as indicated by the number of agreements entered into between 1991 and 1992 alone.[40] The Administrative Process Act of 1994,[41] which formalized the guidelines for administrative guidance to ensure cooperation and reduce the danger of abuse of discretion, will likely increase the number of such agreements further.[42] Administrative guidance contains some inherent limitations such as the danger of arbitrary application, potential conflict with statutory authority, and no judicial review absent clear abuse of discretion.[43] Nevertheless, many commentators have attributed the effectiveness of Japan's environmental program to the use of administrative guidance.[44]

Environmental impact assessment

Japan does not have a mandatory, uniform requirement to conduct EIAs on the national level; the new Basic Act only requires that the Government consider whether it is necessary to legislate such a requirement.[45] This provision appears to be consistent with the Japanese practice of using persuasive, rather than command and control methods, to further environmental goals. Indeed, MITI has recently begun an initiative to urge private business to prepare voluntary EIAs.[46] Courts and local authorities, moreover, have long embraced the concept of EIA. In judging the legality of certain actions, Japanese courts have taken into consideration whether defendants should have conducted an investigation equivalent to an

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[36] Interview with New Oji Paper Company plant managers, Kasugai Mill, Nagoya, Japan (Aug. 29, 1995).

[37] Kawashima, "A Survey of Environmental Law and Policy in Japan," p. 260.

[38] Argonne National Laboratory, *Comparison of International Environmental Policies* (Draft) (1993) p. V-56.

[39] Barrett, "Environmental Policy and Impact Assessment in Japan," p. 81.

[40] OECD, *OECD Environmental Performance Reviews: Japan* (1994), p. 41. From October 1991 through September 1992, 220 agreements on fuel use and 630 on emission controls were made between industry and local authorities and citizens' groups.

[41] *The Administrative Process Act*, Law No. 88 of 1993.

[42] Kawashima, "A Survey of Environmental Law and Policy in Japan," p. 258.

[43] Ibid.

[44] J. William Futrell, "Future Directions in Clean Air: Lessons From The Japanese Experience", C661 ALI-ABA 361, 364 (1991). See also notes 4 and 5, supra.

[45] *The Basic Act for the Environment*, Law No. 91 of 1993, Article 20. One commentator argues, however, that while the provision is abstract and voluntary, it represents an important step toward nationwide legislation of EIAs. Kawashima,"A Survey of Environmental Law and Policy in Japan," p. 249.

[46] "MITI to Ask Private Businesses to Implement Plans Conforming With ISO 14000," *International Environmental Reporter*, Dec. 13, 1995, p. 958.

EIA despite the absence of an EIA statute.[47] Local governments have also enacted laws and established guidelines requiring an EIA or its equivalent to fill in the gap.[48] Almost all the large cities such as Tokyo and Osaka have had an EIA requirement for more than 10 years.[49]

Permits and notification

EA does not require the same stringent permit application procedure as the EPA in the United States. The central Government normally assumes that the facility will operate in compliance with the standards and requires minimal permitting procedures.[50] Japan places more emphasis on post-completion site inspections and monitoring.[51] Local governments are empowered to set their own permit procedure, however. The local permit requests are still usually granted in less than 2 months.[52]

As part of its comprehensive monitoring scheme, Japan has a rather stringent reporting procedure. The Basic Act requires that any person who plans to establish or modify any controlled facilities must report certain information to the prefectural governor.[53] Prior to construction, the petitioner must report to the prefecture government the location of the facility, type of proposed emitting facility and its structure, method of operation, and proposed method of disposal.[54] Following construction and commencement of actual operation, the governor may order the business to submit periodic reports detailing the quantity of smoke and soot and/or particulates emitted.[55] Governors are empowered by law to make unannounced inspections of facilities, and order improvement or suspend operations of factories if necessary.[56]

Enforcement

Japan employs a number of different mechanisms in order to ensure that air quality standards are met. Financial assistance measures and incentives represent perhaps the most effective aspect of these mechanisms. Under Article 22 of the Basic Act, the national Government provides financial assistance, in addition to taking legal measures, to help reduce the burden on the environment brought by industry and public consumption and provides technological

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[47] Kawashima,"A Survey of Environmental Law and Policy in Japan," p. 268, citing the case of *Ushibuka Human Waste Treatment Plant.*

[48] EA, *Establishing a Basic Law on the Environment* (1992), p. 10.

[49] EA, *The Quality of Environment in Japan* (1992), p. 409.

[50] Thomas S. Mackey and Jim S. Hart, "A Comparison of U.S. and Japanese Environmental Laws Governing Emissions From Major Industrial Facilities" 6 Transnat'l Law, (Fall 1993), p. 585.

[51] Ibid., p. 6.

[52] Ibid., p. 4.

[53] EA, *Outline of Air Pollution Control in Japan*, p. 4.

[54] Mackey, "A Comparison of U.S. and Japanese Environmental Laws Governing Emissions From Major Industrial Facilities," p. 585.

[55] Ibid.

[56] Kawashima, "A Survey of Environmental Law and Policy in Japan," p. 257. To ensure compliance, starting in 1972, Japan has required designated companies to appoint pollution control officers on-site to help companies realize energy efficiency and follow the legal requirements. Futrell,"Future Directions in Clean Air," p. 364.

assistance to industry to develop policies and procedures more favorable to the environment.[57]

The national Government provides several types of financial assistance measures and incentives. The government-owned Japan Environment Corporation provides long-term, low-interest rate loans to companies seeking to improve pollution control facilities and technologies or to improve energy efficiency.[58] The Government also provides tax incentives. For example, preferential tax depreciation rates are available for pollution abatement equipment.[59] Also, funds are provided to local authorities to reduce air pollution. Industry may also receive financial assistance for their research, development, and investment in APC technology.[60]

In addition to providing financial incentives, Japan also imposes economic penalties on products that damage the environment, forcing the producers to "internalize the externalities of pollution."[61] Special emissions taxes and user charges are collected from various smoke-emitting facilities. The taxes and charges are based on the volume of emissions, and are imposed even if the facilities comply with the emission standards.[62]

Environmental suits may be brought either under the administrative system (governing litigation involving "public" issues and "official acts") or the civil legal system (private acts).[63] When administrative agencies are named as defendants in litigation, Japanese courts, like German courts, have read the standing and ripeness requirements very strictly and have dismissed many suits on those grounds.[64] Although there are no such barriers under Japan's civil law system, this system does not allow class action suits, or punitive damages, and has only a limited permanent injunctive relief.[65] Civil lawsuits seeking remedy for victims of environmental degradation are frequent and successful; the courts have reportedly proven to be reluctant, however, to engage in an environmental policy making role, for example by enjoining the government to enforce its environmental laws.[66]

Criminal penalties, including imprisonment or criminal fines, are also available to Japanese officials and courts to pressure companies to comply.[67] Even when a plant is in serious noncompliance, however, the government usually responds by negotiating and giving

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[57] Kawashima, "A Survey of Environmental Law and Policy in Japan," p. 251.

[58] OECD, *OECD Environmental Performance Reviews: Japan*, 1994, pp. 105-108.

[59] Ibid. In addition, companies seeking to improve air pollution control equipment may also claim tax exemptions and special depreciation rates. Tax reduction is provided to facilities that relocate from residential areas or from highly polluted areas to other areas.

[60] Ibid.

[61] Kawashima, "A Survey of Environmental Law and Policy in Japan," p. 251.

[62] Barrett, "Environmental Policy and Impact Assessment in Japan," p. 86. T. K. Corwin, "Economics of Pollution Control in Japan," 14(2), Environmental Science and Technology (1980), pp. 154-157. The money collected is added to the general fund of the victim compensation system. OECD, p. 108.

[63] Kawashima, "A Survey of Environmental Law and Policy in Japan," p. 263.

[64] Ibid., pp. 263-265.

[65] Ibid., p. 266.

[66] Ibid., pp. 266-270.

[67] *Air Pollution Control Law*, Article 33.

constructive suggestions, and rarely chooses to prosecute.[68] Criminal penalties have only been sought against malicious violations of waste disposal laws.[69]

Structure of the Industry

Japan's APC industry generated between $3.1 billion and $4.4 billion in revenues in 1994,[70] however these estimates are for equipment only and do not include related services and instruments. The industry consists of at least 110 companies, but is dominated by a few. Like many industries in Japan, the leading producers of APC goods and services are very large and diversified companies. The largest producers (and their related companies) are often captive consumers of their own APC equipment and services, making this industry more integrated than its competitors.

Production/Consumption

The JSIM estimated Japan's production of APC equipment in 1994 to be $3.1 billion; EBI estimated production to be $4.4 billion in 1994. JSIM reported the APC market grew from $1 billion in 1985 to $3 billion in 1994 and averaged 21 percent of the Japanese EGS market over the period.[71] Neither JSIM nor EBI include services in their estimates, however, APC producers in Japan offer APC-related services.

Production of APC equipment and services in Japan is dominated by a single company, Mitsubishi Heavy Industries (MHI). For example, MHI produced 30 percent of the desulfurization and denitrification units in all years 1991 through 1994.[72] Only 19 other companies manufacture desulfurization and denitrification units; market share is highly concentrated in the top four companies (table 4-4). The major producers of APC goods and services are so diversified that one producer could construct an entire electric power plant and its APC facilities, given the large network of companies available for subcontracting.

Consumers of APC equipment and services are sometimes also the producers. For example, New Oji Paper developed a scrubber that is used in several of the company's plants. The firm contracted out the manufacture but installed the equipment itself.[73] Electric utilities and

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[68] Barrett, "Environmental Policy and Impact Assessment in Japan," p. 81.

[69] OECD, OECD Environmental Performance Reviews: Japan, 1994, p. 103. One reason for this is probably the Japanese preference for alternative dispute resolution. Pollution disputes are often settled by mediation or arbitration. At the national level, the Conciliation Committee on Environmental Disputes was established in 1992. Ibid., p. 102. Similar committees are also prevalent at the prefectural and local levels.

[70] JSIM, 1994, p. 7 and EBI, 1996, p. 10.

[71] The Japan Society of Industrial Machinery Manufacturers (JSIM), *Actual Production of Environment Equipment in fiscal 1993 and 1994*. JSIM does not estimate the markets for mobile source equipment.

[72] Yano Research Institute, *Market Share in Japan*, 1993 and 1995.

[73] Interview with New Oji Paper Company plant managers, Kasugai Plant, Nagoya, Japan (Aug. 29,1995).

Table 4-4
Market share of leading Japanese air pollution equipment producers, 1992 and 1994

(Percent)

Producers	Dust collection systems		Desulfurization systems		Denitrification systems		Exhaust gas treatment	
	1992	1994	1992	1994	1992	1994	1992	1994
Mitsubishi	10.3	12.3	31.4	29.4	30.4	29.8	11.5	10.8
Sumitomo	6.0	5.5	11.9	11.8	21.1	20.9	7.7	7.9
Kawasaki			8.3	5.5	16.7	13.6	9.6	7.2
Ishikawajima-Harima	7.3		7.5	6.9	7.4	7.0		
Babcock-Hitachi	9.5	7.5						
Hitachi Plant Eng. & Constr.		12.0						
ABB Gadelius		6.3						
NKK								6.8

Source: Yano Research Institute, *Market Share in Japan,* 1993 and 1995.

manufacturers often hire a service company to operate and maintain the APC equipment.[74] At one power plant, the employees of the service firm that operates and maintains the APC unit were retired employees of the power company.

Waste incineration, prompted by a shortage of space for landfill and a decrease in ocean dumping, is perhaps the single largest growing segment of the APC market in Japan. As a signatory to the London Convention, Japan has agreed to phase out dumping waste into the ocean.[75] Also, a new 5-year program to modernize waste-processing facilities began on April 1, 1996. The program targets a significant increase in electricity generated from solid waste incineration.[76] One source reports that of the approximately 2,000 waste incineration facilities in Japan, only 130 generate power, and that Japan plans to expand power generation via waste incineration 86 percent by the year 2000.[77]

One company's experience illustrates their adaptation to this new market. NKK Steel built the world's largest integrated steel mill in Tokyo Bay in 1979.[78] NKK designed its own desulfurization equipment for the steel plant. However, since there is no longer a market for

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[74] Interview with operators of Isogo Power Station, Yokahama, Japan (Aug. 26, 1995).
[75] State Department Cable #040596. "London Convention on Ocean Dumping: 18th Consultative" (Feb. 1996).
[76] *International Environment Reporter*, Oct. 4, 1995, p. 776.
[77] EBI, *Asia Environmental Business Journal*, vol. I, No. 2 (May/June 1995), p. 13.
[78] Interview with NKK official. Washington, DC, May 24, 1995.

new steel mills in Japan, the company modified the technology for use in municipal solid waste incineration facilities, a market where NKK now has a domestic advantage.

There are at least 110 Japanese manufacturers of four types of air pollution prevention systems: dust collecting systems, desulfurization systems, denitrification systems, and exhaust gas systems.[79] This technology is well established and commonly used in heavy polluting industries. The equipment is usually suited for the treatment of a pollutant after it is created and does not include production process changes designed to reduce pollutant creation. Approximately 60 companies manufacture APC systems and dust collecting systems, while 50 manufacture exhaust gas treatment systems and 20 manufacture desulfurization and denitrification units. Some companies produce more than one type of equipment or service, and two companies seem to provide every type of APC equipment and service (table 4-4).

In fiscal year 1994, equipment orders for APC systems increased by 39 percent to $3 billion (table 4-5), largely due to the strengthening of regulations in the Basic Act enacted in November 1993. Except for exhaust gas processing systems, more orders for all types of air systems were placed. Orders for desulfurization equipment by the coal and oil industry and dust collection and desulfurization equipment orders by electric utilities increased significantly.[80] Domestic equipment sales of APC accounts for 68 percent of EGS expenditures in Japan, excluding public expenditures. (See figure 4-2).

Like many industries in Japan, several big companies dominate the domestic market; approximately 50 percent of domestic market share is held by the five leading companies (figure 4-3) with small or more specialized niche companies supplying the other 50 percent.[81] In recent years, the number of firms producing equipment for municipal solid waste incinerators has increased: however, the concentration of market share among the top companies has not changed.[82]

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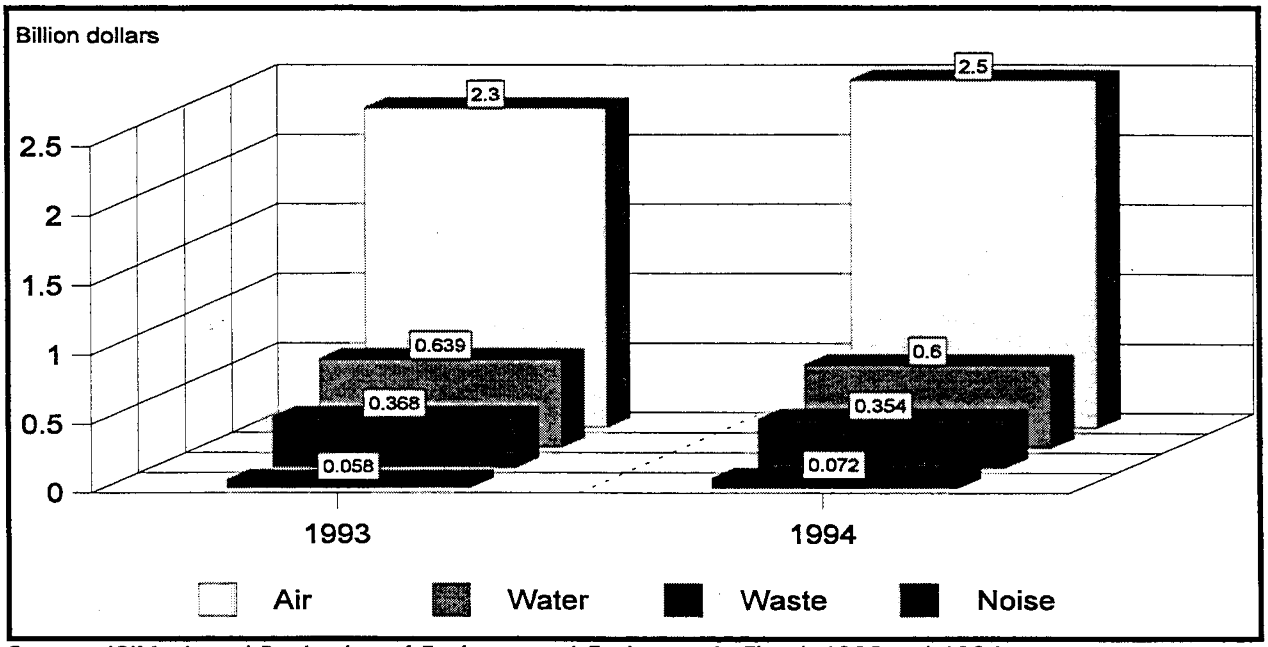
[79] As listed in Japan Society of Industrial Machinery Manufacturers, *Introduction of Japanese Advanced Environmental Equipment* (1993).

[80] *International Environment Reporter*, May 31, 1995, p. 422. Foreign orders, or exports, are contained in these figures, however, they are not broken out.

[81] Interview with JSIM officials, Aug. 24, 1995. JSIM reportedly represents 80 percent of the firms active in the industry. JSIM does not publish data on the services related to the installation of APC equipment such as design, engineering, and operation and maintenance.

[82] Yano Research Institute Ltd., *Markets Share in Japan 1993*, pp. 43-44, and *1995*, pp. 67-69.

Figure 4-2
Domestic environmental equipment sales in Japan, 1993 and 1994



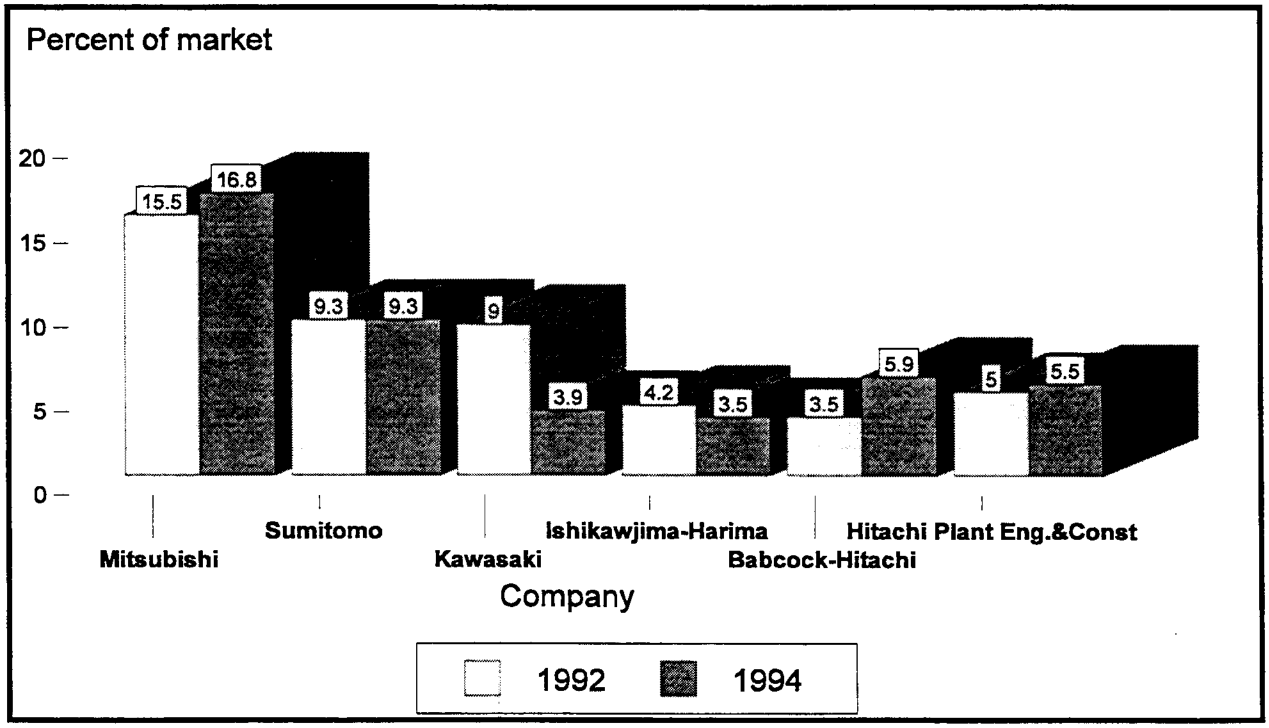
Source: JSIM, *Actual Production of Environmental Equipment in Fiscal, 1993 and 1994.*

Table 4-5
Environmental equipment orders, FY 1994

Equipment	Million dollars	Percent change from 1993
Dust collection system	732	+16.4
Desulfurization system	941	+66.6
Denitrification system	422	+21.0
Exhaust gas processing	120	-25.0
Total	3,000	+39.1

Source: Japan Society of Industrial Machinery Manufacturers (JSIM).

Figure 4-3
Air pollution control systems: Market share by enterprise, 1992 and 1994



Source: Yano Research Institute Ltd., *Market Share in Japan,* 1993 and 1995.

Exports/Imports

Japan's APC equipment exports have grown consistently over the past 5 years and reached $878 million in 1995. According to official Japanese statistics, the United States (26 percent, by value) and South Korea (12 percent, by value) are Japan's top export markets for APC equipment (table 4-6). During 1990-95, exports to the United States increased to $225 million, or by 55 percent. Exports to Korea grew 131 percent to $102 million between 1990 and 1995. About 45 percent of exports went to markets in Southeast Asia and China.[83]

JSIM estimates are more conservative in terms of the absolute value; exports increased 67 percent between 1993 and 1994, from $153 million to $255 million.[84] The content of the JSIM APC equipment categories is unclear, however, and member companies may not fully account for the equipment identified by the harmonized tariff numbers. EBI claims 20 percent of all of Japan's EGS is exported, which, based on EBI's $4.4 billion estimate of

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[83] Japan Tariff Association, *Japan Imports & Exports Commodity by Country* 95.12 (1995).

[84] JSIM, *Actual Production of Environment Equipment in Fiscal 1993 and 1994.*

Table 4-6
Air pollution control equipment: World imports and exports, 1990-95

(Million dollars)

Partner	1990	1991	1992	1993	1994	1995
Exports						
World	458.5	535	597.5	725.7	820	877.9
United States	145.1	159.3	143.1	171.6	219.7	224.6
South Korea	44	40.9	56.6	87.2	101	101.7
Taiwan	35.9	38.2	55	80.5	73.1	88.9
Malaysia	4.1	8.7	12.4	25.3	2.3	61.8
Thailand	23.6	26.4	27.2	39.4	43.1	52.8
China	10.9	2.1	25.4	42	40.9	48.4
Germany	18.5	21.3	27.9	22.4	22.1	22.8
Indonesia	6.5	14.2	15.2	19.4	25.9	22.5
Singapore	5.0	11	13.8	4.9	18.2	16.5
United Kingdom	13.0	13.2	17.7	20.8	12.4	15.8
Italy	.92	0.0	1.3	4.6	8.1	6.1
Total other	151.0	199.7	201.9	207.6	253.2	216
Imports						
World	145.6	186.1	191.6	193.6	205.9	254.5
United States	91.9	125	130.1	132.2	132.9	144.7
United Kingdom	9.9	10.3	6.4	8.5	10.7	16.7
Germany	14.1	11.6	12.5	14.9	20.3	23
South Korea	2.3	2.1	3.3	4.3	7	11.6
France	2.9	3.7	3.5	3.6	6.9	10
China	0.0	.36	.77	2.8	2.2	9.2
Singapore	4.3	3.6	5.5	6.3	4.9	5.9
Sweden	3.4	3.9	8.2	2.9	2.1	5.8
Taiwan	1.3	.96	1.2	1.6	1	2.6
Italy		.11	1.3	.82	1.2	2
Thailand	.33	1.3	.22	1	1.2	1.2
Australia	5	12.1	.72	2.6	.61	
Canada	1.2	.57	.77	.56		
Total other	9	10.5	17.1	11.5	14.9	21.8

Source: *Japan Imports & Exports Commodity by Country,* Japan Tariff Association, 1990-1995.

APC production in Japan, was $880 million in 1994, slightly greater than the $820 million reported by Japan's official trade statistics.[85]

The East and Southeast Asian environmental market was forecast to grow by 12 percent annually throughout the 1990s, and consequently, Japanese companies are concentrating their business in the region.[86] Official Japanese trade statistics report that APC exports to the region overall, increased 202 percent, and exports to China grew 343 percent between 1990 and 1995. In 1990, 28 percent of all of Japan's APC exports were sent to Southeast Asia and China. By 1995, the percentage had grown to 45 percent. JSIM also reports a greater Asia focus for Japan's APC exports; in 1993, 57 percent of total exports were shipped to Southeast Asia and China, 11 percent to Europe and 13 percent to North America; in 1994, 74 percent were sent to Southeast Asia and China, 13 percent to Europe and 12 percent to North America.[87] The bulk of the increase over the 2 years was reportedly made up of desulfurization equipment and dust collectors, and were exported primarily to China.[88] During 1990-95, developing countries accounted for a greater share of Japan's APC exports while developed countries' share declined. In 1990, 39 percent of Japan's APC exports were sent to developed markets, and by 1995 the amount decreased to 31 percent.

Japan's APC imports have increased 75 percent over the past 5 years, reaching $254 million in 1995 (table 4-6).[89] The United States and Germany are the largest APC suppliers to the Japanese market, although the United States supplies nearly 7 times more than Germany. In 1990, 94 percent of Japan's APC imports came from developed countries and by 1995 the figure had decreased to 87 percent. The second tier of leading suppliers in 1990, United Kingdom, Australia, Sweden and France were, by 1995, replaced by Korea, Taiwan, Singapore and China. Imports from China increased from less than $60 thousand in 1990 to $9.2 million in 1995, and for Korea from $2.3 million to $11.6 million during the same period. The increase in imports from the region may be a function of the migration of Japanese manufacturers in search of lower business costs. Industry sources report that the increase in Japan's APC imports is at least partly a reflection of new thermal electric power plant construction and the need for replacement parts for older Japanese power facilities.

Marketing Practices

Marketing practices vary by firm and customer. Customers base purchasing decisions on reputation and track record of the supplier, price, and quality.[90] Transactions often include an arrangement to maintain, and sometimes operate the equipment.

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[85] EBI, *The Global Environmental Industry: A Market and Needs Assessment*, (San Diego, CA: EBI Inc., 1996) for U.S. Environmental Protection Agency.

[86] Ecotec, *The UK Environmental Industry, Succeeding in the Changing Global Market* (London: HMSO, 1994), p. 43.

[87] JSIM, 1994, p. 10.

[88] Ibid.

[89] *Japan Imports & Exports Commodity by Country*, Japan Tariff Association, 1990-1995.

[90] Interview with New Oji Paper Company plant managers, Kasugai Plant, Nagoya, Japan (Aug. 29, 1995).

Marketing tactics used to sell to other Japanese companies take place within the business infrastructure which supports close cooperation between buyer and seller. The marketing practices of the five dominant APC manufactures are closely tied to their *keiretsu* associations.[91] The installation of APC equipment and services is often only part of a much larger project and the choice of APC supplier may be secondary to the choice of primary contractor. One producer reports that a job to install an APC unit is often part of a much larger contract and without participation as a subcontractor on the bid for the larger contract, it is difficult to secure the sale and installment of APC equipment.[92]

Government Programs and Policies

Japan's stated goal to be a leader in environmental technology is consistent with its long-standing policies in energy conservation and new technology development.[93] As in the United States, programs to address this objective have been established throughout the government. The environment, including pollution prevention and control technology, has become a prominent feature in government-sponsored R&D and in assistance to developing countries.

In 1992, Japan issued an Official Development Assistance (ODA) Charter clarifying the principles on which foreign assistance is based, prominently articulating environmental consideration. Since then, foreign assistance for environmental projects has greatly increased. In June 1994, MITI released a study meant to guide industry into implementing environmental measures at every stage of business.[94] The study examines the environmental impact of 15 industries from the raw material stage to the reuse of generated wastes. Energy conservation at the manufacturing stage is promoted as a method for air pollution control. The report uses ISO 14000 standards as a benchmark for industry standards. MITI recently announced new recommendations for businesses to implement environmental measures consistent with ISO 14000.[95] Finally, the Keidanran,.not a government agency but known for its powerful influence among Japanese industrial leaders, issued its own Global Environmental Charter in April 1991, offering guidelines for good global corporate citizenship.[96]

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[91] A complete discussion on Japan's distribution system and the role of keiretsu's is found in U.S.I.T.C., *Phase I: Japan's Distribution System and Options for Improving U.S. Access*, Publication No. 2291 (June 1990) and U.S. Congress, Office Technology Assessment, *Multinationals and the National Interest: Playing by Different* Rules, OTA-ITE-569 (Washington, DC: U.S. Government Printing Office, Sept. 1993).

[92] Interview with U.S.-Japan joint venture official. Osaka, Japan, Aug., 1995.

[93] Ikuo Tomita, Director for Global Environmental Technology at MITI as of May 1992, as quoted by Frederick S. Myers in "Japan Bids for Global Leadership in Clean Industry," *Science*, vol. 256, p. 1144.

[94] Industrial Structure Council Global Environment Committee, MITI, *The Environmental Vision of Industries* (June 27, 1994).

[95] *International Environment Reporter*, Dec. 13, 1995, p. 958.

[96] Louise D. Jacobs and Leigh Harris,"Public-Private Partnerships in Environmental Protection, United States, Japan," The Council of State Governments, p. 7.

Environmental Technology Development

The Government of Japan has a long history of promoting technology development. Until recently this effort was almost entirely directed toward development of technology for use by specific Japanese industries, such as the development of large-scale integrated circuits and medical equipment. Over the past 30 years a large-scale program funded about 30 projects ranging from 4 to 15 years, with funding levels from 1 billion to 22 billion yen.[97] The Agency for Industrial Science and Technology (AIST) within MITI, is responsible for planning and implementing Japan's comprehensive industrial technology policy. The AIST scope of responsibility includes conducting R&D in AIST laboratories, developing budget allocations, tax incentives, and investment loans to promote R&D in the private sector, planning and implementing international R&D cooperation and industrial standardization policy.[98]

Japan began to fund environmental technology development during the 1970s. Two energy R&D programs were implemented in response to the oil crisis.[99] The 1974 Sunshine Program focused on developing technology to increase the use of solar, geothermal, coal, and hydrogen energy, and the 1978 Moonlight Program focused on the development of energy efficient technology. The New Energy Development Organization (NEDO), a nonprofit quasi-governmental agency, was established in 1980 to run these programs and has continued to expand and acquire increased responsibilities.[100] In 1993, the New Sunshine Program, which incorporated the Sunshine and Moonlight missions as well as a 1990 R&D program, Global Environmental Industrial Technology, was established. The New Sunshine program reflected a plan to pursue a comprehensive approach to sustainable economic growth in the face of energy and environmental constraints.

The New Sunshine Program refocused MITI's long-term comprehensive plan originally laid out in 1990 in "The New Earth 21--Action Program for the Twenty-First Century."[101] A driving research goal of New Earth 21 is the stabilization of CO_2 emissions at 1990 levels by the year 2000. NEDO administers New Earth through the New Sunshine Program and two MITI centers, the Research Institute of Innovative Technology for the Earth (RITE) and the International Center for Environmental Technology Transfer (ICETT). RITE's research program is open to research proposals by international research institutes and foreign companies. ICETT is working with a United Nations Environment Program International Environmental Technology Center in Kansai Science City to transfer technology to the developing world. ICETT reportedly intends to train 10,000 foreign officials in energy conservation, pollution control technology, and environmental protection regulations. In

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[97] Unclassified cable 14781 from Tokyo, p. 4.

[98] *Agency of Industrial Science and Technology, 1995* (information brochure).

[99] A special fund was created to support the R&D from taxes on oil producers.

[100] In 1988 NEDO was renamed the New Energy and Industrial Technology Development Organization to reflect its expanded mission although its acronym was retained.

[101] Myers, "Japan Bids for Global Leadership in Clean Industry," pp. 1144-1145.

1991 and 1992, nearly 300 Chinese local government officials and private company staff were trained in air pollution control techniques through ICETT.[102] (See table 4-7).

Export Promotion

Japan spends less on traditional export promotion activities than the United States.[103] Its principal methods of fostering exports are through a comprehensive program of foreign assistance and export finance. Major organizations involved are MITI, the Ministry of Finance (MOF), the Economic Planning Agency, the Ministry of Foreign Affairs

Table 4-7
Government programs for energy and environment technology research and development and training

Program	1994 funding (Million dollars)
Ministry of International Trade and Industry Agency of Industrial Science and Technology (AIST)	
New Sunshine Program	516[1]
Green Aid	128[1]
Development of Clean Coal Technology	70[1]
Industrial Technology for Global Environment	117
New Energy and Industrial Technology Development Organization (NEDO)	310[2]
Research Institute of Innovative Technology for the Earth (RITE)	([3])
International Center for Environmental Technology Transfer (ICETT)	([3])
Center for Coal Utilization, Japan (CCUJ)	([3])
Science and Technology Agency	
Global Environment via S&T	[4]1,700

[1] AIST, Agency of Industrial Science and Technology, 1995, p. 14.
[2] R&D budget.
[3] Programs funded by MITI through NEDO.
[4] FY95 from Budget request IMI950919, Jan. 29, 1996.

[102] Interview with ICETT officials, Aug. 1995.

[103] DOC, ITA, *The National Export Strategy, Second Annual Report* shows Japan spending only $94.3 million in 1992, compared with $149.4 million spent by the United States, p. 153. But these funds largely reflect expenditures by the U.S. Department of Commerce and not by other providers of assistance. Total nonagricultural trade promotion spending by the U.S. Government was $1,102 million in 1993, and $1,486 million was requested for 1995, p. 106.

(MOFA), the Japan External Trade Organization, the Small Business Corporation, and the Export-Import Bank of Japan (JEXIM). Relatively few personnel are maintained abroad, but they are established in markets of importance and supplemented by the commercially oriented Japanese diplomatic service.

Japan has a highly developed official program of export finance and insurance, supporting an average 39 percent of total exports during 1990-93, with a high of 44 percent in 1992.[104] Export credits are administered by the JEXIM. There is no official subsidy of interest rates, which are supposed to be in agreement with OECD Arrangement guidelines.[105] The Export-Import Insurance Division (EID), a division of MITI, provides a comprehensive insurance program for exports, investment, foreign exchange, performance bonds, and service payments. JEXIM supplies guarantees when the credits cannot be covered by EID.[106]

Official Development Assistance

Japan's official development assistance (ODA) is growing, and funding earmarked for environmental projects has increased rapidly. Japan's active R&D agenda for environmental technology and its aggressive program to transfer this technology to the developing world is intimately related to its efforts to administer increasing amounts of environmental development assistance. ODA for environmental projects is but one form of aid. Other forms of environmental assistance include financing for large infrastructure projects, training of foreign public- and private-sector officials in methods of pollution control, international cooperation in environmental R&D, and assistance for the development of environmental regimes in developing countries. Japan has made a clear effort to strengthen its environmental assistance, especially in the Southeast Asian region.

ODA is administered primarily by four agencies: the MOFA, MOF, MITI, and the Economic Planning Agency. Other agencies such as EA contribute some funding, but are precluded from administering aid due to their domestic mission. Japan became the world's top donor country when its ODA increased to $11.3 billion in 1993 (table 4-8), [107] 13 percent of which provided for environmental improvement, down from 17 percent in 1992.[108] ODA for fiscal year 1996/97 is to increase by only 3.5 percent to $11.5 billion.[109] Japan's ODA share of GNP fell to 0.26 percent in 1993 after equaling or exceeding 0.30 percent in 1990-

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[104]Ibid., fn. 5, p. 155. This very high average percentage could be viewed as inflated because a large portion is short term, market risk business that would be handled by commercial banks in other countries.

[105]OECD, *Export Credit Financing,* p. 221.

[106]Ibid., p. 214.

[107] Ibid., pp. C11-12.

[108] Ministry of Foreign Affairs, *Japan's ODA, Official Development Assistance Annual Report, 1994*, p. 196. "Japan defines environmental ODA as aid conducive to environmental conservation and improvement, such as improvement of the living environment, forest conservation and afforestation, disaster reduction, pollution control and conservation of the natural environment." Ibid., p. 194.

[109] Knight-Ridder Financial News, Tokyo, Dec. 25, 1995.

Table 4-8
Japan: The flow of financial resources to developing countries and multilateral organizations, 1990-93

(Million dollars)

Net disbursements	1990	1991	1992	1993
Official development assistance	9,069	10,952	11,151	11,259
Other official flows	3,367	2,582	3,266	3,842
Grants by private volunteer agencies	103	168	190	159
Private flows of market terms (long term)	4,690	10,788	1,547	618
Total resource flows (long term)	17,229	24,490	16,154	15,877

Source: OECD, Development Co-operation 1994: Effects and Policies of the Members of the Development Assistance Committee (1995), pp. C11-12.

92. Its total net flow of financial resources to developing countries and multilateral organizations fell to $15.9 billion in 1993, down substantially from $24.5 billion in 1991.

The United Nations Conference on Environment and Development in June 1992, often referred to as the Rio Conference, intensified Japan's commitment to global environmental concerns. In Rio de Janiero, the Japanese delegation announced that Prime Minister Miyazawa intended to budget $7.2 billion to $8 billion of environmental ODA for the 5 years April 1, 1992 -March 30, 1997. Environmental ODA had previously become a key element in the country's diplomatic agenda with the announcement at the G-7 summit in Paris in 1989 that Japan would increase its ODA for the environment by $3 billion during the period 1989-92. In reality, however, that amount exceeded $4 billion.[110] The commitment was reinforced in 1993 at the G-7 Summit in Tokyo with the reiteration of the amount of funding for environmental ODA expenditures; to be $7 to $7.5 billion for the period 1993-97.[111] Japan had already committed more than half that amount by 1994.

Japan supports other activities for the global environment, which are not included in ODA. For example, funding for implementation of the Basic Environmental Law is in the Environmental Agency budget. The Basic Law includes a provision for the "promotion of international cooperation in the conservation of the global environment," and appears to broaden the scope of Japan's environmental policy into the international arena.[112] Another EA budget item, the "Promotion of Environmental Conservation in Global Perspective," increased 14 percent in 1996 to $87.6 million.[113] The study of the global environment, joint research and international cooperation, and measures to prevent global warming are provided for under that heading. The 1996 budget expands EA's international activities, although MITI funding for similar activities dwarfs that of EA.[114]

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[110] Tokyo cable 18412, p. 5.

[111] ISA9308 - Japan Environmental Development Assistance Jan. 29, 1996.

[112] *The Basic Environment Law* (Law No. 91 of 1993), section 6, "International Cooperation for Global Environmental Conservation."

[113] USDOC, Market Research Report, Jan. 22, 1996.

[114] Cable 18412, p. 11.

China has been the principal recipient of Japanese environmental assistance, receiving 16 percent of Japanese bilateral aid in FY 1993.[115] The negative effects of transboundary air pollution generated by China's coal-fired power plants motivate Japan to fund facilities to control SO_2. Japan's ability to offer financial assistance and China's need for inexpensive pollution control equipment appear to have combined to create a hybrid government program that incorporates both technology development and development assistance and involves each country's public and private sectors. The MITI Green Aid program supports the demonstration and dissemination of Japan's environmental technology.[116] The total Green Aid budget increased from $20 million in 1992 to $160 million in 1994.[117] Approximately 20 percent of this is ODA; the other 80 percent is administered by MITI organizations with environmental missions such as NEDO, the Clean Coal Utilization Center of Japan (CCUJ), and the Engineering Advancement Association (ENAA).[118] Japanese industry associations cooperate with government agencies to demonstrate equipment overseas, conduct personnel exchanges, and arrange cooperative research. Japanese manufacturers gain exposure to new markets by participating in these activities. The program now operates in six Asian countries. However, over one-half of the funding supports projects in China.[119]

One major contribution to China is the Japan-China Friendship Environment Protection Center, built with a grant of $105 million.[120] All of China's environmental ODA will be coordinated from the center, which opened in Beijing in April 1995. The center also houses several other Japanese ministry offices. In addition, separate nearby buildings will house scientific laboratories, education facilities, computer access points, and a dormitory. Similar Friendship Centers have opened in Jakarta and Bangkok.

China is the only country for which Japan maintains a 5-year plan for external assistance. A budget of $264 million was committed to environmental projects in the third 5-year plan. The fourth plan began in April 1996 and will reportedly include a stricter "guided" approach for environmental and social projects instead of the infrastructure projects the Chinese have previously requested. Japan is reportedly currently using "policy dialogue" to encourage China to submit more environmental projects in its request for assistance in response to China's fiscal year 1996 ODA request which contained few such projects.[121]

[115] Japan's ODA Annual Report, 1994.

[116] Peter Evans, "Clean Coal Technologies in Asia," *Independent Energy*, Apr. 1995, pp. 28-34. and Yukiko Suzuki, "Green Aid Plan," *Japan Eco Times*, Aug. 1995.

[117] Peter Evans, "MITI's Green Aid Plan: Adapting Environmental Technologies to Emerging Markets," *The MIT Japan Program Science, Technology and Management Report*, May/June 1994, pp. 12-15.

[118] Peter Evans, *China Business Review*, June-Aug. 1994.

[119] State Department cable Tokyo, 018412.

[120] Ibid.

[121] Tokyo cable 001410, "TPCC Initiative on Japanese Untied Aid and Credits," Feb. 1996.

Indonesia, the largest recipient of Japan's foreign aid until it was surpassed by aid to China, received soft loans in the amount of $1.78 billion in 1995, a 6.3-percent increase from 1994. At a 2.3- percent annual interest rate, one-quarter of the loans will be used to finance environmental projects.[122]

[122] Knight-Ridder, *Tribune Business News,* "Japan to raise 1995 soft loans to Indonesia," July 17, 1995.

CHAPTER 5
The Competitiveness of U.S. Industry

Introduction

This chapter presents the principal findings with respect to the air pollution prevention and control (APC) market, industry, trade, technology environmental regulation, and government programs, summarizing the results presented in the three country chapters. Table 5-1 presents ranges of available estimates on some of the basic characteristics of the industries and markets of Germany, Japan, and the United States.

The analysis of the factors of competition, both internal and external to the industry, is largely qualitative due to the scope of goods and services produced by the APC industry and the unavailability of necessary data. While factors internal to the firm and industry, such as price and quality of APC equipment and services, are key competitive factors for the industry, such competition takes place at a discrete product level where the necessary information is the least available. This analysis focuses on the broader competitive factors, mostly external to the industry, where governments typically play a more important role.

The analysis presented here includes two case studies of industries that are major consumers of APC equipment and services. This review of their procurement processes and decisions for APC equipment and services, under slightly different air quality regulations and market situations, provides some insights concerning the competitiveness of the supplying industries.

Chief USITC Findings

Global Market

Estimates of the current annual global market for environmental goods and services range from $250 billion to more than $400 billion. The global APC market for goods and services is estimated to be about $25 billion to $30 billion. The market for environmental goods and service (EGS) is estimated to be growing at 4 to 8 percent annually.[1] The growth rate for APC equipment and services is also estimated to be in that range. Growth rates for the United States, Western Europe, and Japan are expected to average 4 percent per year through 2000. Growth rates in Latin America, Asia, and Africa are expected to be in double digits.[2]

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[1] Organisation for Economic Co-operation and Development (OECD), 1996, p. 16.
[2] Environmental Business International (EBI), 1994, p. 98.

Table 5-1
Summary of competitors' industries and markets

	United States	Germany	Japan
Market for Env. Goods & Services			
Total market for EGS	$80-165 billion	$17-36 billion	$21-153 billion
Pollution investment/capital formation	1.4%	2.1%	2.6%
Exports	$10.1 billion	$5-10 billion	$0.5-13 billion
Imports	$5.0 billion	na	$1.0-1.2 billion
Market for APC	$12-35 billion	na	$4.4-7 billion
Market for stationary source control	$10-20 billion	na	50-70%
Market for mobile source control	$10-18 billion	na	30-50%
Structure of the industry (APC)			
Number of equipment producers	750-2,500	250-500	110
Number of service providers	500-1,500	na	95-120
Domestic market share by top 5 firms	20%	na	50%
Production (APC)			
Total value of shipments/consumption	$11-15 billion	na	$4.9-20 billion
Equipment	75%	na	$3.1 billion
Services	25%	na	$1.1-5.0 billion
Exports (APC)			
Total	$1.3-2.1 billion	na	na
Equipment	$0.6-1.1 billion	$1.0-2.2 billion	$0.3-1.0 billion
Services	$0.7-1.0 billion	na	na
Export Destination (region, LA, EE, Asia)	Canada 41%. Japan 12%, Korea 5%, Germany 4%, Mexico 3% United Kingdom 3%	U.S.--5-8% Japan--1-2%	SE Asia 45-75% Europe 13% N. America 12%
Imports (APC)			
Total value	$0.9-1.4 billion	na	$0.4-1.0 billion
Equipment	$0.2-0.9 billion	$0.4-0.7 billion	$0.3 billion
Services	$0.3-0.5 billion	na	$0.1-0.2 billion

Table 5-1 —*Continued*

	United States	Germany	Japan
Services	$0.3-0.5 billion	na	$0.1-0.2 billion
Import Sources	Canada--30%; Japan--14% Germany--11%; China--10% United Kingdom--6% Mexico--8%	U.S.--13-20% Japan--4-10%	United States - 60%
Government Programs and Policy			
Export promotion	EGS--$1.2 billion (1995) Finance 6% of total exports	Promotion system is largely private; Finance 4% of total exports	Finance 39% of total exports
Research and development (Total environmental technology)	EGS--$2.4-3.5 billion (1994) APC--na	EGS--na Air--$240 million (1994)	EGS--$2.7 billion (1994) APC--na
Development assistance (Total ODA and environmental)	Total-$9.7 billion (1994) Env.-$611 million (1994) $623 million (1995)	Total-$7.6 billion (1992) $7.0 billion (1993) Env.-$640 million (1993)	Total-$11.3 billion (1993) Env.-$1.4 billion (1993)

Source: Compiled from text and various tables in Chapters 2, 3, and 4.

The OECD countries are estimated to have currently between 80[3] and 90[4] percent of the world market for EGS, and more than 90[5] percent of the world market for APC goods and services. Despite the higher growth rates in the developing countries, the developed economies have a larger base and are expected to account for about 70 percent of the growth in the global market for EGS over the next 15 years.[6]

Industry

The EGS industries of the three countries are structured differently. The structure, particularly the relative size of the firms in the three industries, may be a key competitive factor in the export markets in developing countries. In the United States, the industry is characterized by a small number of large firms and a large number of small and medium-sized firms. In Germany, large firms may be more important than in the United States. In Japan, that is certainly the case; five large enterprises dominate the Japanese market.

The three countries are well represented among the largest 15 APC equipment and services firms in the world, according to 1990 estimates of their production (table 5-2). Germany has five, Japan has three, and the United States has four of the top 15 APC firms. Nearly all these firms have U.S.-based affiliates or subsidiaries that

[3] OECD, 1996, p 16.
[4] EBI, 1996, p. 13.
[5] EBI, 1996, p. 10.
[6] EBI, 1996, p. 12.

Table 5-2
Top 15 APC firms in the world

Firm	Location of Firm's Headquarters	Estimated Production (Million dollars)
Mitsubishi	Japan	3,400
Hitachi	Japan	3,200
Flakt	Sweden	3,000
Handel	Germany	1,200
Lurgi	Germany	1,200
General Electric	United States	1,000
Engelhard	United States	900
Wheelabrator	United States	800
Kawasaki	Japan	800
KWU	Germany	740
Saarberg-Holter	Germany	510
Bischoff	Germany	380
AAF Ltd.	United Kingdom	230
Dresser Industries	United States	130
Bacho	Sweden	130

Source: U.S. Agency for International Development, *Capabilities and Competitiveness of U.S. Environmental Technologies,* March 1992, p. 8.

reportedly account for significant shares of U.S. production. The two largest Japanese firms are far larger in terms of production than their competitors in the United States and Germany.

According to respondents to the USITC questionnaire, U.S. firms, for the most part, produce either equipment or services. While some firms produce both equipment and services, those that do are primarily equipment firms that provide some design and installation services that account for a minor portion of their revenues. The larger firms, particularly those in Japan, are more apt to produce a wider range of both goods and services than their foreign rivals. The larger firms are also more likely to have easier access to financing for their exports.

Technology

The United States, Germany, and Japan are among the technology leaders in APC goods and services. Some observers suggest that the United States lost its technology leadership position, acquired following passage of the Clean Air Act in

1970, to Western Europe and Japan in the 1980s.[7] [8] The authors suggest that the tougher standards in Europe and Japan resulted in the development of Western European and Japanese firms to the point where they were able to acquire some of the major U.S. APC firms. These acquisitions have reportedly resulted in the transfer of technologies to the foreign parent firms and, thus, contributed to a relative decline in U.S. competitiveness. Both Germany and Japan have also reportedly made technological gains owing to their greater emphasis on incineration of solid municipal waste than the United States, and their higher population densities that encouraged a focus on air pollution measures.[9] However, while technological advances and leadership can create opportunities for the innovative firms, it is unclear that such advances in technology have significantly altered the relative competitiveness of the U.S., German, and Japanese industries in terms of exports of APC equipment and services.

Technology is often transferred through joint ventures and licensing. Such transactions are common in the APC industry and have occurred between firms from all three countries. The value of production or trade resulting from such technology transfers is undetermined, although joint ventures are reportedly important in obtaining contracts in export markets.[10]

Many current market opportunities, in both domestic and foreign markets, are for well-established APC methods.[11] New technologies are being developed for some projects, but it appears that the application of existing technologies, not new technologies, may yield the largest growth in the APC market, particularly for mobile sources and coal-fired power plants in non-U.S. markets. For stationary sources, construction and operation are major expenditure items for air pollution prevention and control.[12]

Although most of the current global APC market is for end-of-pipe technology, future growth may occur in technology focused on cleaner production processes. The greatest potential growth market may be that for pollution prevention and waste minimization rather than for pollution abatement and control. A gradual shift may occur as industries build new facilities or upgrade existing plants and equipment. Equipment, such as low NO_X burners, that reduce the creation of pollutants during the combustion process is often more economical than installation of control equipment to capture emissions. However, no current data are available to identify

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[7] EBI, 1996, p. 10.

[8] Curtis Moore and Alan Miller, *Green Gold: Japan, Germany, the United States, and the race for environmental technology (Boston: Beacon Press, 1994)* p. 13, and EBI, 1996, p 10.

[9] Ibid.

[10] U.S.I.T.C. questionnaires.

[11] P.J. Adam, "Environment and the Economics of Integration," *Environmental Export Report*, (Washington, DC: Environmental Export Council), vol. 3, No. 11 (Sept. 1995), p. 2.

[12] See Census, *Pollution Abatement Control Expenditures*, 1995.

the equipment and services used for pollution prevention in the domestic or foreign markets and to track this market segment.[13]

The shift from end-of-pipe approaches to pollution prevention presents both opportunities and problems for the industries serving the APC markets. The shift to pollution prevention, or waste minimization, may require firms to broaden their expertise and be able to offer complete solutions to industrial pollution problems. Thus, this shift may provide an advantage for the larger firms and those with multimedia capability.

Trade

International trade accounts for a growing share of the goods and services consumed for air pollution prevention and control. Given definitional problems and lack of data, comparisons of trade flows and relative export percentages of competing industries with a significant degree of accuracy are nearly impossible. It thus remains unclear which of the three primary countries has the largest share of the global APC market.

According to Census data, U.S. exports of APC equipment in 1995 were valued at $848 million. Official data for Germany and Japan valued their 1995 APC exports of equipment at $1,233 million and $878 million, respectively. The United States imported $204 million in APC equipment in 1995, while Germany imported $441 million and Japan imported $255 million worth of APC equipment. While not perfectly comparable, these data indicate that the United States is not the leading exporter of APC equipment.[14] Differences in definition are apparent in the bilateral trade balances of the three countries. For example, according to Census data, the United States had trade surpluses in APC equipment with both Germany and Japan in each year 1990-95. In contrast, the German data show that Germany had a trade surplus with the United States in 1990, deficits in 1991 through 1993, and surpluses again in 1994 and 1995. Japan's data indicate that Japan has a significant trade surplus with the United States and a slight surplus with Germany.

The distribution of the three countries' APC export shipments varies significantly. According to both responses to USITC questionnaires and Census data, most U.S. APC exports go to the developed countries of Canada, Japan, and Germany (table 5-1; also see Ch. 2). Japan appears to be focusing on the emerging markets of Asia and their need for the development of electrical power. Most of Germany's exports are believed to stay within the European Union (EU).

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[13] On the demand side, industry estimates of expenditures on air pollution prevention and control equipment may overstate the size of the market owing to the inclusion of equipment not manufactured by the industries covered here and generally not included in the definition of APC equipment. For example, new coke oven doors may be installed at an integrated steel mill in order to meet air quality regulations for toxic emissions of coke oven gas; such expenditure is widely reported as air pollution prevention or control.

[14] See the respective country chapters for more detail on trade in APC equipment.

One source cites the United States as having a trade deficit in stationary equipment.[15] This information is not apparent in either the questionnaire responses or the U.S. trade data using the existing codes for APC equipment. Since mobile source equipment is often a component part of vehicles, trade in such equipment is difficult to determine, although some observers have noted that U.S. exports are about equal to imports.

The fact that items such as U.S. instruments are exported in higher proportions (40 percent of production) than other equipment tends to support some observers' contentions that the most promising markets for U.S. APC exports are those for sophisticated equipment and professional services.[16] It appears that instruments, including those for monitoring ambient air quality and emissions, are one area where it is clear that the United States is the world leader.

Environmental Regulation

Environmental regulation and enforcement will continue to drive the markets in both the developed countries and in the developing countries, and are probably more significant as market drivers for APC equipment and services than in the case of water and wastewater. For example, as in the United States, the APC market in Europe is driven by laws and regulations relating to pollution discharges. Since the mid-1980s, the EU has issued a number of directives requiring member states to meet specific environmental standards. To meet these standards, member states are enacting legislation, or promulgating regulations, and industries are procuring equipment and services. An obvious example of environmental regulation driving the market is the large investment, $14.4 billion for APC alone, to be made in the eastern half of Germany to bring that region up to the standards of the western half of the country.[17]

Standards and regulations are often hard to compare between countries because different countries use different forms of measurement over different time periods, as well as different forms of monitoring and enforcement.[18] Although the form of environmental regulation for APC is relatively similar in the major competitor countries, implementation or enforcement is managed differently.

On an institutional front, Japan and Germany are in some sense similar in that the local government has a strong role in plant-by-plant implementation and enforcement. In Japan, this is done through administrative guidance, and in Germany largely through the licensing process. Essentially, this appears to be largely an ad hoc, plant-by-plant development of standards. This process would appear to favor firms that have an established local presence; such a process may give an advantage to domestic companies.

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[15] EBI, 1996, p. 10.

[16] U.S.I.T.C. questionnaire data.

[17] OECD, *Environmental Performance Reviews: Germany*, 1993, p. 33.

[18] EPA Report, p. 3-3. See OECD (1984) and OTA (1994) which explain the comparison problem in more depth.

While the United States also has a permitting process, the standards are generally set before a plant gets its permit, in most instances, through federal legislation and regulations, and through specific State Improvement Plans (SIPs).[19] These different national approaches do not mean that there are broad differences in the level of the standards. With the exception of the fact that Japan does not have much in the way of national standards for volatile organic compounds (VOCs) and other hazardous pollutants, all three countries seem to cover the same pollutants to similar degrees of stringency. One other difference appears to be that the U.S. standards and regulations seem to focus more on ozone and acid rain than those of the other two countries.

A review of the ambient and emission standards for oxides of sulfur (SO_X), oxides of nitrogen (NO_X), and the standards for VOCs and ozone illustrate the apparent similarities of stringency of the regulations in the United States, Germany, and Japan. With regard to both ambient levels (table 5-3) and emission levels (table 5-4) of SO_X, the U.S. Environmental Protection Agency (EPA) characterizes these three countries as having stringent regulations compared to those of other countries in the world, although Germany appears to control electric utility SO_2 emissions to lower levels than the United States.[20] The relative stringency is very hard to compare given the different approaches taken; U.S. specifies total annual emissions and Germany specifies flue gas concentrations.

For NO_X, Japan appears to have the most stringent standard of the three competitors (table 5-5). The 24-hour mean for ambient concentrations is about the same as the annual mean for the United States and Germany. This means that the Japanese limit could be exceeded on many days in those other countries without exceeding the limits in those countries. For NO_X emissions, standards vary (table 5-6). With respect to weight of NO_X per million Btu heat input, Germany's standard for large coal-burning facilities appears to be the most stringent.[21]

Japan has imposed a stringent ozone ambient air standard, but has no VOC program in place (table 5-7). Germany has issued extensive regulations that apply to hazardous chemicals, but the regulations do not reference ozone. The United States also has a stringent ozone standard and national standards for more than 160 hazardous air pollutants.

Environmental regulation may not be closely related to the competitiveness of the national industries pursuing business in export markets. Certainly, the promotion of environmental standards, practices, and testing protocols in the home country may further that country's technologies toward meeting foreign standards and procedures. However, if consuming industries in the domestic markets of the competitors are making essentially the same purchase decisions under different environmental regimes, then factors other than the home country market's environmental standards and enforcement would appear to be more important in determining competitiveness.

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[19] See Chapter 2 for more on the U.S. air permitting process.
[20] EPA report, p 3-19.
[21] EPA report, p 3-21.

Table 5-3
Comparison of SO_2 ambient air standards

Country	Standard	Industries affected	Comments
United States	80 micrograms/cubic meter (0.03 ppm)--annual arithmetic mean 365 micrograms/cubic meter (0.14 ppm)--maximum 24-hour concentration not to be exceeded more than once per year	Major SO_2-emitting facilities in specified areas - non-utility power plants (utilities covered by acid rain program), industrial facilities	Regulated under NAAQS to control smog. NAAQS controls vary by state and local area, depending on level of pollution.
Japan	100 micrograms/cubic meter (0.05 ppm)--daily average values 260 micrograms/cubic meter(0.1 ppm)--hourly value	33 source categories, including factories, natural gas and gasoline engines	Ambient air standard under Air Pollution Control Law.
Germany	140 micrograms/cubic meter (0.05 ppm)--annual mean 400 micrograms/cubic meter (0.15 ppm) half hour mean For clean areas: 50 micrograms/cubic meter (0.02 ppm)--annual mean	Any facility required to obtain a license	Monitoring required to determine if facility requires additional controls.

Source: EPA, *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them (Draft)* (1994), pp. 3-15.

There were no significant U.S. legislative initiatives to strengthen the Clean Air Act (CAA) standards under active consideration at the time this report was prepared.[22] Substantively, changes in CAA regulation continue to be forthcoming through the rulemaking process, however, as a large portion of the implementing regulations for the 1990 Amendments are still being developed. There is also some indication that the manner in which regulations are formulated is evolving. U.S. environmental regulation is generally structured through what has been characterized as a "one-pipe-at-a-time" approach to environmental protection, which means that there is separate legislation, regulation and implementation for different media, such as water or air.[23] EPA has recently begun experimenting with a "multimedia" approach however, under the "cluster rule" approach, where EPA focuses on all of the polluting activity of an industry at the same time.[24] The trend toward the multimedia approach and the experimentation with negotiated regulation discussed above, indicate that the U.S. may be moving more toward the Japanese model of formulating pollution control strategy through direct negotiation with industry representatives affected by pollution control regulation.

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[22] There were some initiatives under consideration that opponents argue would weaken the CAA's controls.

[23] Office of Technology Assessment, *Industry Technology and the Environment: Competitive Challenges and Business Opportunities* (1994), p. 264.

[24] Ibid., p. 269. EPA is using this approach, for example, to develop guidelines for the discharge of toxic substances in both water and air by the pulp and paper industry.

Table 5-4
Comparison of SO_2 emission standards

Country	Standard	Industries affected	Comments
United States	Facility specific annual emissions allowances; Phase 1 allowance generally based on maximum emission rate of: 2.5 lbs. SO_2/ million Btu Phase 2 based on: 1.2 lbs. SO_2/ million Btu	Phase 1: 110 largest, highest emitting coal-burning utilities Phase 2 to cover all coal-burning utilities	Regulated under CAA Title IV to control acid rain; intended to decrease total emissions of SO_2 to 8.9 million tons per year by the year 2000.
Japan	Emission standards based on stack height and location of facility. More stringent requirements apply in some areas.	33 source categories	Desulfurization of heavy oils required. Flue gas desulfurization required.
Germany	Limit for SO_2 in flue gas: 400 mg/cubic meter, 85% SO_2 removal (approx. 0.325 lbs. SO_2/million Btu) 2000 mg/cubic meter, 60% SO_2 removal (approx. 1.630 lbs. SO_2/million Btu) 2000 mg/cubic meter (approximately 1.630 lbs.SO_2/million Btu) (local standards may be more stringent)	Coal burning utilities: Capacity > 110 MW Capacity 35-110 MW Capacity 18-35 MW	Coal-burning utilities must have flue gas desulfurization equipment.

Source: EPA, *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them (Draft)* (1994), pp. 3-17.

Table 5-5
Comparison of NO_x ambient air standards

Country	Standard	Industries affected	Comments
United States	0.053 ppm (100 micrograms/cubic meter) annual arithmetic mean concentration	Major NO_x -- emitting, combustion facilities in specified area	Regulated under NAAQS to control smog and ozone. NAAQS controls vary by state and local area, depending on level of pollution.
Japan	0.04 ppm - 0.06 ppm-daily average of hourly values	Factories, boilers, offices, autos	If locality's emission level is within designated range, efforts should be made to maintain that level. Emphasis on regulation of non-stationary sources.
Germany	0.04 ppm (80 micrograms/cubic meter) annual mean	Any facility requiring a license	Monitoring required to determine if facility needs additional controls.

Source: Source: EPA, *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them (Draft)* (1994), pp. 3-22.

Table 5-6
Comparison of NO_X emission standards for acid rain control

Country	Standard	Industries affected	Comments
United States	NO_X emission limits set for specific facilities and boiler types. Tangentially fired boilers: 0.45 lb NO_X/million Btu. Dry bottom wall fired boilers: 0.50 lb. NO_X/million Btu.	Specific coal-burning utilities	Regulated under CAA Title IV to control acid rain.
Japan	Emission limits vary by source type and size; more stringent limits in some areas.	Many industrial sources	Stationary sources have low-NO_X burners and catalytic controls.
Germany	Limits for NO_2 in flue gas: 200 mg/cubic meter (approx.0.165 lb. NO_X/million Btu) 400 mg/cubic meter (approx. 0.326 lb. NO_X/million Btu) Dry bottom burners: 650 mg/cubic meter (approx. 0.53 lb. NO_X/million Btu) Wet bottom burners: 1,300 mg/cubic meter (approx. 1.06 lb. NO_X/million Btu)	Coal burning Utilities: New & Existing, >110 MW New, 18-110 MW Existing, 18-110 MW Existing, 18-110 MW	Likely to require selective catalytic reduction to achieve limits.

Source: EPA, *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them (Draft)* (1994), pp. 3-23.

Table 5-7
Comparison of VOC standards

Country	Standard	Industries affected	Comments
United States	Ozone ambient air standard is 0.12 ppm/maximum average hourly concentration	Chemical Industry; coating and painting operations; various industrial processes	VOCs regulated under NAAQS; controls vary by geographical area, depending on pollution level. Different levels apply to new or modified sources.
Japan	Ozone ambient air standard is 0.06 ppm/hour	Many industrial sources.	No designation of ozone nonattainment areas; no formal VOC regulations at present.
Germany	Specific chemicals regulated without reference to ozone; 0.09 ozone ppm/hour.	Any facility requiring a license.	Ozone limit is health warning standard, not ambient air standard; VOCs controlled as organic chemicals under TA Luft.

Source: EPA, *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them (Draft)* (1994), pp. 3-27.

Government Programs

The principal government programs that bear on the competitiveness of the APC industry are research and development (R&D), export promotion, and development assistance. All three countries are relatively active in supporting R&D efforts, particularly efforts directed toward increased energy efficiency. From a standpoint of mutual interest in the various international protocols on air pollution, they are also very interested in transferring technology to other countries in support of international efforts for atmospheric improvement. Differences between export promotion programs are the least apparent. The U.S. program is accelerating. Export promotion in Japan, especially financial, is reportedly a relatively established pursuit. Development assistance for the environment by all three countries has increased over the last decade and have made strong statements in support of their programs, even though assistance in real terms as a share of GNP of all three have fallen recently.

Research & Development

The U.S. and Japanese Governments have funded a considerable amount of environmental R&D. In FY 1994, the United States federal government's total R&D budget was approximately $75 billion for all purposes, $5.5 billion for environmental research, and $2.4 billion for environmental technology. In FY 1993, Japan had budgeted about $15 billion for a period extending through the year 2000 on R&D to stabilize CO_2 emissions, to encourage international cooperation to reduce greenhouse gases, and to transfer technology to developing countries.[25] Germany has a program of environmental research, but there is very little data on actual expenditures.[26]

Export Promotion

The often-made claim that U.S. firms have less access to government support, including export financing, than their competitors is hard to verify. While countries could be viewed as trying to support environmental exports in general, it is difficult to say that any one country is giving the APC industry special treatment or that one country's industry is gaining a comparative advantage owing to a particular government program.

The United States has increased promotion of exports through a coordinated, multi-agency initiative with lead efforts by the Department of Commerce (DOC) and the U.S. EximBank. Environmental technology is a key element of this agenda with a strategic framework of action, a new Office of Environmental Technology Exports, and an Advocacy Center to promote an active role by U.S. government leaders in their travels abroad. Germany reportedly has not actively supported exports, especially at the federal level; state governments and private associations have been much more active. Japan has long promoted its overall exports, especially through financial assistance. Its official program of export finance and insurance

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[25] Unclassified cable 14781 from Tokyo, p. 5.

[26] Germany had budgeted 333 million DM on R&D for renewable energy sources in 1994, or approximately $200 million at 1.6 DM to the dollar.

supported an average 39 percent of its total exports during 1990-93, with a high of 44 percent in 1992.[27]

Development Assistance

Japan became the largest provider of Official Development Assistance (ODA) in 1993 when ODA increased substantially to $11.3 billion. Environmental ODA is a key element of its program, and its funding exceeded $10 billion for the 5 years 1991-95. Whether this level of support is solely due to Japan's assumption of a leadership role in helping developing countries attain their environmental goals, or whether it reflects an organized Japanese effort to promote its exports is the subject of speculation. U.S. ODA is also substantial, but along with German ODA it declined in 1993. The U.S. Agency for International Development (AID) recently announced a new program to promote U.S. exports of environmental equipment and technology to Latin America. It is similar to an AID program in the Asia-Pacific region, which has so far provided approximately $100 million in export promotion. Germany's ODA efforts do not appear to be as substantial as the United States and Japan, but Chancellor Kohl has announced his intention to significantly increase the ODA share of German GNP. Germany's development assistance is oriented to the other countries of Central and Eastern Europe.

Competitive Position

The global market is becoming more and more competitive. As discussed in chapters 2, 3, and 4, the domestic markets for the major competitors, except the recently reunified Germany, are mature. The industries in the United States, Germany, and Japan are looking to export their goods and services. Other than competition in their respective home markets as indicated by their imports of each other's products, the three APC industries each appear to be focusing on different markets. It is believed that a significant portion of trade in APC equipment is between related companies.[28] The trade with third markets, particularly developing countries, may provide a gauge of relative competitiveness. In this regard, Japan's focus on the growing markets in Asia indicates a probable advantage in these markets and supports the notion that the Japanese APC industry currently may be better equipped to serve the developing markets than is the U.S. APC industry. Data are not available on the orientation of German exports to make such a comparison.

Most U.S. firms tend to target the U.S. domestic market, where they face increasing competition from foreign capital, technology, and expertise. The U.S. market is not only attractive to foreign firms, but is one that provides opportunities for acquisitions, joint ventures, and licensing of technologies. The large foreign firms have increased their presence in the U.S. market, through acquisition and joint venture.

According to the OECD, competitive advantages in the EGS industry are based on four factors: technological innovation, quality and service performance, marketing and export strategies, and

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[27] DOC, ITA, *National Export Strategy*, Second Annual Report, fn 5, p. 156. These are much higher levels than for other countries. The support levels for environmental technology exports are presumably in the same range as for all exports.

[28] U.S.I.T.C. questionnaire responses.

flexibility in production.[29] Cited as less important were scale economies, size and breadth of a firm's abilities, and cost. The OECD cited the United States and Japan as having potential advantages in global markets in air pollution prevention and control,[30] while other sources clearly state that the United States is trailing both Germany and Japan in APC markets.[31]

The factors noted above are probably the most relevant for competing in the developed world. However, for the APC industry competing in the developing world, firm size, breadth of capability (either singly or through joint ventures), experience negotiating standards on a facility-by-facility basis, and cost may be more important. On the basis of these factors, Japan would appear to have a competitive advantage.

Case studies of two large consumers of APC equipment and services, electric power and pulp and paper, were developed to try to determine whether the APC equipment purchasing decisions differed in the three countries' home markets. These two industries were studied because the production processes and basic output of each of the industries are quite similar in all three countries. Thus, the study could focus on the APC purchasing decisions of power plants and paper plants to see whether the market and regulatory conditions in Germany, Japan, and the United States led to the selection of different equipment from different sources. Such differences, if any, should provide some insights into the factors of competition in the APC industry.

The review of the electric power industry (see text box) indicated that the power industries in the three countries use similar APC technologies to meet their respective environmental regulations. Data are not available as to the country of origin of the basic scrubbers and electrostatic precipitators used in the three countries. However, anecdotal evidence suggests that such equipment is primarily of domestic origin in all three countries.

An examination of the pulp and paper industry, is also revealing (see text box). Although the regulatory regimes of the United States and Japan[32] are implemented differently, the APC equipment installed is not only similar in both countries, but comes from largely the same sources. Paper plants in both the United States and Japan use a combination of domestic and imported technology. The method of acquisition of a particular technology or piece of APC equipment may in fact be different. While a paper manufacturer in the United States may elect to import a particular technology directly from a foreign manufacturer, the counterpart in Japan may be more likely to acquire the same technology from a domestic firm who has obtained a license to manufacture that equipment in Japan.

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[29] OECD, 1996, p. 24.
[30] OECD, 1996, p. 25.
[31] Moore, 1994, p. 33. And EBI, 1996, p. 10.
[32] Information was not available on the pulp and paper industry in Germany.

Case Study: The Electric Utility Industry, A Consumer of Air Pollution Control and Prevention Goods and Services

The U.S. electric power industry is composed of traditional (investor-owned, publicly owned, cooperative, and Federal electric utilities) and non-traditional (non-utility power producers) electricity-producing companies. Investor-owned utilities account for more than 75 percent of U.S. electricity generating capacity; most of which simply provide basic service for the generation, transmission, and distribution of electricity. The remainder of the industry is composed of publicly owned utilities, cooperative electric utilities, and 10 Federal electric utilities.[1]

In 1994, U.S. demand for electricity increased to 2,935 trillion kilowatt-hours, a 2.6 percent increase from 1993, primarily from fossil fuels.[2] In 1994, coal-fired plants and petroleum-fired plants accounted for about 43 percent and 10 percent, respectively, of domestic electricity generation. Of the planned additions to generating capacity for the domestic industry for 1995 through 2004, only 12 percent are coal-fired.

In 1994, air emissions from domestic fossil fueled electric utility plants were estimated to include:

SO_2 .... 13 million short tons
NO_X .... 6 million short tons
CO_2 .... 1,910 million short tons

Each of these pollutant emission figures represent a decrease from previous years' emissions, particularly SO_2 emissions. In general, compliance with the rules of Phase 1 is being attained by the domestic industry through the initiation of two programs: (1) a change in the type of material used to generate energy in coal-burning facilities (switching to low-sulfur coal) and (2) the addition of new pollution abatement equipment, such as flue gas desulfurization units (FGDs) with wet or dry scrubbers.

Usage of low-sulfur coal increased approximately 52 percent during 1985-94. Total coal usage dropped by almost 6 percent between 1990 and 1994. Use of FGDs has also increased, with 168 FGDs attached to scrubbers in 1994, compared with 153 in 1993 and 137 in 1985.[3] Installation of a FGD in a plant burning coal with a generating capability of 595 megawatts would cost approximately $76 million, and operation and maintenance (O&M) costs would be approximately $678,000.[4]

U.S. companies with major power generating facilities have reported that installations of scrubbers since 1993 cost between $135 and $170 million. Additional capital expenditures are estimated by U.S. firms to range from $30-$150 million to reach the requirements of Phase II, with O&M costs projected to range from $5-$25 million annually.

Electric power firms reported that their process sourcing major equipment purchases and service contracts consists of a simultaneous evaluation of both segments. Prior U.S. firms' equipment purchases do not appear to obligate firms to again associate with the same vendor for either the equipment purchase or for O&M services. Also, it is not often taken into consideration when making such purchase decisions whether a supplier may or may not be a domestic firm. Most often, as described in Chapter 2, the largest providers of services and equipment in the domestic market are multinational firms. A number of these firms are not U.S.-based, although a significant share of their revenues is derived from U.S. affiliates and the U.S. market.

Once bids are solicited, the purchase decision itself appears to be made on a cost-basis, with consideration given to initial capital outlay, as well as anticipated future outlay associated with credits accrued from exceeding existing APC standards.[5] These credits may be applied to meeting future (Phase II) standards in lieu of placing additional units on other plants, or also may be sold to other firms.

The Japanese electric power industry is composed of a group of 10 independent electric companies given exclusive rights to provide electricity in their regions. These companies participate in the Government of Japan's "Business Global Partnership Initiative" and are committed to promote foreign products in the Japanese market. As of 1992, however, the import share of foreign goods in relation to these firms' total procurement of goods is only 2-3 percent, most of which entered from the United States. Also, as of 1992, no U.S. firms had entered into contracts for engineering or construction of new power stations in Japan.[6]

The overall demand for electricity was reported to be 6,668 billion kilowatt-hours in 1992, with an increase in overall demand expected to reach 9,270 billion kilowatt-hours in 2000.[7] The supply side of the Japanese industry was generated as follows:

	Number of facilities	*Electricity Supply* (100 million kilowatt-hours)
Hydroelectric plants	1,529	886
Nuclear	16	1,776
Thermal plants	198	
Coal		636
Liquefied natural gas		1,414
Petroleum-based		1,944
Other		897

In October 1990, the Council for Ministers for Global Environment Conservation developed "The Action Program to Arrest Global Warming," a national climate change program for Japan to be implemented between 1991 and 2010. This measure calls for specific CO_2 emissions targets, including stabilization at 1990 levels by 2000, as well as emission reduction targets for other greenhouse gases. In November 1993, the Diet enacted the "Basic Environment Law," which incorporated the October 1990 measure. In order to meet the requirements of their environmental legislation, the Japanese power industry is expected to spend approximately $25 billion in 1995, of which about $1 billion is expected to come from U.S. firms.[8] However, the majority of the U.S.-supplied goods and services are anticipated to involve remediation of soil and groundwater contamination, an area in which the U.S. products are considered more advanced than those of Japanese environmental firms.

The largest expenditures in the Japanese market for APC equipment occurred during 1974-76. A combination of factors created a large demand for APC equipment at that time, including a regimen of SO_2 controls which took effect in 1975, and a major series of plant renovations related to the rapid increase of fuel costs for the Japanese electricity generation industry.[9] In 1974, Japanese APC expenditures accounted for 47 percent of gross investment, while in 1990 APC expenditures' share of gross investment was only 4.9 percent.[10]

Purchase decisions of members of the individual firms within the Japanese electric power industry are not necessarily accomplished by the same mechanism, but appear to generally reach the same ends as their U.S. counterparts. The process of decision-making in Japan involves both an individual enterprise level process as well as a decision at the industrial group[11] level. Also, Japanese firms' standards for reduction of pollutants is regulated differently from those of the United States. Japanese firms' efforts for compliance are based on a balance of federal and local regulations, with local standards representing a far larger share of the controlling regulations than in the United States. Also, there exists a culture within the Japanese industry in which successive iterations of plants tend to implement controls based on the immediate previous plant's successes in treating emissions.[12]

The demand for electric power in Germany for 1993 is estimated to have been 459 billion kilowatt-hours.[13] German electricity generating capacity (as of January 1, 1993) depended primarily on thermal sources, of which petroleum-based plants accounted for 43 percent of total capacity and coal 27 percent.[14] The major emphasis of the current government in Germany in relation to regulating electric power industry emissions appear to concentrate on the former East German states. There has been a very large shift away from processes which are highly polluting to those which are cleaner and which are more energy efficient. For example, the East German energy industry used a significantly higher share of brown coal for power generation than the respective former West German firms. Other factors reportedly influencing a major decline in overall release of such pollutants as CO2 include the shift of industrial activity from the former East Germany to the former West Germany, a program of economic restructuring, and significant improvements in energy efficiency among the domestic industrial consumers of electric power.

The majority of the retrofitting of the German electric power industry with the necessary APC equipment (predominantly FGDs) to reduce emissions of pollutants was accomplished during 1983-88, at a cost estimated to have been approximately DM 14 billion.[15] As of 1990, there are estimated to be 159 FGDs operating at 72 power plant facilities of public utilities. The measures taken at these public utilities' plants allowed the power industry to surpass goals of SO_2 reduction for 1989. The maximum permissible sulfur emission standard was set at 15 percent for heavy petroleum-or coal-fired plants was exceeded by approximately 20 percent.[16]

In the former East Germany, between 1989 and 1991 there were planned to be 131 FGDs installed or placed into operation at 60 locations, significantly reducing NO_X emissions.[17] The goal for NO_X reductions in these plants is approximately 67 percent. It was reported that the retrofitting process to reduce SO_2 emissions, especially with wet scrubbers in conjunction with the electrostatic precipitators already in use (reported to have already had collection efficiencies of 99.8 percent), also influenced the subsequent additional reduction in particulate emissions, which declined by about 12,100 tons.[18]

Purchase decisions as to APC equipment and service for Germany's power industry is probably based on similar product evaluation measures as in the United States and Japan. However, it can be assumed that most APC equipment and services purchased to be used in Germany are of German origin, as the German industry is reported to be the ranked first in the world in production and export of environmental technology, and is reported to dominate its own home market.[19]

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[1] All information concerning the U.S. electric power industry taken from: U.S. Department of Energy, *Electric Power Annual, 1994*, February 1996.

[2] Energy Information Administration, Form EIA-860, *Annual Electric Generator Report.*

[3] Energy Information Administration, Form EIA-767, *Steam-Electric Plant Operation and Design Report.*

[4] Energy Information Administration, Form EIA-767, *Steam-Electric Plant Operation and Design Report.*

[5] This assumes bids are accepted and evaluated only from firms that are already known to meet certain standards set forth by the soliciting company.

[6] U.S. Department of Commerce, *Market Research Report - ISA9305: Japan - Power Generation Market,* April 27, 1995, market information compiled from MITI data.

[7] U.S. Department of Commerce, *Market Research Report - ISA9305: Japan - Power Generation Market,* April 27, 1995, information compiled from Electricity Utility Council.

[8] U.S. Department of Energy, Energy Information Administration, *Japan - Environmental Review,* June 1995.

[9] The Japanese industry relies on petroleum-based fuels to a far greater extent than does the U.S. industry, primarily fuels imported from OPEC-member nations. During the energy crisis of the 1970's, the Japanese industry in general initiated a major restructuring, similar to that of the U.S. industry at the same time, to improve their efficiencies and to reduce their existing level of dependence on imported fuel.

[10] *Japan's Experience in Urban Environmental Management,* EX Corporation, Tokyo, Japan March 1994.

[11] An association of enterprises with common interests.

[12] Field work.

[13] U.S. Department of Energy, *International Energy Annual, 1993,* May 1995, p. 84.

[14] U.S. Department of Energy, Energy Information Administration, *Germany: Energy and the Environment,* July 1995, p. 5.

[15] Manfred Hildebrand, Association of German electricity supply companies, *Emissions development in the electricity utility sector of the former Federal Republic of Germany in the years 1989 and 1990,* p. 14.

[16] Ibid.

[17] Ibid., p. 15.

[18] Ibid., p. 17.

[19] U.S. Department of Energy, Energy Information Administration, *Germany: Energy and the Environment,* July 1995, p. 4.

Case Study: The Pulp and Paper Industry, A Consumer of Air Pollution Control and Prevention Goods and Services

Pulp and paper manufacturers are major consumers of (APC) equipment and services. In the United States and Japan, manufacturers must control air emissions from the power source and from the chemical recovery boilers used in the production of pulp. No significant factors internal to the pulp and paper (P&P) industry influence the type of emission control equipment purchased and the patterns of consumption apparent in the P&P industry in the United States and Japan.

The United States and Japan are world leaders in paper production, supplying 30 and 11 percent respectively, of the world market. Each country consumes nearly as much as it produces, and manufacturers in both countries are increasing production capacity to meet growing demand.

The P&P manufacturing process is highly polluting. It is extremely energy intensive, and involves large quantities of water and chemicals. Water pollution is most commonly identified as the industry's environmental problem. Prior to the environmental movement that began in the early 1970s, many rivers and lakes served as repositories for untreated wastewater although secondary wastewater treatment is now an industry standard in the United States and Japan.

The P&P manufacturing process, in particular fuel incineration and chemical pulp production is a source of air pollution. The incineration of fossil fuels, black liquor, and wood wastes such as bark and sawdust, commonly used in the P&P industry are a source of CO_2, SO_2, NO_x, and particulate matter. A non-condensible gas is produced when black liquor, a by-product of the kraft pulping process, is incinerated in the recovery boiler.[1] Emissions of total reduced sulfur compounds and particulate matter as well as VOCs are released when organic chemicals are incinerated during the pulping process. Incinerated wood waste releases particulate matter and VOCs which must be treated.

U.S. and Japanese P&P producers use similar air pollution control technology, however, the choice of fuel effects the emissions, and may require different controls. P&P manufacturers in the United States and Japan differ in their choice of fuel. By sheer volume, the U.S. produces much more pulp than Japan and therefore, black liquor is the U.S. P&P industry's main source of fuel. In Japan, black liquor is in short supply and coal and other fossil fuels are the common fuel source in the P&P industry. Although the use of wood-waste fuel is increasing in Japan, P&P producers are reliant on fossil fuels.

Low-sulfur coal, wood-based fuel and black liquor are not significant sources of sulfur emissions, however, most SO_2 is controlled by the installation of desulfurization scrubbers on the power source and the recovery boiler. Scrubbers are also installed on the lime kiln where the chemicals recovered from the black liquor are converted into cooking chemicals. Inadvertently some VOCs are eliminated by desulfurization scrubbers. The control of NO_X is less prescribed, and particular to the physical arrangement of the plant. For example, the configuration of duct work set up to control the temperature during fuel incineration is one commonly used way to reduce NO_X emissions. Electrostatic precipitators are installed on the power sources and recovery boilers to control particulate matter. In the U.S., the new cluster rule regulations for the P&P industry are currently under consideration. If implemented, the rules would place restrictions on some hazardous air pollutants and would require industry members to install steam strippers for methanol and scrubbers on bleach plants and precipitators on lime kilns. Industry members claim that compliance with the new regulations would surpass $11.5 billion.[2]

The consumption of the equipment mentioned above by P&P mills in the U.S. and Japan is also, to an extent, determined by the mill's production. For example, a recovery boiler for pulp production is required to have a sulfur scrubber. If a mill does not produce pulp, which is often the case in Japan, and instead makes paper from imported pulp, investment in APC is reduced. On the other hand, it is not uncommon in Japan for one mill to operate 3-6 paper machines, while 1-2 paper machines per plant are typical in the United States. The greater the number of paper machines, the greater the energy requirement and additional desulfurization and denitrification units. At least 75 percent of Japan's P&P producers are dependent on fossil fuels to generate power, and in many cases P&P companies own their own power plant.

P&P manufacturers purchase APC equipment from the same firms that supply other smokestack industries with scrubbers and electrostatic precipitators. No APC producer in the U.S. and Japan supply only the P&P industry. The Kasugai mill, a New Oji Paper Co. mill in Nagoya, Japan, described APC equipment at their facility as mainly domestic purchases, although several pieces of equipment were purchased from Japanese companies who had licensing agreements with American companies. A customized sulfur scrubber developed at the Kasugai mill was manufactured by an affiliated company and has been installed in 60 other New Oji mills in Japan. Mill managers claim that when purchasing equipment, they tend to go to suppliers with whom they have done previous business, but price and quality guide their decision.

U.S. mills install equipment similar to the Japanese mills. In the United States, investment in large pieces of equipment are often handled by headquarters, not individual mills. U.S. producers claim that they choose from a multiple base of suppliers when purchasing their APC equipment, although there are many more scrubber manufacturers than electrostatic precipitator manufacturers. The control of air emissions is different for each mill, and since the installation of new APC equipment may happen only every 15 years, each case appears to present different challenges. In all cases, however, bids are usually solicited by companies with a proven track record and price usually determines the contract winner.

The consumption of APC equipment by U.S. and Japanese P&P manufacturers appears to be directly related to the imposition of new regulations or the strengthening of a current regulation. Japan's P&P manufacturers are regulated by national and local standards. Local regulations set by administrative guidance between plant managers and local government officials often lead to more stringent standards than those required by national regulations. New Oji Kasugai plant managers claimed to have an ongoing dialogue with local government officials about the next environmental improvements in the mill. Many of the chemicals deemed hazardous in the U.S. are not regulated in Japan. Pulping chemicals fall into that category.

In the United States, regulations and public pressure have influenced the emergence of a cleaner pulp and paper industry. Campaigns sponsored by environmental groups have educated the public about harmful industrial processes and have helped raise the standards to which manufacturers are held. U.S. manufacturers have invested $13.2 billion in environmental protection capital expenditures between 1970 and 1993. During 1993, investment measures were estimated at $750 million, or 14 percent of total capital expenditures. Of this total, 46 percent was for water quality, 37 percent for improved air quality, and 17 percent for solid waste disposal. Expenditures for 1994 are estimated to be $950 million.[3] The P&P industry in the U.S. ranked third among all industries for APC expenditures. Only the petroleum refining and chemical industry invested more.

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[1] More than 80 percent of the world's pulp is produced by the kraft process, which involves the use of chemicals to dissolve lignin, a natural substance in wood fibers that must be removed to produce paper.

[2] Gary L. Stanley, *Industry Forecast*, Tappi Journal Vol. 79, No. 1.

[3] NACSI, *A Survey of Pulp and Paper Industry Environmental Protection Expenditures* - 1993 Special Report No. 94-13, December 1994.

Outlook

Environmental regulation and the availability of capital, particularly in developing countries,[33] will probably continue to affect the prospects for the APC industries of the United States and major foreign competitors. These two variables will determine overall growth of the global market and the relative U.S. emphasis on domestic or foreign sales.

The future development of environmental regulations is difficult to predict for the United States and for both the developed and developing markets abroad. The strength of commitments to reduce greenhouse gases, particularly CO_2, and stratospheric ozone, and transboundary air pollution problems, such as acid rain, may determine the course of the world's air quality regulations and ambient air quality.

As noted previously, the need for environmental investments, including APC equipment, in the developing country markets appear to far exceed effective demands. International financial assistance, in addition to transfer of pollution abatement technology, will continue to be required to ensure that industrial facilities and electric power plants in the developing countries are adequately equipped. The source of such assistance, whether multilateral, such as the Global Environment Fund, or bilateral, such as loans or ODA, may affect the competitive position of the three industries.

Continued slow economic growth in the world economy may hold back investment in new or upgraded air pollution control equipment to reduce current emissions or prevent future emissions. However, at the same time, slow growth may also hold back investment in industrial facilities and demand for consumer products such as automobiles which could slow growth in air pollution emissions.

[33] New plants are more likely to get international financial assistance, especially if they contain good environmental controls.

APPENDIX A

United States Senate

COMMITTEE ON FINANCE
WASHINGTON, DC 20510-6200

October 14, 1993

1779

Office of the Secretary
Int'l Trade Commission

Dear Mr. Chairman:

As part of its policymaking process, the Senate Committee on Finance anticipates a need for impartial and detailed information on the competitiveness of environmental technology manufacturing and service industries in the United States. Recent reports prepared by the Office of Technology Assessment (OTA) at the request of the Committee have highlighted the emerging market opportunities for U.S. exporters of these goods and services. The OTA reports have also underscored the need for better data about the extent to which U.S. competitors are involved in export promotion of their environmental technology goods and services.

Accordingly, the Committee hereby requests, pursuant to section 332(g) of the Tariff Act of 1930 (19 U.S.C. 1332(g)), the Commission to collect and analyze information on the competitiveness of U.S. industries producing environmental goods and services. Specifically, the Committee requests that the Commission provide two reports. These should be comparative in nature, reviewing the export promotion/technical assistance policies of the United States' top competitors in the environmental technology field, including but not limited to Japan and Germany.

The first report should focus on the industry providing goods and services for municipal and industrial water supply and for municipal and industrial wastewater treatment and disposal. The second report should focus on the industry providing goods and services for air pollution prevention and abatement. The first report should be delivered within 12 months of the release of OTA's final report in its series on American Industry and the Environment, which is anticipated before the end of this year; the second report should be delivered not later than 12 months after delivery of the first report.

In defining the scope of its investigations, the Commission should focus on:

(1) those industries that provide such conventional environmental goods and services as pollution abatement, pollution prevention, or environmental remediation; or goods and services that have as a central component the reduction of energy or materials consumption or the reduction of environmental impact during use or upon disposal; and

(2) those industries that would benefit in foreign markets from greater coordination among export promotion and market development, environmental regulation, technology transfer, technical development assistance, economic development or other financial assistance, and intellectual property protection policies.

Thank you for your attention to this request.

Sincerely,

Daniel Patrick Moynihan
Chairman

The Honorable Don E. Newquist
Chairman
U.S. International Trade Commission
500 "E" Street, S.W.
Washington, D.C. 20436

APPENDIX B

APPENDIX B

USITC Questionnaire

The USITC's questionnaire was sent to a total of 603 firms that were identified as providers of goods and services for facilities using air pollution prevention and control (APC) equipment and services. There was one questionnaire sent out to all firms, regardless of whether they specialized in provision of equipment or services, and therefore all firms had the opportunity to respond to questions concerning both equipment and services components of the industry. A breakdown of the response rates is shown in table B-1.

The mailing list of firms to whom the questionnaire was mailed was prepared through a compilation of mailing lists and membership lists of organizations whose memberships were known to be composed primarily of those firms that market the types of equipment and services covered by this investigation. The various listings ranged in size from fewer than 100 firms to more than 500 firms. Overall industry data are not available to permit assessment of the share of industry revenues and exports for which respondents to the questionnaire account.

The overall response to the Commission's mailing of 603 questionnaires consisted of 212 questionnaires returned with usable information, 140 questionnaires from firms asserting their non-involvement with the APC industry, and 7 duplicate questionnaires which had been mailed to firms/divisions that either conduct their business under different names or otherwise would have been reporting duplicate information. Of the firms responding, 115 reported revenues associated with equipment only, and 45 reported revenues associated only with the service component. And of the 52 firms that reported both equipment and services revenues, 50 were primarily oriented towards the equipment side of the industry, while only 2 were primarily oriented toward services.

Based on the information provided by the respondents, 26 percent of gross revenues reported were attributable to services, and 74 percent to equipment. The equipment revenues can be further broken down to show that of the 74 percent share, 14 percent of revenues derived from instrumentation, while 60 percent derived from equipment used to remove potential pollutants.

Table B-1
Questionnaire recipients and response rates

	Quantity	Percent of total
Questionnaires mailed	603	--
Questionnaire responses	359	60
Usable responses	212	35
Services firms	47	22[1]
Equipment firms	165	78[1]
Instrument firms	61	29[2]

[1] Based on all usable responses.
[2] Based on all usable responses, instrument producers accounted for 37 percent of equipment firms.
Source: USITC questionnaires.

APPENDIX C

APPENDIX C
Ambient Air Quality and Emission Standards

United States

Title I of the Clean Air Act (the CAA or the Act) sets forth emission standards for stationary sources. Under section 109, the Environmental Protection Agency (EPA) is required to establish the national ambient air quality standards (NAAQS) for various pollutants deemed to be harmful to human health.[1] There are currently NAAQS for sulfur dioxide (SO_2), particulate matter smaller than 10 microns in size (PM10), carbon monoxide (CO), ozone (O_3), nitrogen oxides (NO_X), and lead (Pb).[2] The NAAQS serve as ceilings for individual pollutant concentrations in any given area of the United States. Although not directly enforceable, NAAQS are the basis for the development and implementation of emission limitations pursuant to other sections of the Act. They are the benchmark that is used to determine the level of control required for existing sources and to potentially restrict the creation of new sources. The Act contains primary and secondary NAAQS (table C-1).[3]

New Source Performance Standards

Section 111 of the CAA requires EPA to identify specific sources which ". . . contribute significantly to air pollution which may reasonably be anticipated to endanger public health or welfare."[4] For the specific types identified, EPA is then to set emission standards applicable to new sources, as well as to modifications of existing sources.[5] These are called "new source performance standards" (NSPS). The standards for each source must reflect the "degree of emission limitation achievable" through the best technology EPA determines has been "adequately demonstrated," taking into account both cost and "nonair quality health and environmental impact and energy requirements."[6] This provision thus requires the same degree of control on all technologically-like new sources, regardless of their location. Where numerical

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[1] 42 U.S.C. § 7409 (1994).

[2] 40 C.F.R. § 50.

[3] Primary NAAQS must represent the level of air quality that, based on the "criteria" (compilation of scientific studies on the health effects of the pollutant in question), "and allowing an adequate margin of safety," will protect human health. The secondary NAAQS represents the level of air quality that protects the public welfare from any known or anticipated adverse effects of the pollutant. CAA § 109(b), 42 U.S.C. § 7409(b) (1994).

[4] CAA § 111(b)(1)(A), 42 U.S.C. § 7411(b)(1)(A) (1994).

[5] CAA § 111(b)(1)(B), 42 U.S.C. § 7411(b)(1)(B) (1994).

[6] CAA § 111(a)(1), 42 U.S.C. § 7411(a)(1) (1994).

Table C-1
National ambient air quality standards

Pollutant	Standards
Sulfur dioxide	Primary standard: 0.03 ppm annual arithmetic mean 0.14 ppm maximum 24-hour concentration, not to be exceeded more than once per year Secondary standard: 0.5 ppm maximum 3-hour concentration not to be exceeded more than once a year
Carbon monoxide	Primary Standard: 9 ppm/ 8 hours average concentration, not to be exceeded more than once per year 35 ppm/ hour average concentration not to be exceeded more than once per year
Suspended particulate matters	Primary and secondary standards: 150 micrograms per cubic meter, 24-hour average concentration 50 micrograms per cubic meter, annual arithmetic mean
Photochemical oxidants (ozone)	Primary and secondary standards: 0.12 ppm. The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal or less than 1, as determined by a formula prescribed by regulation.
Nitrogen dioxide	Primary standard and secondary standards: 0.053 ppm, annual arithmetic mean concentration
Lead	Primary and secondary standards: 1.5 micrograms per cubic meter, maximum arithmetic mean averaged over a calendar quarter

Source: Technical Instructions on Air Quality Control (TA Luft), Article 2.5.

emission limitations are not feasible, section 111 of the CAA authorizes EPA to set design, equipment, work practice or operational standards.[7] Once a NSPS has been established, it serves as a ceiling on emissions for that particular new source type nationwide.[8] Thus, for example, EPA has established a NSPS for fossil-fuel fired steam generators, specifying emission limits for nitrogen oxides, sulfur dioxide and particulate matter.[9] To date, EPA has promulgated final NSPSs for 72 source types.[10]

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[7] CAA § 111(h)(1), 42 U.S.C. § 7411(h)(1) (1994).

[8] The NSPS may be only a starting point, however, because the standards developed pursuant to the programs for non-attainment and "prevention of significant deterioration" programs are more stringent.

[9] 40 C.F.R. §§ 60.40-47 (1995).

[10] See, generally, 40 C.F.R. § 60 (1995).

New Source Review: Non-attainment and Prevention of Significant Deterioration

Distinct from the NSPS standards, the Act contains specific emissions standards for sources in areas classified as "attainment" (areas of the country which meet or exceed NAAQS), called the "prevention of significant deterioration" (PSD) program. In addition, the Act contains separate and distinct emissions standards for sources in areas classified as "non-attainment" (areas of the country which do not meet NAAQS). These standards are thus applied geographically, not in reference to the type of source at issue as with the NSPS program.

The PSD program, contained in Part C of Title I of the CAA, is designed to "protect and enhance" the nation's air quality.[11] This program is administered through a review of new sources and modifications to existing sources. For new or modified sources in such areas, this program imposes technology-based requirements more stringent than NSPS and air quality-based emission limitations more stringent than NAAQS. Owners or operators of such sources must obtain permits and commit to meet a particular technology-based standard. At present, the PSD program tightens the air quality standards for major stationary sources of particulates, sulfur dioxide, and nitrogen dioxides.[12] The first requirement a source must meet in order to obtain a PSD permit is a showing that it will use the "best available control technology" (BACT) to reduce emissions.[13] These limitations must be at least as stringent as those required by NSPS.[14] Under the EPA's "top-down" policy, it often proposes the best control technology for a new or modified source.[15] The second requirement of this program is the maintenance of air quality standards which are higher than NAAQS. This requirement ensures that the emissions from any new or modified facility do not cause a projected degradation in pre-existing air quality beyond the amount of an allowable "increment."[16] In determining the allowable "increments" of additional pollution EPA adopted a zoning approach: Class I areas have minute increments of permissible deterioration, so as to effectively preclude any significant growth; Class II increments are designed to allow moderate and controlled growth; Class III areas are allowed additional pollution up to the secondary NAAQS standard.[17] Areas classified as Class I are national parks and other areas where there is a strong interest in maintaining pristine air quality; all other areas in attainment have been classified as Class II.[18] The air quality requirements, i.e., the permissible "increment," for any given new or modified source, are thus determined by the zoning classification of the area in which the source is located.

The non-attainment program contained in Part D of Title I of the CAA, is also administered through a review of "major" new sources (a source with potential emissions of 100 tons per year

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[11] CAA § 101(b)(1), 42 U.S.C. § 7401(b) (1994).

[12] Russell V. Randle and Mary Elizabeth Bosco, "Air Pollution Control," *Environmental Law Handbook* (1991), p. 544.

[13] CAA § 165(a)(4), 42 U.S.C. § 7475(a) (1994).

[14] Timothy A. Vanderer, Jr., ed., *Clean Air Law and Regulation* (1992), p. 170.

[15] Randle and Bosco, "Air Pollution Control," p. 542.

[16] Ibid., pp. 542-543.

[17] Ibid., p. 541.

[18] CAA § 162, 42 U.S.C. § 7472 (1994).

(TPY) or more) and modifications to existing such sources. This program imposes a technology-based requirement, referred to as the "lowest achievable emission rate" (LAER), which is also more stringent than NSPS. The LAER standard must reflect the most stringent of either (1) the most stringent emission limitation contained in any state improvement plan (SIP) or (2) the most stringent emission limitation achieved in practice within that particular industry.[19] LAER cannot be less stringent than any applicable NSPS, and can be more stringent than a BACT standard in the same industry, as unlike the BACT standard, economic considerations are not taken into account in determining the applicable LAER technology.[20]

The non-attainment program also requires "offsets," which are supplemental reductions in emissions from neighboring sources to more than offset the emissions resulting from the new or modified source.[21] These offsets are legally enforceable reductions in emissions from other sources above those which would otherwise be required. The offset requirement is met by installing advanced controls which produce additional reductions in emissions from existing sources or by shutting down such sources. Offsets can be traded and in appropriate circumstances they can be "banked" for future use.

The Act contains non-attainment programs for ozone, carbon monoxide, sulfur dioxide, lead, NO_2 and particulates. The ozone non-attainment program is the most significant and complex of the non-attainment programs. An area must be classified as an ozone non-attainment area where ozone is measured at 0.121 parts per million (ppm) or greater.[22] Depending on the measured ozone level, (or "design value"), ozone non-attainment areas are in turn classified as "marginal" (0.121 up to 0.138 ppm), "moderate" (0.138 up to 0.160 ppm), "serious" (0.160 ppm up to 0.180 ppm), "severe" (0.180 ppm up to 0.280 ppm) or "extreme" (0.280 ppm and above).[23] Deadlines for attainment for a particular area are linked to the severity of the ozone problem. Deadlines range from 3 years for areas classified as "marginal," to 20 years for areas classified as "extreme." In addition to the standards governing new sources, the ozone non-attainment provisions also extend to existing sources, requiring existing sources to install "reasonably available control technology" (RACT). Further, while in general the CAA is applicable only to "major sources" (those with a potential to emit up to 100 TPY) in more polluted areas, RACT applies to smaller sources under sections 172 and 182 of the CAA.[24]

The nonattainment programs for the other pollutants are designed in a similar manner to the ozone program. Areas which do not meet NAAQS for the pollutants carbon monoxide and particulate matter, for example, are divided into "moderate" and "serious."[25] Depending on the level of carbon monoxide, nonattainment areas will be required to introduce measures such as enhanced emission inspection programs and oxygenated fuels.[26] Areas exceeding the particulate

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[19] CAA § 171(3), 42 U.S.C. § 7501(3) (1994).

[20] Organisation for Economic Development and Co-operation (OECD), *Environmental Performance Review: United States* (1996), pp. 113-114.

[21] CAA § 173(c), 42 U.S.C. § 7503(c) (1994).

[22] CAA § 181(a), 42 U.S.C. 7511 (1994).

[23] Ibid.

[24] 42 U.S.C. cites.

[25] CAA §§ 186(a), 188(a), 42 U.S.C. §§ 7512, 7512 (1994).

[26] CAA § 187(a)-(b), 42 U.S.C. § 7512a (1994).

matter standard will have to implement either "reasonably available control measures" or "best available control measures," depending on their classification, among other measures.[27]

Acid Deposition Control

The 1990 Amendments substantially reworked the provisions addressing the problem of acid rain. The sole focus of the acid rain provisions contained in Title IV is power plant emissions of sulfur dioxide and nitrogen oxides.[28] Sulfur dioxide emissions are to be reduced by approximately 10 million tons annually in two phases-- the first phase began in 1995 and the second begins in 2000.[29] The key innovative feature of the sulfur dioxide emissions reduction plan is the market-based system under which the power plants are allocated an "emissions allowance."[30] The allowances are set at a level which is designed to require plants either to reduce their emissions or obtain allowances from other plants to achieve compliance. The program also establishes an emissions "cap" to maintain the reductions that will be achieved through the two-phase program. Plants which have a capacity of 100 NWe or greater and an emissions rate of 2.5 lbs/mmBtu or more are targeted in Phase I of the acid rain program. One hundred ten such plants are specified by name in the statute and have been allocated specific allowances.[31] Unless a plant acquires additional allowances, it will be required to reduce emissions to the level equivalent to the sulfur dioxide emissions that would be generated by burning the average fuel consumed between 1985 and 1987, at an emission rate of 2.5 lbs./mmBtu.[32] In Phase II, each plant will be allocated allowances sufficient to enable each plant with 1985 sulfur dioxide emissions greater than 1.2 lbs/mmBtu to emit sulfur dioxide at that rate (assuming a fuel consumption equivalent to the average amount burned from 1985 through 1987).[33]

The emissions trading system is designed to give utilities flexibility to determine the most efficient means to reduce emissions. In the event that any plant reduces its emissions more than the level required at each phase, it will generate excess allowances which can be banked, traded, or used at another plant under common ownership. Conversely, if allowances are available, plants can acquire allowances from others to allow them to emit more than initially allocated. The acid rain program is reportedly designed to give power plants flexibility in another respect. Utilities must decide whether to install control technology sufficient to achieve the reductions required for Phase II at the outset, or whether to opt for methods of emission reduction sufficient only for Phase I, such as the use of low- sulfur coal or natural gas.[34]

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[27] CAA § 189(a), 42 U.S.C. § 7513a (1994).
[28] CAA § 401(b), 42 U.S.C. § 7651(b) (1994).
[29] CAA §§ 404, 405, 42 U.S.C. §§ 7651c, 7651d (1994).
[30] CAA § 403, 42 U.S.C. § 7651b (1994).
[31] CAA § 404, Table A, 42 U.S.C. § 7651c (1994).
[32] CAA § 404(a)(2), 42 U.S.C. § 7651c(a) (1994).
[33] CAA § 405(b), 42 U.S.C. § 7651d(b) (1994).
[34] John Quarles and William H. Lewis, Jr., *The New Clean Air Act: A Guide to the Clean Air Program as Amended in 1990* (1990), pp. 39-40.

The 1990 Amendments have a targeted reduction of 2 million tons for nitrogen oxides.[35] EPA has set emission reduction standards for coal-fired power plants using tangentially fired boilers (0.45 lb. NO_X/million Btu) and dry bottom wall-fired boilers (0.50 lb. NO_X/million Btu).[36] The Act requires EPA to set emissions limits for other kinds of utility boilers by January 1, 1997.[37] While EPA does not require a specific technology to meet the NO_X standard, the statute intends for plant owners to install low NO_X burner technology.[38] In the event the emissions standards cannot be met with NO_X burner technology, EPA may apply a less stringent standard.[39]

Hazardous Air Pollutants

The CAA regulates the emission of hazardous air pollutants in two phases. The first phase uses technology-based standards to regulate emissions of a list of 189 toxic substances,[40] requiring companies to install the "maximum achievable control technology" (MACT). The MACT "floor" is the minimum level of stringency required, defined as "the average emission limitation achieved by the best performing 12 percent of existing sources."[41] The MACT standard applies to all major sources, which is defined as a stationary source which emits or has the potential to emit 10 tons or more of any hazardous air pollutant or more than 25 tons per year of any combination of hazardous air pollutants.[42] EPA is permitted to set less rigorous technology based standards for existing sources than for new sources.[43]

Once EPA issues a MACT standard for a source category, owners have up to three years to bring the source in compliance. In the event that EPA fails to issue a MACT standard for a particular industry by the statutory deadline, however, the CAA contains a measure that nonetheless ensures the regulation of hazardous emissions. Section 112(j) requires sources of hazardous emissions to timely apply for permits even where no federal standard has been set.[44] It is then left to the state to set permit requirements, by determining a MACT standard on a case-by-case basis.[45] To date, EPA has issued final MACT standards for coke ovens, cooling towers, dry cleaners and synthetic organic chemical manufacturing industry production processes.[46]

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[35] CAA § 401(b), 42 U.S.C. § 7651(b) (1990).

[36] CAA § 407(b)(1), 42 U.S.C. § 7651f(b) (1990).

[37] CAA § 407(b)(2), 42 U.S.C. § 7651f(b) (1990).

[38] Environmental Protection Agency (EPA), *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them: Report to Congress Under CAA Section 811* (Draft) (1994), p. 2-9.

[39] CAA § 407(b)(1), 42 U.S.C. § 7651f(b) (1990).

[40] CAA § 112(b), 42 U.S.C. § 7412(b) (1994).

[41] CAA § 112(d)(3)(A), 42 U.S.C. § 7412(d)(3)(A) (1994).

[42] CAA § 112(a)(1), 42 U.S.C. § 7412(a)(1) (1994).

[43] CAA § 112(d)(3), 42 U.S.C. § 7412(d)(3) (1994).

[44] 42 U.S.C. § 7412(j) (1994).

[45] CAA § 112(j)(5), 42 U.S.C. § 7412(j)(5) (1994).

[46] EPA, *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them*, p. 2-8.

Once MACT standards are met, facilities in areas where the residual emissions will create harmful air toxic concentrations will be subject to a second phase of regulation.[47] In addition, EPA is to promulgate regulations to prevent accidental release of such pollutants.[48]

Mobile Sources

Title II of the Act sets forth emission standards and fuel requirements for mobile sources. As part of the ozone and carbon monoxide nonattainment programs, the 1990 Amendments contain more stringent controls on motor vehicle emissions. They establish reduced emission standards for tailpipe emissions of hydrocarbons, carbon monoxide and nitrogen oxides on a graduated, phased-in basis beginning with model year 1994. In addition, automobile manufacturers must develop technology to reduce evaporate emissions caused by refueling.[49] The 1990 Amendments also require petroleum companies to develop alternative fuels and the auto industry to produce vehicles capable of using such alternative fuels.

Stratospheric Ozone Protection

Title VI of the CAA, added by the 1990 Amendments, establishes requirements to restrict the emission of chlorofluorocarbons (CFCs) in an effort to address the problem of stratospheric ozone depletion and global warming. The 1990 Amendments set forth a plan to phase out the production and sale of CFCs and many other chemicals, in addition to requiring controls on various CFC containing products.[50] Chemicals are regulated in two classes. Class I chemicals, with the exception of methyl chloroform, must be phased out by 2000; this class includes CFCs, halons and carbon tetrachloride.[51] Class II principally consists of halogenated chlorofluorocarbons (HCFCs), which must be phased out by 2015 for some uses.[52]

Germany

The Technical Instructions on Air Quality Control (TA Luft) establishes two sets of ambient air quality standards. The goal of the first set is to prevent serious health hazards (table C-2); the goal of the second is to prevent "considerable disadvantages or substantial impairments" (table C-3).[53] Like the United States, these standards are the benchmark that is used to determine the level of control required for new and existing sources; the acquisition of a license, for example, is contingent on a showing that the ambient air standards for these pollutants will not be exceeded.[54]

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[47] CAA § 112(f), 42 U.S.C. § 7412(f) (1994).
[48] CAA § 112(r), 42 U.S.C. § 7412(r) (1994).
[49] CAA § 202(k), 42 U.S.C. § 7521(k) (1994).
[50] CAA § 601, 42 U.S.C. § 7671 (1994).
[51] CAA § 602, 42 U.S.C. § 7671a (1994).
[52] Ibid.
[53] Technical Instructions on Air Quality Control (TA Luft), Article 2.5.
[54] OECD, *OECD Environmental Performance Reviews: Germany* (1993), p. 37.

Table C-2
Health related emission standards

Pollutant	Standard
Sulfur dioxide	annual mean: 014 milligrams per cubic meter short-term average: 0.40 milligrams per cubic meter
Chlorine	annual mean: 0.10 milligrams per cubic meter short-term average: 0.30 milligrams per cubic meter
Hydrochloric acid	annual mean: 0.10 milligrams per cubic meter short-term average: 0.20 milligrams per cubic meter
Carbon monoxide	annual mean: 10 milligrams per cubic meter short-term average: 30 milligrams per cubic meter
Suspended particulates	annual mean: 0.150 milligrams per cubic meter short-term average: 0.30 milligrams per cubic meter
Cadmium and inorganic cadmium compounds (as components of suspended particles)	annual mean: 0.04 micrograms per cubic meter
Nitrogen dioxide	annual mean: 0.08 milligrams per cubic meter short-term average: 0.20 milligrams per cubic meter
Lead and inorganic lead compounds (as components of suspended particles)	2.0 micrograms per cubic meter

Source: Technical Instructions on Air Quality Control (TA Luft), Article 2.5.

Table C-3
Protection against considerable disadvantages and substantial impairments

Pollutants	Standards
Non-hazardous dust deposition	annual mean: 0.35 grams/(m^2d); short-term average: 0.65 milligrams/(m^2d)
Lead and inorganic lead compounds (as components of dust deposition)	annual mean: 0.25 milligrams/(m^2d)
Cadmium and inorganic cadmium compounds (as components of dust deposition)	annual mean: 5.0 micrograms/(m^2d)
Thallium and inorganic thallium compounds (as components of dust deposition)	annual mean: 10.0 micrograms/(m^2d)
Hydrofluoric acid and inorganic gaseous fluorine compounds	annual mean: 0.10 micrograms per cubic meter short-term average: 3.0 micrograms per cubic meter

Source: Technical Instructions on Air Quality Control (TA Luft), Article 2.5.

Regulation of Stationary Sources

TA Luft regulates a broad range of stationary industrial sources such as oil refineries, chemical factories and steel production plants. Emissions have been set for approximately 200 pollutants which apply to both new and pre-existing plants, the only distinction being the amount of time allowed for existing plants to comply with the regulations.[55] TA Luft requires the use of "state-of-the-art" technology for all pollutants,[56] which is defined in the Act as the current "state of development of advanced processes, of facilities or of modes of operation which is deemed to indicate the practical suitability of a particular technique for restricting emission levels."[57] In determining such a technology, regulators are to consider measures for limiting emissions which have been successful in practice.[58]

The Ordinance on Large Firing Installations[59] sets emissions standards for power plants for nitrogen oxides, sulphur oxides, particulates, carbon monoxide and halogen compounds. The standards cover solid, liquid and gaseous fuels for plants with a capacity greater than 50 megawatts.[60] Emission standards may vary depending on the type and scale of the plant. Coal-fired plants covered by the ordinance in general, for instance, must not exceed 400 milligrams per cubic meter of SO_2 and a 15-percent sulfur emission rate; coal-fired fluidized-bed firing installations with a capacity of 50-300 megawatts are permitted a 25-percent sulfur emission rate, however.[61] The Ordinance also specifies the use of state-of-the-art technology for SO_2 and NO_2 emissions.[62] The SO_2 standards require the installation of flue gas desulphurization technology.[63] Selective catalytic reduction is necessary to keep NO_X emissions within the standards of the Ordinance.[64]

Toxic substances

German regulations do not distinguish between hazardous and non-hazardous pollutants. Approximately 170 out of 200 toxic substances are regulated under TA Luft.[65] TA Luft prescribes emissions limits for the following general groups of toxic substances: carcinogenic substances, inorganic dust particles, total dust, gaseous or vaporous inorganic substances and

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[55] Ibid., p. 35.

[56] TA Luft, Article 3.1.2.

[57] Federal Immission Control Act (FICA), Article 3(6).

[58] Ibid.

[59] *Thirteenth Ordinance Implementing the Federal Immission Control Law* (13th Ord.) (13th BimSchV) (June 22, 1983).

[60] Combustion facilities with a capacity of less than 50 megawatts are regulated by the TA Luft.

[61] 13th Ord., Article 6.

[62] See, e.g., 13th Ord., Articles 10, 11.

[63] OECD, *OECD Environmental Performance Reviews: Germany* (1993), p. 35.

[64] Ibid.

[65] EPA, *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them*, p. 3-57.

organic substances.[66] Within each of these categories, chemicals are classed on the basis of relative carcinogenicity, toxicity, odor and bioaccumulation.[67] As with other stationary source emissions, state-of-the-art technology is required.[68] The hazardous air pollutants regulated by the United States and Germany are considerably different; more than 100 of the 189 pollutants regulated by the United States are not regulated in Germany, while Germany regulates 60 hazardous pollutants that are not regulated under the CAA.[69]

Volatile Organic Compounds (VOCs)

As with hazardous substances, Germany does not have a specific VOCs program. VOCs are regulated in TA Luft in the organic substances category without reference to ozone. Further, Germany does not have an ambient air standard for ozone, although there is a non-regulatory, health warning threshold of 0.09 ppm/hour for ozone.[70]

Regulation of Mobile Sources

Motor vehicles are subject to both German and European Commission (EC) emission standards and fuel requirements. EC directives 91/441/EEC and 91/542/EEC provide for phased-in NO_X standards for motor vehicles.[71] These directives also establish hydrocarbon emission limits, which also have the effect of reducing non-mobile volatile organic compounds (NMVOCs).[72] The 21st Ordinance on the Federal Immissions Control Act[73] sets evaporative emissions standards. Other measures include economic incentives for the use of three-way catalytic converters, the banning of leaded gasoline and certain gasoline additives, the use of state-of-the-art control technology for automobiles, and emission standards for heavy-duty vehicles.[74]

Stratospheric Ozone Protection

German industry has pledged to discontinue production of CFCS by 1994 in an effort to address the problem of stratospheric ozone depletion.[75]

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[66] Hans-Hermann Eggers, "TA Luft '86 -- Experience with Emission Control Strategies, Interim Results, and Outlook," in OECD, *Hazardous Air Pollutants: The London Workshop* (1995), pp. 196, 199.

[67] EPA, *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them*, p. 3-35.

[68] OECD, *Hazardous Air Pollutants: The London Workshop* (1995), p. 197.

[69] EPA, *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them*, p. 3-58.

[70] Ibid., p. 3-29.

[71] Federal Environment Ministry, *First Report of the Government of the Federal Republic of Germany Pursuant to the United Nations Framework Convention on Climate Change* (1994), p. 134.

[72] Ibid.

[73] 21 BImSchV.

[74] OECD, *OECD Environmental Performance Reviews: Germany* (1993), p. 37.

[75] Ibid., p. 193.

Ambient air quality standards have been set for five pollutants: sulfur dioxide, carbon monoxide, suspended particulate matter, photochemical oxidants, and nitrogen dioxide (table C-4).[76] In addition, the Environmental Agency (EA) has set air quality guidelines for other pollutants including hydrocarbons, tetrachloroethylene, and trichloroethylene.[77] Recently, Japan formed a task force to investigate the need for regulations of additional substances.[78]

Emission Standards for Stationary Sources

The Air Pollution Control Law contains national emission standards for stationary sources for specific pollutants, with a particular focus on what are termed "soot and smoke" emission resulting from combustion.[79] Specific pollutants include SO_X, NO_X, particulates and toxic substances such as cadmium, hydrogen fluoride and lead.[80] The standards vary with the type and scale of the facility. There are three types of facilities under control: (1) soot and smoke emitting facility, including any industry plant which generates or emits air pollutants such as SO_X and NO_X (there were 32 types of facilities and 183,000 facilities under control in 1992); (2) general dust, or particulate discharging facility, including conveyer and crusher and any other facility that discharges dust (there were five types and 7800 facilities nationwide in 1992); and (3) specific dust discharging facility, depending on the specified dust (there were 2600 facilities under this category of control in 1992).[81] New facilities are subject to more stringent emission standards.[82]

Japanese air pollution regulations appear to require best available technology (BAT). The EA states that air quality standards are established based on available "scientific knowledge,"[83] and suggests that standards are revised once the new technology has been developed.[84] Indeed, emission standards have been amended four times to reflect changes in technical progress.[85] An OECD study has also indicated that Japanese companies are required by law to use the "highest level of technology and knowledge" to take preventive measures.[86]

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[76] *Environmental Agency (EA) Outline*, p. 3.

[77] *EA Outline*, p. 3.

[78] A priority list for the study includes 175 substances. "Japan: Air Pollution Control Seen Being Tightened," *Japan Chemical Week*, June 15, 1995, p. 4.

[79] *Air Pollution Control Law*, Articles 1, 3.

[80] Ibid., Article 2.

[81] *EA Outline*, p. 4.

[82] Lovedale Murley, ed., *Clean Air Around the World* (1991), p. 227.

[83] *EA Outline*, p. 3.

[84] Accord, Staff Meeting with New Oji Paper Co., Inc. (Aug. 29, 1995) (Environmental regulation is not passed until there exists the means among effected industries to meet the performance level).

[85] OECD, *OECD Environmental Performance Reviews of Japan*, (1994), p. 104.

[86] Ibid. Japanese courts have interpreted the Pollution Health Injury Compensation Act, Law No. 11 of 1973, to require companies to employ the best technology available to control its anticipated pollution when they select a facility site near human settlements. Thomas S. Mackey and

Table C-4
Ambient air quality standards

Pollutant	Standard values
Sulfur dioxide	below 0.01/hour below 0.04/day
Carbon monoxide	below 20 ppm/8 hours below 10 ppm/day
Suspended particulate matters	below 0.20 mg/m^3/hour
Photochemical oxidants (ozone)	below 0.06 ppm/hour
Nitrogen dioxides	below 0.04-0.06 ppm/average daily value

Source: Environmental Agency Outline, p. 16.

Emission standards vary depending on the type and scale of the facility for all pollutants regulated under the Air Pollution Control Act. Sulfur dioxide emission standards are calculated using a formula which accounts for variations in the location and the stack height of the emission source.[87] Depending on the location and stack height, meeting emissions limits for coal-fired power plants may require the installation of flue gas desulfurization technology; whereas for some plants in some areas, the emission limits may be met with low-sulfur fuel.[88]

Nitrogen oxide emission standards also vary with the type and scale of facilities, as well as the type of soot emitted.[89] Standards are subject to frequent amendments to reflect changes in energy and the development of new technology.[90] Selective catalytic reduction has been required since 1972 for oil and gas firing facilities, and since 1979 for coal firing facilities in order to meet NO_X emission control requirements.[91]

Emission standards for particulates also vary with the type and scale of the facility.[92] Japanese regulations distinguish between general particulate sources, which cover particulate matter generated by mechanical means, and the category of hazardous particulates, which is comprised

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Jim S. Hart, "A Comparison of U.S. and Japanese Environmental Laws Governing Emissions From Major Industrial Facilities," *6 Transnat'l Law* 579, 10 (Fall 1993).

[87] Enforcement Regulation of Air Pollution Control Law, Ordinance No. 1 of June 22, 1971. In the case of serious threat of SO_X pollution, the governor may order the observance of fuel standards within a prescribed period. *Air Pollution Control Law*, Article 15.

[88] *EA Outline*, p. 5. The geographical variables for the formula are determined by the prefectural governor. Argonne National Laboratory, *Comparison of International Environmental Policies* (Draft) (1993), p. V-56.

[89] EPA, *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them*, p. 3-26.

[90] *EA Outline*, p. 6.

[91] Argonne National Laboratory, *Comparison of International Environmental Technologies*, p. V-58.

[92] *EA Outline*, p. 7.

of asbestos. General particulate emissions are controlled through construction, use and maintenance standards.[93] These standards are more stringent than the uniform national standards, which are applicable to newly installed facilities in specified geographical areas with acute air pollution.[94] Japan does not currently regulate volatile organic compounds for stationary sources although it has a stringent ambient air limit for ozone.[95]

"Total Emission Control" for sulfur oxides and nitrogen oxides

Similar to non-attainment in the United States, local authorities also establish "total emission control" in particularly polluted areas. The prefectural governors for a concerned area determine the total volume of tolerable emissions, and then prescribe total volume of emissions on a plant-by-plant basis.[96] For nitrogen oxides, total emission control is applicable in three geographic areas, Tokyo, Kanagawa and Osaka.[97] For sulfur oxides, 24 regions are subject to such controls.[98]

Toxic substances

The Air Pollution Control Law prescribes emission standards for four groups of substances designated as toxic, including (1) cadmium and its compounds, (2) chlorine and hydrogen chloride, (3) fluorine, hydrogen fluoride and silicon fluoride, and (4) lead and its compounds.[99] EA has also begun to reinforce the regulations on chlorine-family compounds.[100] .

Emission Standards for Mobile Sources

EA has established permissible limits of motor vehicle exhaust standards, regulating the following pollutants: CO, HC, NO_X, diesel smoke, and SPM.[101] OECD's comparison also characterized Japan's CO standards as twice as stringent as those of California, hydrocarbon standards slightly more stringent than California, and NO_X emission standards equivalent to California standards.[102] Japan has also announced the implementation of five new measures to reduce levels of CO_2, in anticipation of its inability to meet the official target.[103]

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[93] *Air Pollution Control Law*, Article 18-3; L. Murley, ed., *Clean Air Around the World* (1991), p. 239.

[94] *EA Outline*, p. 7.

[95] EPA, *The Competitiveness Impacts of the Clean Air Act Amendments and EPA's Strategy to Address Them*, p. 3-27.

[96] *EA Outline*, p. 2.

[97] Ibid., p. 6.

[98] Ibid.

[99] Ibid., p. 7.

[100] "Environment Agency Begins Work on Strengthening Chlorine Regulations," *International Environment Reporter*, Mar. 22, 1995, p. 228.

[101] *EA Outline*, p. 8.

[102] OECD, *OECD Environmental Performance Reviews: Japan* (1994), p. 43.

[103] "Five Measures To Reduce CO_2 Emissions," *International Environment Reporter*, Jan. 11, 1995, p. 26.

APPENDIX D

List of equipment identified as air pollution prevention and control equipment

1. Absorption equipment:
    - Spray towers/chambers and mist eliminators
    - High energy absorbers/scrubbers
    - Packed columns
    - Plate tower/scrubber
    - Mobile packed beds
    - Entrainment separators/scrubbers
    - Wet flue gas desulfurization equipment
    - Spray dryers
    - Dry injection systems
    - Liquid phase/gas phase contacting scrubbers
    - Other

2. NO_x combustion control equipment:
    - Flue gas recirculation equipment
    - Low NO_x burners
    - Other NO_x equipment

3. NO_x post combustion control equipment:
    - Selective catalytic reduction equipment
    - Selective non-catalytic reduction equipment
    - Non-selective catalytic reduction equipment
    - Gas reburn equipment
    - Other NO_x post combustion controls

4. Adsorption equipment:
    - Non-regenerable systems:
        - Fixed bed adsorbers
        - Moving bed adsorbers
        - Fluidized bed adsorbers
    - Regenerable systems:
        - Fixed bed adsorbers
        - Moving bed adsorbers
        - Fluidized bed adsorbers
        - Adsorption media
    - Other adsorption media

5. Electrostatic precipitators:
    - High voltage, single stage electrostatic precipitators
    - Low voltage, two-stage electrostatic precipitators
    - Parts of electrostatic precipitators:
        - Discharge electrodes
        - Collection electrodes

Shell structures
Rappers
Hoppers
Other parts of electrostatic precipitators
Other electrostatic precipitation equipment

6. Combustion equipment:
   - Flaring equipment
   - Incinerators
   - Catalytic oxidizers
   - Heat recovery systems
   - Other combustion equipment

7. Fabric filtration equipment:
   - Baghouses
   - Parts of baghouses:
     - Filter mediums and supports
     - Filter cleaning devices
     - Collection hoppers
     - Shells
     - Other parts of baghouses
   - Other fabric filtration equipment

8. Condensation equipment:
   - Direct contact condensers
   - Surface condensers
   - Other condensation equipment

9. Gravity settling chambers

10. Cyclones

11. Auxiliary equipment and parts:
    - Hoods
    - Ducts
    - Fans
    - Pumps
    - Nozzles
    - Other auxiliary equipment and parts

12. Monitoring and analyzing equipment:
    - Stack and chimney continuous emission monitors
    - Automotive emission analyzers
    - Nuclear radiation monitoring instruments and systems
    - Ambient and confined air chemistry and particulate monitoring and analyzing instruments and systems
    - Process control instruments and systems
    - Meteorological monitoring instruments and systems

Space remote sensing equipment for atmospheric modeling and monitoring
Other monitoring and analyzing equipment

13. Mobile source pollution control equipment and instruments:
    - Diesel oxidation catalysts
    - Diesel particulate filters
    - Gasoline catalytic converters
    - Oxygen sensors
    - Exhaust gas recirculation valves
    - On-board diagnostic equipment
    - Alternative fuel catalytic converters
    - Alternative fuel conversion kits
    - Utility engine catalytic converters
    - Motorcycle catalytic converters
    - Other mobile source pollution control equipment