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CAPABILITIES AND COMPETITIVENESS OF U.S. ENVIRONMENTAL TECHNOLOGIES

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EXECUTIVE SUMMARY

This preliminary study was conducted to examine the international competitiveness of U.S. environmental technologies and services. Potential marketing opportunities were exemplified by investigating the environmental problems of select Asian countries. Key findings of this study include:

1. The U.S. is by far the largest producer of pollution abatement equipment. The U.S. is competitive in most segments of the industry and is without peer in the waste management and environmental services sectors. Germany is the largest exporter of pollution abatement equipment and is particularly strong in the water treatment sector. Japan is a leading exporter of air pollution control products and technology.

2. Government funding of environmental technology research and development (R&D) is increasing in developed nations but remains well below traditional research domains. Although the U.S and Germany both spent $420 million on environmental R&D in 1989, the percentage share of Germany's total R&D was seven times greater than the percentage allotted by the United States (3.4% vs 0.5%). Japan's investment of 150 million dollars represents 1.4% of their total R&D (roughly three times the U.S. percentage).

3. The U.S. government agencies, most notably the Agency for International Development (AID) and the Export Import Bank, provide a variety of assistance related to environmental improvement and trade promotion investment promotion in Asia. The Japanese are spending an increasing amount of money on development assistance, 50% of which is targeted to Asian countries. The German government coordinates activities among industry, special trade and R&D groups, and financial institutions that results in a "tied-aid" donation of German industry services, not money that might be spent on another nation's products. In fact, most Western European nations and Japan use a "tied-aid" approach to capture capital projects. Assistance funds provided by AID are also restricted to U.S. procurement.

4. Improved environmental management has become a priority for each of the Asian countries. These problems can deter regional development, with accompanying threats to human health, economic growth, and political stability. Our own historical environmental mismanagement provides a very clear example that these issues are easier and cheaper to solve if attacked early and at the source, rather than cleaned up after. Therefore, it is especially important for the U.S. to market and transfer our environmental expertise to the six member countries of the Association of South East Asian Nations' (ASEAN) as these traditionally agricultural based economies evolve into their industrial infancies.

5. The environmental technology and services market is a growing industry with worldwide markets now estimated at $200 billion. Governments that view the environmental industry in strategic terms and provide appropriate supports will be better placed to assist their industrial and services sector. Of particular importance is the development of a statistical classification system for the environmental industry and improved data collection.

1.0 INTRODUCTION

On January 4, 1992, President George Bush announced in Singapore at the commencement of the U.S. - Asian Environmental Partnership that "Asia's continued economic and social progress and increased environmental protection will be beneficial to both the region and the United States. Greater use of U.S. environmental expertise, goods, and services will result in improved environmental quality in Asia while building stronger economic links, expanding markets and providing new business opportunities for Asia and the U.S.". The United Nations, the World Bank, the United States Agency for International Development, as well as other international financial institutions and government entities are providing enormous levels of funding for training and key capital improvement projects in Asia. These projects, as well as the billions of dollars of annual commercial investment into the construction and updating of industrial and municipal facilities, are indicative of the growing opportunities available to U.S. firms selling environmental technology and services.

Due to the time and scheduling constraints of this preliminary study, investigative research focused on the Asian countries that constitute the Association of South East Asian Nations (ASEAN) which includes Indonesia, Brunei, Singapore, Thailand, Malaysia, and the Philippines. These countries provide a classic example of developing countries whose ambitious industrial programs have been accelerated without due attention to environmental issues. Consequently, ASEAN's unchecked high levels of economic growth have translated into severe environmental problems.

However, a growing level of environmental awareness and concern has begun to take root in ASEAN. The rapid deterioration of their limited land and other natural resources has instilled the political will in the leaders to address this issue. Governments are beginning to emphasize selective industrial growth and economic development that minimizes environmental damage. Expanding and enforcing the current environmental regulatory structures has been identified as a national priority by all six ASEAN countries.

This report contains direct excerpts from US-ASEAN's 1991 Council for Business & Technology report, ASEAN Environmental Markets: Opportunities for U.S. Equipment and Service ; USAID's January 1992 project paper, ASEAN Environmental Improvement Project (EIP); and US-ASEAN's 1991 seminar materials, Southeast Asian Markets for U.S. Environmental Equipment and Services. Additional sources include: the United Nations Economic and Social Commission for Asia in the Pacific's (UNESCAP) 1990 report, State of the Environment in Asia and the Pacific; the Organization for Economic Cooperation and Development's (OECD) 1992 report, The OECD Environment Industry: Situation, Prospects and Government Policies; and the U.S. Department of

Commerce's (DoC), Competitive Assessment of the U.S. Industrial Air Pollution Control Equipment Industry, August 1990. Literature research and extensive telephone conversations to appropriate government agencies and technical associations were also conducted (Appendix 1).

Although there is abundant data on individual pieces of environmental technology equipment and services, there is little information other than the OECD and DoC reports cited above currently available that examines the viability and international competitiveness of whole sectors of the industry (i.e. wastewater treatment, hazardous waste). This is principally due to the fact that environmental technologies, with the exception of air pollution control equipment (APC), do not have Standard Industrial Classification (SIC) codes. Consequently, the extensive statistics that the U.S. Governrnent collects on American industry are either not available or not assembled in a meaningful fashion.

There are, however, several investigations into America's competitiveness in the arena of pollution prevention and control currently underway. The Office of Technology Assessment is undergoing a detailed examination of the viabilities and competitiveness of U.S. Environmental Technologies. This project is due to be complete in July of 1993 and will be titled, American Industry and the Environment: Implications for Trade and U.S. Competitiveness. The American Academy of Environmental Engineers and the EPA are independently assessing the viabilities of air and water pollution control and hazardous waste remediation technologies (for project descriptions, consult Appendix 2). These sources should be consulted during any follow-up study to reduce duplication of efforts.

Chapter 2 of this report examines the technical capabilities and international competitiveness of U.S. environmental technology and services versus other OECD nations. Chapters 3 and 4 examine the current environmental status of the six ASEAN members and the potential marketing opportunities available to U.S. industry.

2.0 U.S. ENVIRONMENTAL TECHNOLOGY CAPABILITIES AND INTERNATIONAL COMPETITIVENESS

The world market for environmental goods and services is forecast to grow at a rate of 5.5 percent per year to the year 2000. Within the equipment sector, demand for products for waste management and land remediation is expected to show relatively stronger growth than that for water and air pollution control equipment. The environmental services sector is experiencing the most rapid growth as the fuller incorporation of clean technologies into industrial processes requires greater engineering and analytical expertise. The largest exporters of environmental products are those OECD countries with the most advanced environmental policies and frameworks. Germany is the world's leading exporter of pollution abatement equipment and is particularly strong in the water treatment sector. Japan is a major exporter of air pollution control products and the United States is the leading international competitor in waste management techniques.

Although the American (and the rest of the world's) relatively young and emerging environmental industry does not have the data accessibility of older established industries, the OECD and DoC reports cited in the Executive Summary provide important performance indicators for assessing the major performance trends.

The Commerce report indicated, and industry representatives confirmed, that the most important factors leading to a successful U.S. industry performance are technology, price, export financing, and foreign rules for market entry. These same sources indicated that U.S. product quality and technology are fully competitive with foreign offerings (See Appendix 3), but that foreign governments provide better support for their environmental firms. To sustain long-run competitiveness, this U.S. industry must continue R&D investment. These factors will continue to shape the competitiveness of our environmental industry in the years to come.

Industries in the developed nations area have long recognized that environmental compliance is a necessary part of doing business, largely to ensure the sustainability of their activities. It is increasingly apparent that caring for the environment is also a business opportunity. The production of goods and services for pollution abatement and environmental protection is a growing industrial sector with markets now estimated at $200 billion worldwide. Both ecological and economic objectives may be served by a commercial approach to the environment, but this also raises issues regarding industrial competition and the role of governments.

2.1 PRODUCT STRUCTURE

The environmental industry is not easily defined but may be described as including firms which produce pollution abatement equipment and a range of goods and services for environmental protection and management. For an expanded look at the various products and services offered by the industry, consult Appendix 4. It is a diversified industry spanning a variety of industrial products and services which have not been statistically classified and for which data are limited.

Table 1 gives estimates of the product structure of the environmental industry by segment and by region. Over three-quarters of industry output is equipment produced for environmental purposes, primarily end-of-pipe pollution abatement equipment. Environmental equipment and related services can be subdivided into four main types of products according to end-use: water and effluent treatment, waste management, air quality control and other (primarily land reclamation and noise reduction). Environmental technologies, which are incorporated in industrial processes -- generally termed clean technologies -- are not included in this classification. General environmental services, which now account for almost a quarter of industry output and are often related to the installation of clean technologies, are listed as a separate category.

Table 1
Main Components of the Environment Industry : 1990 (%)

	North America	Europe	Japan	Total OECD
EQUIPMENT/RELATED SERVICES	74	76	79	76
Water and Effluent Treatment	24	34	22	29
Waste Management	25	15	22	21
Air Quality Control	12	17	25	15
Other (land remediation, noise)	13	10	10	11
GENERAL SERVICES	26	24	21	24
Total	100	100	100	100

Source:OECD, The OECD Environment Industry: Situation, Prospects and Government Policies

The structure of environmental industry output differs by region and reflects local environmental concerns as well as variations in environmental legislation. Overall, equipment for water and effluent treatment is believed to account for the largest share of industry output (almost 30 percent) in the OECD area. Water treatment equipment accounts for a relatively larger output share in the European countries, while waste management products and services now account for the largest share of industry value in the United States. Japan has focused more on the

development and production of equipment for air pollution control. The production of other types of equipment is relatively equal among regions, with land remediation technologies predominating in the North American industry and noise abatement products relatively more important in European and Japanese output. The general environmental services sector is most developed in North America and least developed in Japan.

2.1.1 Wastewater Treatment

The production of equipment for water and effluent treatment within both public facilities and manufacturing industry is a mature market using well-established technologies. Its status as the largest segment of the environmental industry is due to significant government expenditures on municipal water and wastewater treatment plants. Equipment for water and effluent treatment is generally designed to remove pollutants from an aqueous stream or body of water or to convert the pollutant to a non- or less-polluting form prior to discharge or use. Products consist of primary treatment equipment to remove solid particles (filters, clarifiers), secondary treatment equipment to remove bacteria (biological treatment, chlorination), and tertiary treatment equipment to remove chemical or metal compounds (reverse osmosis, chemical recovery systems). Water treatment equipment generally employs mechanical techniques (raking, screening, gravity separators, sand traps, settling basins, flotation) or physio-chemical techniques (centrifuging, neutralization, precipitation, adsorption). Newer types of equipment or processes for treatment of wastewater are aerobic methods, ion exchange and membrane technologies. Equipment for monitoring water and groundwater quality and use of specialty chemicals for water treatment are important sub-markets. Auxiliary products include pumps, pipes, tanks and handling equipment.

Firms supplying equipment for water and effluent treatment tend to be large systems suppliers since water treatment is generally more than just a pollution control activity (see Table 2). The largest firms in this market segment are European, led by Alfa Laval of Sweden and Bilfinger and Berger and Steinmuller of Germany. An increasing number of larger water utilities in Europe (such as Lyonnaise des Eaux and Compagnie Generale des Eaux in France) are becoming involved in the development and supply of water treatment technology. The many English firms involved in this market segment are headed by John Brown Engineering, Portals Water Treatment and Biwater. NALCO and Calgon Carbon are the largest American firms supplying water treatment equipment. The Netherlands makes its strongest showing in the water equipment market led by Esmil Water Systems and Jansen Vanneboer. Japanese firms supplying products in the water treatment equipment market include Ebara, Hitachi and Kurita. There are many smaller specialized firms with products ranging from aerobic treatments to sedimentation.

Table 2
Major Water Treatment Equipment Firms : 1990

Firm	Headquarters	Estimated Environmental Product Turnover ($ millions)
Alfa Laval	Sweden	3,000
Bilfinger and Berger	Germany	3,000
Steinmuller	Germany	2,800
Cie, Generale des Eaux	France	2,500
Lyonnaise des Eaux SA	France	2,000
John Brown Engineering	United Kingdom	1,000
Portals Water Treatment	United Kingdom	900
Thyssen	Germany	800
NALCO	United States	800
Calgon Carbon	United States	760
Biwater	United Kingdom	600
Degremont	France	400
Ebara	Japan	400
Hitachi	Japan	350
Metcalf & Eddy	United States	350
Kurita	Japan	300
Noell	Germany	200
Esmil Water Systems	Netherlands	100
Jansen Venneboer	Netherlands	50
Purac	Sweden	50

Source: OECD.

2.1.2 Air Pollution Control Equipment

Equipment for air quality control, which accounts for about 15 percent of industry output, is designed to remove pollutants from a gaseous stream or to convert pollutants to a non- or less-polluting form prior to discharge into the atmosphere. Pollutants include solid particulates (dust, metallic fumes), gases (carbon monoxide, nitrous oxides, sulphur dioxide) and liquids or liquid fumes (sulfuric acid, hydrocarbon solvents). Air pollution control equipment may thus address particulates (fabric filters, electrostatic precipitators, mechanical collectors), acid emissions from power stations and other large-scale combustion plants (scrubbers, catalytic reduction, electron beam methods) and emissions of gases and vapors (desulfurization, oxidation, carbon adsorption). Particulate emissions collectors are estimated to account for about 60 percent of the value of air pollution control equipment. Air quality control techniques increasing in importance are biological scrubbers and filters to treat flue gases, activated charcoal and catalysts to reduce organic emissions, and combined particulate and acid gas control through electrostatic methods. Auxiliary products include fans, hoods, ducts, stacks, and handling and storage equipment.

Leading the market in air pollution control equipment are the diversified Japanese firms, Mitsubishi and Hitachi, which license pollution control technology to numerous OECD firms (see Table 3). Flakt of Sweden, the environmental control arm of Asea Brown Boveri, specializes in air and energy technology for environmental purposes and is one of the largest purely environmental companies in the world. The German firms active in the air quality equipment market are generally subsidiaries of larger conglomerates: Handel is part of Deutche Babcock, Lurgi of Metallgesellschaft and KWU of Siemens. General Electric of the United States is an increasingly important producer of environmental equipment, but most US and UK firms in the air quality sector tend to be specialist suppliers.

Table 3
Major Air Pollution Control Equipment Firms: 1990

Firm	Headquarters	Estimated Environmental Product Turnover ($ millions)
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: OECD.

2.1.3 Waste Management

Waste management includes products and services to collect, transport, treat and dispose wastes from homes, municipalities, commercial establishments and manufacturing plants. It includes equipment for management of solid waste (compactor trucks, separation methods), liquid waste (tank trucks, treatment chemicals), toxic or hazardous waste (landfilling, incinerators) and waste recycling. Products for the collection and transportation of solid waste are the largest component of the waste management segment, followed by equipment for incineration and landfilling of toxic wastes and recycling. Centralized plants for chemical and thermal treatment of solid, sludge or hazardous wastes prior to

landfilling are a small but growing market component. Newer technologies are being developed for the physio-chemical treatment of hazardous waste, including neutralization, detoxification and evaporation. Auxiliary waste management products include shredders, screening devices, containers and handling equipment.

Waste Management and Browning-Ferris of the United States and Laidlaw Transport of Canada are the leaders in the waste management segment of the industry, which is more of a service than an equipment sector, and outsize most other firms in this area (see Table 4). The waste management sector tends to be fragmented with the larger US-type conglomerates operating alongside thousands of small waste disposal companies. European waste equipment companies are led by Edelhoff and Hoechst of Germany. Waste management companies generally tend to be smaller in Europe, specializing in particular materials handling or recovery markets, such as chemical waste treatment (Leigh and Rechem in the United Kingdom), fluidized bed waste combustion and incineration (Von Roll of Switzerland) or the growing area of hazardous or toxic wastes (France Dechets). SITA and SAUR are the waste management subsidiaries of the French water utility Lyonnaise des Eaux and of the construction firm Bouygues. In the United States,

Table 4
Major Waste Management Firms : 1990

Estimated Environmental Firm	Headquarters	Turnover ($ millions)
Waste Management	United States	4,500
Browning-Ferris	United States	2,200
Laidlaw Transport	Canada	2,000
Edelhoff	Germany	1,500
Hoechst	Germany	1,000
RWE	Germany	800
Rollins	United States	600
Von Roll Ltd.	Switzerland	600
Attwoods	United Kingdom	500
Shanks & McEwan	United Kingdom	500
SITA	France	440
SAUR	France	400
Steag AG	Germany	400
Veba	Germany	300
Allwaste	United States	200
Cleanaway	United Kingdom	180
Saur	France	140
Voest-Alpine	Austria	140
Chambers Development	United States	130
Leigh Interests	United Kingdom	70
Rechem	United Kingdom	50
France Dechets	France	50

Source: OECD.

Waste Management, Inc. has set up a subsidiary, Chemical Waste Management, which has become the largest US commercial disposer of hazardous waste. Large companies in a variety of fields have targeted waste management as an area for diversification (Hoechst in Germany, Voest-Alpine in Austria, BET PLC in the United Kingdom). It should be noted that by international agreement there are constraints on the transfrontier shipment of waste, particularly hazardous waste.

2.1.4 Environmental Services and Other Categories

General environmental services account for almost a quarter of the total value of industry output and are largely based on engineering and consultant services to solve specific environmental problems. There are three main types of environmental service activities: 1) technical engineering (site assessment, process design, control specifications, project management), 2) environmental consulting (impact assessments, environmental audits, environmental monitoring, risk management), and 3) management services (expert systems, financial analyses, data base management). Service firms act as troubleshooters, solving pollution problems for firms, advising on best available control technologies, monitoring compliance records, and testing products and processes for environmental friendliness. Among environmental management services, there are now more than 100 computer programs or expert systems which can be applied to various environmental tasks, such as estimating costs for different types of equipment installations, performing environmental impact assessments or estimating the ecological impacts of industrial processes.

Other significant categories of environmental equipment are products for land reclamation and noise reduction. The former is primarily equipment for sanitation, remediation or reclamation of contaminated land as well as for the evacuation, transportation and storage of contaminated soil. Land reclamation techniques include surface sealing, soil washing, stabilization, encapsulation and biological, thermal and chemical treatment. Specific soil enhancement activities include runoff management systems, pit management practices and restructuring by adding wastewater sludge. Products manufactured for noise control are designed to either eliminate the source of noise or to contain or muffle noise. These include integrated encapsulations, acoustic products, soundproofing and buffers for industrial equipment. Auxiliary products are noise measurement instruments, acoustical test chambers and vibration control equipment.

The general environmental services segment is dominated by the large engineering firms which provide technical engineering and construction services, many of which have formed special subsidiaries for the environment (see Table 5). These include Foster Wheeler and Davy Corporation in the United Kingdom; Bechtel, Dames and Moore, and Brown and Root in the United States; and Phillip Holzmann and Preussag in Germany. There are numerous smaller specialist environmental

consultancies such as Huntingdon and Roy Weston in the United States and Robertson Research and Environmental Resources in the United Kingdom. Overall, there are an estimated 12,000 consulting and engineering firms in the US environmental industry, including analytical services firms such as Tech/Ops Landauer, Barringer Laboratories, Compuchem Corp, National Technical Systems and Nytest Environmental. Environmental auditing is a growing area especially in the United States and the United Kingdom; the largest providers of environmental auditing services are Arthur D. Little of the United States and Taylow Woodrow PLC of the United Kingdom. But many smaller firms are also active in the auditing field with a recent UK directory listing 225 consultancies performing environmental audits among their other services; it is estimated that environmental auditing occupies about 5 percent of their time.

Table 5
Major Environmental Services Firms: 1990

Firm	Headquarters	Estimated Environmental Product Turnover (US $mil)
Bechtel	United States	920
Foster Wheeler	United Kingdom	620
Phillip Holzmann	Germany	600
Davy Corporation	United Kingdom	600
Dames and Moore	United States	500
Brown and Root	United States	400
Preussag	Germany	250
Roy Weston	United States	100
Huntingdon International	United States	80
W.S. Atkins	United Kingdom	70
Geraghty and Miller	United States	50
Rintekno	Finland	40

Source: OECD and the Engineering News Record.

2.2 INDUSTRY STRUCTURE

The environmental industry has a dual structure with a small number of large firms accounting for about 50 percent of output in individual market segments and a large number of smaller firms accounting for the remainder. In the major developed countries, surveys show that about half of the environmental industry is composed of small firms employing fewer than 50 people. However, product markets in North America, Europe and Japan are dominated by the presence of a few, large companies who compete on the basis of advanced technologies. The Japanese market is the most highly concentrated as the major suppliers are generally subsidiaries of large diversified firms who are active in several product markets.

Because of the diversity of the environmental market and relatively low barriers to entry, suppliers have found numerous routes of access to the industry. It has proved fertile ground for start-ups and entrepreneurial ventures with smaller environmental firms ranging from high-technology suppliers of chemicals, instruments and consultancy services to low-technology producers of recycling bins and suppliers of waste transportation services. Most small and medium-sized environmental enterprises are specialized, owner-managed and offer a limited range of equipment and services. In total, there are estimated to be some 30,000 such firms in North America, 20,000 in Europe and 9,000 in Japan.

Diversification into production of environmental equipment and services is seen as a growth area by many large developed countries' companies, particularly those in the chemicals, engineering and electronics industries. In the United States, companies such as DuPont, Dow, Westinghouse and Hewlett Packard have established subsidiaries for, respectively, toxic waste management services, plastics recycling, waste processing services and environmental laboratory instrumentation. The German firms Deutsche-Babcock, Robert Bosch and Siemens are among the firms developing new lines of environmental equipment, while BASF, Bayer and Hoechst have formed a venture to develop methods for recycling plastic wastes. In France, major firms such as Alsthom, Fenwick, Saint-Gobain and Ciments Lafarge are estimated to have over 20 percent of their turnover in environmental products. Many of the large chemical companies such as Ciba-Geigy of Switzerland and metals companies such as Metallgesellshaft of Germany are active in the market for water and waste treatment equipment. Japan's leading environmental firms are the large conglomerates Mitsubishi and Hitachi.

Due to its relatively young status, the environmental industry, particularly the waste management sector, is now going through a period of mergers and acquisitions as companies and activities are rationalized in both regional and product markets. Many mergers have been intended to create firms better situated to take advantage of individual product markets and reduce the fragmentation of the industry. The rising expense of waste disposal and stricter environmental standards, has led to consolidation in the waste management sector with large companies absorbing smaller ones and takeovers becoming more common. For example, the British firms Shanks and McEwan, Leigh Interests, Attwoods and Caird have all recently been involved in restructuring of the UK waste sector through mergers and acquisitions. In the UK water treatment sector, both Portals and Biwater are enlarging operations through purchasing other companies. Environmental companies in the United States have been part of the general merger wave as large concerns such as Waste Management and Calgon Carbon have absorbed smaller companies in related fields.

2.3 PRODUCTION AND TRADE TRENDS

2.3.1 Production and Employment Estimates

The OECD countries, led by the United States, Germany and Japan, are the main producers of environmental equipment and services accounting for 90 percent or more of the value of world output (see Table 6). Production statistics are estimated and should be taken only as indicative of the relative size of the environmental industry in different OECD countries. Output of environmental goods and services is included in the standard industrial classification under a variety of sectors, mostly within the industrial machinery, electrical engineering, chemicals and services sectors. Employment statistics are also estimated as environmental industry employees are counted within the labor forces of other industrial sectors. Overall, there are believed to be about 1.7 million employees in the OECD environmental equipment and services industry.

Table 6
Production and Trade of Environmental Technology

Country	Production ($ billion)	Employment (thousands)	Percentage Exported	Trade Balance ($ millions)
United States	80.0	800	10	4,000
Canada	6.0	50	-	-
Europe (total)	68.0	600	20	8,000
Germany	27.0	250	40	10,000
France	12.0	90	14	500
U.K.	9.0	75	17	500
Italy	5.0	40	-	-
Other	15.0	145	-	-
Japan	30.0	200	6	3,000
TOTAL	185.0	1,700	-	26,000

Source: OECD

2.3.2 Trade Profile

Environmental equipment and services are rapidly becoming an international business, dominated by large multinationals in fields ranging from waste

management to catalytic converters. Trade data are limited and only estimates can be made of export shares (the percentage of production exported) and trade balances in the environmental industry for the major OECD countries (see Table 6). Germany, Japan and the United States are the largest exporters of pollution control equipment and other environmental products and maintain large trade surpluses in this sector.

The United States exports an estimated 10 percent of its production of environmental products and is experiencing import penetration in waste treatment and collection systems by European firms and in air pollution control equipment by Japanese and East Asian (Taiwanese, Hong Kong) firms. Although the United States exports about 16 percent of its production of industrial air pollution control equipment, import penetration in this sector has now reached 26 percent of consumption (imports are primarily, low-tech equipment being produced by NICs). Canada, although it has a vibrant and growing environmental products and services industry, is a net importer of environmental equipment mostly from the United States.

Germany leads in trade in environmental products and is believed to be the world's largest exporter, currently exporting about 40 percent of the value of production. Import penetration is less than 5 percent of the market in Germany and is primarily in lower-technology environmental products. German exports are largely of water treatment equipment (an estimated 40 percent) and air pollution abatement products (an estimated 35 percent). About half of exports are to other European countries, with the remainder divided more or less equally among North America, East Europe and the Middle East and Africa. German firms are also exploiting new opportunities in the fast-growing Southeast Asian Market.

Overall, Europe maintains a trade surplus in environmental products with the United Kingdom, France, the Netherlands and Sweden as net exporters in addition to Germany. The United Kingdom, France and the Netherlands export about 14 to 20 percent of production, much of it to non-OECD countries in the Middle East and Africa. However, imports tend to be rising at a faster rate than exports in these countries as manufacturing industries purchase air purification, water and waste treatment systems from German, Japanese, and American companies. Import penetration is now about 14 to 15 percent in France and the United Kingdom and almost 25 percent in the Netherlands. Sweden is a significant exporter of both water and air quality equipment to other OECD countries and maintains a sizable trade surplus in environmental goods. A number of European countries -- Denmark, Finland, Norway, Italy -- are neither significant exporters nor importers of environmental products, having an industry developed enough to be relatively self-sufficient. Other smaller European countries or those with less advanced environmental industries -- Austria, Belgium, Greece, Spain, Portugal -- are not importers of environmental equipment.

Japan has assumed a larger presence in environmental trade due to its advanced pollution control technology. Japan is now believed to export about 6 percent of the value of production of environmental equipment with import penetration remaining below 3 percent of consumption. Japanese firms are large exporters and licensors of air pollution control equipment and are also expanding exports of water treatment technology and waste management products such as refuse furnaces.

A large share of international exchanges in the environmental industry is through technology licensing rather than imports and exports of equipment. Many larger firms develop pollution control technologies for their own operations, increasing returns through licensing the technology to other companies for production and sale or for internal use. For example, the Japanese firms Mitsubishi, Hitachi and Kawasaki license flue gas emission control systems to European and American firms and expect to strengthen their dominance of this market due to expected legislative changes in the United States and the European Community. The US firm General Electric, licenses air pollution control equipment internationally, while Waste Management, Browning-Ferris and Ecova sell waste treatment and incineration technologies under license to foreign firms. The German firms, Thyssen and Passavant, license water and wastewater treatment technologies while Lurgi widely sells its air quality know-how. UK firms such as Biwater and Portals market patented water treatment technologies. Other large recipients of license fees are Ecotechniek (Netherlands) for land remediation technology, Flakt (Sweden) for gas emission control technologies, Von Roll (Switzerland) for waste incineration systems and SGP (Austria) for air pollution control techniques.

In the past few years, the environmental industry has embarked on globalization strategies led by the large multinationals from Europe and the United States. There is an increasing tendency for environmental equipment and service suppliers to enter foreign markets through direct investment, cross-border mergers and acquisitions, joint ventures or collaboration with foreign partners. Waste management is the most internationalized segment of the environmental industry. Attwoods (UK) derives more than 50 percent of its business from its US operations, while the US firms Waste Management and Browning-Ferris have more than 20 percent of their turnover in Europe and continue to expand overseas facilities. Similarly, Lyonnaise des Eaux (France) and Edelhoff (Germany) derive 15 to 20 percent of turnover from their foreign operations, mostly in West and East European countries. In other sectors, the swedish firms Flakt (air) and Alfa Laval (water) are truly international with production and employees spread over many countries; Flakt now has more than 21,000 employees in 33 countries with 75 percent of turnover from foreign operations. Environmental services, particularly auditing and consulting, are also becoming more international; firms such as Arthur D. Little (US) have large European divisions serving mostly European subsidiaries of American firms.

Global acquisition strategies, intended to internationalize operations and provide entry to foreign markets, have been demonstrated by American waste management firms such as International Technology and Browning-Ferris which have purchased smaller European firms in Spain and Italy. Asea Brown Boveri (Switzerland) has acquired Combustion Engineering, the largest US manufacturer of scrubbers for air quality control. The UK firm Foster Wheeler, one of the largest engineering firms involved in the environmental sector, is now acquiring US contracting firms including Barsotti. Groundwater Technology and Ecova have expanded into Europe via joint ventures with EVT GmbH of Germany and Italimpresse of Italy. Other examples of international joint ventures are those between Waste Management and Edelhoff to develop waste collection systems, Lyonnaise des Eaux and Cockerill Sambre of Belgium in waste management, and ENSR (US) and Taylor Woodrow (UK) in environmental consulting. Several Japanese suppliers have established joint ventures with European firms partly to gain a foothold in the European air and water equipment markets (e.g. Nissan-Groller, Eban-Infilco, Hitachi-Babcock). The need to exploit the global market has led some firms to enter into collaboration agreements for production, marketing or distribution with foreign counterparts (Biffa, Saarberg Holter).

2.4 INDUSTRY COMPETITIVENESS

It is generally those countries with comprehensive environmental policies and well-developed regulations and standards which have the most competitive environmental industries. The more advanced technologies (advanced tertiary water treatment, flue gas desulfurization and biological land remediation methods) have been developed either by suppliers in countries with a history of stringent environmental legislation (the United States, Germany) and/or by suppliers responding to specific legislative initiatives (Japan, the Netherlands). Thus Japanese firms are generally placed at the forefront of air pollution control equipment and technology and have developed denitrification equipment and processes for desulfurizing heavy oil. German firms lead in many advanced water treatment technologies, while American firms are especially competitive in hazardous waste technology (plasma incineration techniques) and in biotechnology. Other European countries have firms which are competitive in certain product niches, such as the Netherlands in soil remediation technology and Switzerland in specific waste and water pollution control techniques.

In addition to the direct correlation with the content of environmental legislation, several other critical factors have been identified as being important to competitiveness in the environmental industry (see Table 7). The environmental market is increasingly technology-driven indicating that suppliers must make continuing large research and development expenditures. The large multinational environmental companies are most R&D intensive, spending 8 to 10 percent of turnover on research, while smaller firms in lower-technology environmental

sectors may spend less than 2 percent of turnover on research and development. German and US firms have been leaders in basic research on environmental technologies, while Japanese firms have conducted relatively less research to date and have even developed some air pollution control technologies based on German patents. Continuing R&D to resolve technical problems in waste handling and combustion and water treatment have led to US, German, Swiss and Swedish companies being most competitive in these sectors. Related to basic research strength is the capability to integrate environmental technologies into total productive systems, where U.S. and German firms excel owing to their strength in systems engineering.

Labor and materials constitute the major cost in the production of environmental equipment. For example, the costs of materials may be 50-55 percent for a sizable flue gas desulfurization system. Steel is the major materials cost. Over the last decade, domestic steel prices have placed U.S. pollution control producers at a competitive disadvantage compared with their foreign competitors (see Table 8).

Hourly labor costs in Japan, the United Kingdom, Korea, and Taiwan have been consistently less than in the United States while those in Germany, Sweden, and Denmark have at times surpassed the United States (Table 9). Because low-tech pollution control equipment is even more material and labor intensive, NICs have now been able to make in-roads into traditionally developed nations markets.

Table 7
Competitive Factors in the Environmental Industry

Factors Contributing to Competitiveness	United States	Germany	Japan
Environmental Legislation	High	High	High
Basic Research	High	High	Low
Integrated Technology	Medium	High	Medium
Global Marketing	Low	Medium	High
Price Competitiveness	Medium	Medium	High
Venture Capital	High	Low	Medium

Source: Helmut Kaiser, OECD.

Table 8
Prices for Carbon Steel and Plate
(dollars per metric ton)

YEAR	COMPOSITE			PLATE		
	U.S.	JAPAN	W.GERM	U.S.	JAPAN	W.GERM
1980	503	425	502	461	380	419
1983	586	437	421	566	398	375
1986	572	527	514	444	533	472
1987	587	557	607	470	614	570
1988	656	578	598	587	615	541
1990	649	567	595	579	603	539

Source: Paine Webber, World Steel Dynamics, Steel Strategist, #16, December 1989.

Table 9
Hourly Compensation Costs for Production Workers
(dollars)

YEAR	U.S.	JAPAN	W.GERM	U.K.	SWEDEN	DENMARK	KOREA	TAIWAN
1980	9.84	5.61	12.33	7.43	12.51	10.95	1.03	1.00
1985	12.96	6.43	9.56	6.19	9.66	8.13	1.35	1.50
1987	13.40	10.83	16.91	8.97	15.12	14.56	1.78	2.26
1988	13.85	12.80	18.11	10.46	16.82	15.86	2.50	2.82
1989	14.31	12.63	17.58	10.44	17.52	15.16	3.57	3.53

Source: U.S. Department of Labor, October 1990, Report #794

Global marketing ability also plays a role in the competitiveness of environmental firms, with Japanese firms enjoying the most success in the marketing and pricing of products and now increasing their presence in many global markets. Although in the past small specialized companies have operated successfully in niche markets, the ongoing concentration of the industry will yield conglomerate firms with more general marketing experience and the ability to offer a wider range of products. Diversified suppliers, such as the large Japanese companies, are favorably situated to sell environmental products to existing clients in related markets such as process plant, power generation and heavy engineering and to

offer comprehensive service packages, including equipment supply, design, installation and after-sales service.

Smaller firms may need to review their marketing strategies, including possible increased emphasis on product promotion through trade fairs and trade associations. International industrial trade fairs are held for several environmental product areas, such as the Enprotech and Water and Waste Treatment Fairs in the United Kingdom; Envitech and Aquatech in Germany; and the American Water Works Association Fair in the United States. Organizations or trade associations representing environmental products have been an important stimulus to the industry in countries such as Germany, the Netherlands and Denmark, but in most countries, associations are fragmented with no clear focal point for the industry through which marketing or government initiatives could be undertaken.

The small size of many suppliers in the environmental industry means that venture capital or external financing is crucial to entering the market. Access to financial resources or support for development and demonstration activities is important to the overall competitiveness of environmental products and service suppliers in most countries. In this respect, European firms have been at more of a disadvantage than US or Japanese companies. In the United States, environmentally-related start-ups are estimated to have attracted more than $100 million in venture capital in 1989-1990. Examples of these smaller environmental industry entrants are Galson Remedial, which sells chemical treatment technology; In-Process Technologies, which sells industrial waste-processing systems; Groundwater Technology Inc., which sells groundwater treatment equipment; and Tetra Technologies Inc., which provides recycling and waste treatment products.

2.5 STRATEGIC SECTOR POLICIES

The environmental industry is a relatively new sector, characterized by fragmented markets, high research and start-up costs and limited coordination. Yet it is a sector whose technology and products are important to improving performance in many industries, enhancing national trade balances and preserving the world's environment. This raises the issue of the role of governments in regard to the environmental sectors and the appropriate areas for instituting government programs and/or policies. Internal debates regarding new environmental policies and regulations often consider the availability of technology to meet legislative aims, but not the capability of the national industrial base to deliver this technology and the effects on trade balances. Countries which lag behind in developing environmental products and services may find themselves with substantial trade deficits in this area or a lower quality of environment. Governments which view the environmental industry in more strategic terms may be better placed to realize the ecological and economic benefits of a competitive environmental sector.

There are still relatively few examples of government initiatives to assist the environmental industry in comparison to schemes for other industrial sectors such as electronics and aerospace. However, programs are now emerging in the OECD countries. Some governments are undertaking economic evaluations of markets for environmental products and services and attempting to provide commercial and market information to their environmental sectors. These studies have generally sought to evaluate the scope of domestic and world environmental markets and to identify opportunities and areas of weakness in the indigenous supply base. Other governments are initiating technology development or financial support schemes aimed specifically at expanding the environmental industry and its export potential.

The best U.S. example of government/industry cooperation to date may be George Bush's recently announced U.S. - Asian Environmental Partnership (AEP). The U.S. Government will establish and develop an environmental partnership with over 25 Asian nations that will draw heavily upon American environmental expertise and technology. This effort will be coordinated by the President's Trade Promotion Coordinating Committee (TPPC). The TPPC, chaired by the Secretary of Commerce, consists of 18 government agencies and is responsible for integrating and streamlining trade promotion activities. The program will foster technology transfers; financing of environmental and energy infrastructure projects; conduct fellowships and training; and create a Regional Biodiversity Conservation Network.

The German government has a policy of giving project grants to companies in the environmental industry when the technical risks of developing a specific product or technology are too great, when the structure of the company or business (as in the case of smaller firms) will not allow for costly R&D projects or when specific solutions are required to identified environmental problems. The German government has also been active in commissioning consultant studies of the market potential for specific segments of the environmental industry and in funding technology development programs in the areas of waste management, air quality maintenance and protection of water resources and supply. Through a coordinated policy and continuing program support, the government has contributed to the leading position of its environmental firms in the world market.

In one of the more ambitious efforts, Canada launched an Environmental Industries Sector Initiative in 1989 to formulate an industrial development strategy for the environmental industry. The first three-year phase is aimed at evaluating the industry's economic characteristics and structure, the markets for environmental products and services and the critical science and technologies necessary for Canadian companies to be internationally competitive. The second phase will develop a set of coordinated activities to enhance the performance and international competitiveness of the Canadian environmental industry.

Norway declared environmental technology to be a national priority area in trade and industry in 1989. The objective is to make Norway internationally competitive in environmental products, processes and services, specifically environmental technologies for aquaculture, oil and gas processing and metals refining. Norway is also concentrating efforts on the development of integrated monitoring systems for air, water, terrestrial ecosystems and oceans. During 1989, 30 pilot projects were initiated under the Royal Norwegian Council for Scientific and Industrial Research (NTNF) with funding from both the Ministry of Environment and Ministry of Industry.

The Nordic Council of Ministers (which includes Norway, Sweden, Finland, Denmark and Iceland) is providing grants through the Nordic Fund for Technology and Industrial Development to develop environmental technologies which have export potential. The 4-year program on Industrial Environmental Technology was initiated in 1989 and is emphasizing environmental techniques relating to advanced materials, including electroplating, semiconductor materials, packaging, recyclable composites and wood conservation.

Japan has launched an environmental technology development scheme as part of the New Earth 21 Program which will promote the development and transfer of innovative technologies to address global environmental problems. MITI has established a new research and development center, the Research Institute of Innovative Technology for the Earth (RITE), to coordinate research on environmentally-oriented industrial and energy technologies.

The environmental industry could possibly be considered a strategic sector -- a sector whose development is important not only in terms of its own contribution to national economic growth but also in regard to its effects on the competitiveness of other industrial sectors. The growing significance of the environmental industry in manufacturing production and exports in some OECD countries coupled with projections of expanding markets foreshadows its potential contributions to economic growth and trade balances. In providing environmental equipment and services to a variety of industrial sectors, the environmental industry is also key to the competitive performance of firms in the chemicals, utilities, pulp and paper and oil refining industries as well as in higher-technology sectors such as electronics and advanced materials.

Strategic sector considerations may warrant greater government attention to the environmental industry and prompt initiatives such as market information programs, schemes in support of small and medium-sized enterprises or focused research and development assistance for environmental firms. It is generally agreed that subsidies to specific industries and other government support measures may increase economic inefficiencies and distort international trade flows. However, attempts to classify subsidies (in both the GATT and the OECD)

according to their relative acceptability indicate that public support for research and development and for environmental protection are among the types of government subsidies which are relatively more beneficial in economic terms and less actionable in terms of trade countermeasures. Despite the sector's ecological and economic contributions at both the national and international levels, extensive strategic sector supports to the environmental industry could eventually contribute to trade frictions. OECD governments may want to review the costs and benefits of different types of environmental industry supports within the context of the potential economic and trade consequences at the global level.

3.0 ASEAN BACKGROUND ENVIRONMENTAL DATA

3.1 BACKGROUND

Exceptionally high growth rates in the ASEAN countries have established it as one of the fastest growing regions in the world (see Table 10). Originally major suppliers of key raw materials such as rubber, metals, and petroleum to industrialized nations, the last decade has seen ASEAN members diversify into a broad range of manufactured goods, including textiles, petroleum refining, plastics, chemicals, leather tanning, cement, electronics, and consumer goods. Today, manufacturing accounts for more than 25% of the GDP of these countries (excluding Brunei). This growth is principally due to the countries' favorable investment climates (low wage rates, abundant natural resources, and historically low levels of regulation - including environmental). There has been significant transplantation of these industries from Newly Industrialized Countries (NICs) such as Taiwan, Hong Kong, and South Korea, as increased wage rates and environmental regulations have accompanied the NICs new-found prosperity.

Table 10
Economic Development Patterns in Asean Countries

COUNTRY	GNP/CAPITA (1990 $s)	AVERAGE GDP GROWTH % 1980-1989	ANNUAL GROWTH RATE %, 1990	URBAN AREA % OF TOTAL GDP
Brunei	17,000	n.a.	4.5	n.a.
Indonesia	555	5.7	7.0	37
Malaysia	2,305	5.7	9.4	37
Philippines	727	2.0	3.1	53
Singapore	11,575	7.3	9.2	100
Thailand	1,418	7.3	10.0	41

Source: USAID, EIP Project Paper, 01/23/92

Because the economic growth has been accompanied by a shift from an agricultural based economy to an industrial one, the already overburdened population centers such as Bangkok, Jakarta, and Manila are being stretched to levels that pose serious resident health risks (Table 11). The lack of proper infrastructure such as wastewater treatment, solid and hazardous waste disposal, and air pollution control have reached the critical stage. The resultant air, water, and soil contamination restrict both the quality of life and the continued expansion of the industrial sector.

3.2 WATER POLLUTION

Urban water quality is the primary environmental concern in ASEAN countries. Although improvements are anticipated to begin within the next five years, only minor percentages of ASEAN urban populations have access to safe drinking water

Table 11
Urbanization Trends in ASEAN Countries

Country	Total Pop. (millions)	Annual Pop. Growth (%) 1985-1990	Urban Share of Total Pop. in 1990 (%)	Urban Share (%) of Total in 1990	Urban Pop. (%) Below Poverty Level
Brunei	0.27	n.a.	3.4	57.7	n.a.
Indonesia	180.51	1.6	4.2	28.8	26.0
Malaysia	17.34	2.3	4.3	42.3	12.6
Philippines	62.41	2.5	3.8	42.4	32.0
Singapore	2.70	1.1	1.1	100.0	n.a.
Thailand	55.70	1.5	4.2	22.6	15.0

Source: UNESCAP, State of the Environment in Asia and the Pacific, 1990

and sewage treatment facilities. Environmental legislation developed in the ASEAN nations has been difficult for leaders to enforce when they have been principally concerned with economic growth (Table 12). Singapore is the only ASEAN nation that currently treats city sewage and stormwater prior to their release into the sea. Open storm drains are used by the other five ASEAN countries for both household sewage and waste disposal and small scale industry. These drains feed into river systems or directly into the sea.

Table 12
Status of Pollution Prevention Legislation in the ASEAN Countries

Country	Water Pollution	Air Pollution	Hazardous Waste
Brunei	moderate	moderate	minimal
Indonesia	minimal	minimal	moderate
Malaysia	moderate	moderate	moderate
Philippines	moderate	moderate	moderate
Singapore	extensive	extensive	extensive
Thailand	minimal	minimal	modr rate

Source: UNESCAP. State of the Environment in Asia and the Pacific 1990

Industrial waste water is a major contributor to the poor water quality. In Indonesia, for example, industry is responsible for 50% of the pollution load. In Malaysia, most larger factories located on industrial estates have some form of waste water treatment facilities and seek compliance with discharge limits. However, industries located in municipalities are allowed to discharge in excess of limits under the pretext that they will eventually be connected to the sewerage facility. In Manilla, over 300 industrial plants dump an estimated 11 million gallons per year of untreated or partially treated industrial effluent into the Pasig River. In Thailand, all polluting factories must install suitable treatment facilities in order to obtain their annual operating permit. However, in the Philippines, Malaysia, Indonesia and Thailand smaller factories do not have access to treatment facilities due to lack of funds, space, or both.

Urban migration has also placed a disproportionate burden on the major ASEAN cities, increasing the number of poor residents without sewer connections or adequate household waste disposal. These infrastructure shortages are leading to severe health problems and aggravating issues of social inequities.

3.3 AIR POLLUTION

Industrial activities, along with fossil fuel combustion for power generation and transportation, are the major sources of air pollutants in ASEAN. The transportation sector contributes the most to carbon monoxide and hydrocarbon emissions, power generation to particulate and sulfur dioxide emission, while remaining industries contribute significantly to both of these sets as well as additional pollutants (including lead, cadmium, mercury, beryllium, mercaptan, hydrogen sulfide, fluorides, chlorine, asbestos, and many other wastes and by-products of industrial processes). This problem is exasperated by the fact that most industry is concentrated in urban areas. For example, 60% of the Philippines manufacturing firms are located in Metro Manilla.

Emissions standards for both stationary and point sources have been implemented in all of the ASEAN countries, but only Singapore has shown any noticeable improvement in air quality. Industry-specific standards that set concentration limits for individual contaminants are vague or absent completely and have not been enforced historically.

3.4 HAZARDOUS WASTE

The most alarming feature of the region's hazardous waste issue could be the projected growth rate of both the quantities and types of material that will be generated and improperly disposed. Industries that generate large quantities of hazardous waste have historically gravitated toward nations with less stringent environmental regulations. Because the ASEAN nations are export-oriented, rapidly

industrializing countries, they are likely to continue to attract pollution-intensive industries for the remainder of this decade.

Singapore is the only ASEAN nation where large companies have in-house treatment or recovery facilities. Few treatment/disposal facilities currently exist in Thailand, or Indonesia. None exist in Malaysia or the Philippines. Storage of waste in anticipation of future facilities is reaching critical proportions, while illegal dumping remains rampant throughout the ASEAN countries (EIP Project Paper, 1992).

Comprehensive regional data on the amounts and characteristics of industrial hazardous wastes are not currently available. In Java, Indonesia, only 202 of a potential total of 425,000 firms have been clearly identified as hazardous waste generators. By comparison, in Singapore, 2,188 firms generated over 28,000 tons of hazardous waste in 1985 alone. Industries in Thailand have produced over one million tons of hazardous waste to date.

3.5 SOLID WASTE

The ASEAN nations have differing solid waste problems due to their varying economic status, available land, and population densities. Singapore's laws involving the disposal of trash ranks among the world's most stringent and are strictly enforced. However, solid waste regulations and their enforcement in the remainder of the ASEAN nations tend to be minimal at best. In Jakarta, 30% of solid wastes are dumped into canals, rivers, and roads. In Bangkok, approximately 50% is dumped into canals or is left in-place to decompose. In Metro Manilla, 70% of the total of 2,650 tons per day is disposed in nine open dump sites. The remaining 30% is either recycled, burned, scavenged, falls into sewers, or is left to decompose.

Where solid wastes were once mostly domestic, exponential contributory growth is now being realized by industry (including hospitals) as well. These wastes pose additional problems such as non-degradability (plastics) and acute potential health risks.

4.0 KEY MARKETING CONSIDERATIONS

Although the leaders of the ASEAN states have in recent history foregone environmental considerations to ensure rapid economic growth, their marketplace is anticipated to become a major consumer of environmental technology over the next five years. The economic growth has not only increased the amount and concentration of pollution, but indirectly has educated the people of these countries to understand the dangers of these policies. Projects financed by international financial agencies have begun to require adequate consideration of environmental impacts. World organizations, such as the United Nations and the World Wildlife Federation have had success in sending the message that environmental resources are finite and must be managed accordingly. The leaders of the ASEAN countries have responded by developing and implementing both national and regional environmental accords.

4.1 KEY ASEAN MARKET FINDINGS

The 1991 U.S.- ASEAN Council for Business and Technology publication on ASEAN environmental markets highlighted the following key market findings:

1. ASEAN environmental markets are viewed as "emerging". Growth in foreign and domestic investments in pollution-intensive industries, which are fueling ASEANS's booming economies, will continue into the next century. Pressure from domestic and international public interest groups, international organizations and citizens directly affected by water pollution, deforestation and other forms of environmental degradation will require shifts in policies and budget priorities in coming years in favor of environmental upgrades.

   Increases in education and per capita incomes will also bring demands for improvements in quality of life. Rising expectations will pressure governments toward public works infrastructure development and also engender support for the current global trend in favor of "the polluter pays principal", placing the burden for environmental quality on the polluter rather than the general public.

2. Enforcement efforts are increasing. These trends are both a general sign of "political will" behind environmental improvements and an indication of near-term opportunities. Indonesia's crackdown on industrial effluent, for example, has created a potentially very large market for monitoring and testing equipment as well as pollution abatement equipment for targeted industries(i.e., textiles and chemicals).

   Increases in enforcement also require commitments for developing institutional resources, namely staff training and decision support

capabilities. For service firms, environmental training and seminars will be "in vogue" over the next five years and are one means of acquainting oneself with markets and potential partners/clients. Demand for sophisticated modeling and decision support (computer) systems are likely to be relatively low for the near-term due to cost. However, assistance related to sampling, testing and related analysis will be critical for government agencies and for new domestic environmental firms and laboratories.

3. Of primary importance throughout the entire region is training. This includes management training of personnel responsible for leading government and industry environmental efforts and technical training of environmental analysts, technicians and scientists. To date, lack of competently trained personnel in areas of environmental management, monitoring, evaluation, etc. has been a major hinderance to effective design and implementation of environmental regulations. On-the-job training, seminars and teaming between domestic environmental firms and foreign companies - emphasizing technology transfer - will be crucial over coming years.

4. Demand for environmental products and services in the 1990's will be predominantly from ASEAN governments and select polluting industries. As education and income levels improve, demand for consumer-oriented environmental products will pick up - especially in Singapore and certain urban areas - but ASEAN will not experience high levels of consumer demand for these products (similar to those in the West) until the late 1990's (see Table 13).

5. Financing constraints will ease at the national-level as environmental priorities gain against competing demands for limited development monies. Increased burden on the private sector to control pollution at-the-source will open-up new opportunities involving industrial pollution abatement equipment. While increased financing for these upgrades should be forthcoming from government and IFIs, U.S. companies must be prepared to develop their own financing packages - especially for big ticket items.

6. Personal relationships are the key to success. U.S. firms partnering in the initial stages of the ASEAN markets will receive greater payback as the markets mature. The pace with which these environmental markets are developing requires that relationships be cultivated now to address opportunities in the near-term.

7. While ASEAN environmental markets have yet to mature, positioning your firm today will be key to receiving contracts and orders two to five years from now. Western products are still associated with quality

and value. However, name recognition is very important in ASEAN. Companies will find selling directly in ASEAN, without adequate in-country or regional representatives, is difficult at best.

Potential investors and traders must consider setting up representational offices to learn the market and product requirements prior to investing large sums. In some urban sites, especially Singapore, there are professionals who routinely represent multiple firms. While such relationships are unlikely to result in big payoffs for your firm, they are viewed by many companies as an inexpensive first-step toward positioning companies/products in the region or in a particular country.

8. For firms specializing in "pollution prevention", trends in enforcement and investment indicate new opportunities for modernizing industrial processes and practices. ASEAN governments are emphasizing prevention as the favored means of controlling pollution from new industrial investments. Projects financed through international financial institution (IFI) grants or loans now require environmental assessments. Designs must also incorporate best available technology and waste minimization strategies. Planned power generation projects throughout the region must adhere to these requirements.

4.2 NATIONAL ACTIVITIES ENHANCING ASEAN MARKETING OPPORTUNITIES

Some of the activities occurring in the ASEAN nations that could bolster environmental technology marketing opportunities for U.S. industry include (source US/ASEAN,1991):

INDONESIA

o Recent deregulation/de-bureaucratization has enhanced investment and operating climates (increased environmental enforcement viewed as "leveling the playing field").
o New EPA created in 1990 supporting requirements for Environmental Impact Statements (EISs) and Indonesia's innovative Prokasih Program.
o Extensive IFI investments in environmental upgrades and training.

MALAYSIA

o Government acknowledges major investments needed for:
  -Hazardous and toxic waste Treatment/Storage/Disposal (TSD) facilities
  -Municipal and industrial waste water treatment plants
o Key issues: 1) role of national vs. municipal government in financing/regulation, and 2) role of private sector.

PHILIPPINES

o Philippines Strategy for Sustainable Development (PSSD) viewed as model of region.
o Department of Energy and Natural Resources (DENR) flexes muscles backed by growing public support.
o Major U.S. corporate presence represents near-term market (economic/budgetary constraints to limit government projects).

SINGAPORE

o Key site for multi-national corporations' regional headquarters.
o ASEAN's regional center in the environmental sector, 1/2 of US environmental exports.
  -Pollution Control Department (PCD) actively recruiting participation of foreign environmental firms
  -Technologies/services tailored to meet unique ASEAN needs

THAILAND

o Environment heralded as cornerstone of Sixth National Plan
  -Increased domestic investments supplemented by international financial institutions
  -$230M slated for government funded waste water treatment facilities
  -$700M targeted for private waste collection/treatment operations
  -$44M in USAID funding
o Purchases of US environmental products almost tripled in 1990 with continued growth anticipated.
o Energy conservation and clean coal technologies targeted.

Table 13
Trade and Investment Picks (Next 1-3 Years)

Indonesia	Malaysia	Philippines	Singapore	Thailand
Industrial effluent	Hazardous Waste Treatment and Disposal	Industrial Effluent	Hazardous Waste Treatment and Disposal	Hazardous Waste Treatment and Disposal
Water Treatment	Municipal Waste		Solid Waste Disposal	Industrial Effluent
EIS Services	Training		Consulting Services	Municipal Waste Disposal
	Air Quality Monitoring		Emissions Control	Solid Waste Disposal
	Waste Water Treatment		CFC Alternatives & Disposal	Training
Trade & Investment Picks (Next 3-6 Years)				
Emission Control	Industrial Effluent	Municipal Waste	Consumer Products	Emissions Control
Hazardous Waste Treatment and Disposal	CFC Alternatives & Disposal	Hazardous Waste Treatment and Disposal	Recycling	Consulting Services
Municipal Waste	Auto Pollution	Training		Clean Coal
Clean Coal				

Source: US ASEAN, 1991

APPENDIX 1
Points of Contact

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EPA
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EPA
Assistant Administrator for Research & Development
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EPA
Office of Modeling, Monitoring Systems
and Quality Assurance
(202) 382-5767

EPA
Office of Research & Development
Center for Environmental Research Information
26 West Martin Luther King Drive
Cincinnati, OH
Contact: Dennis Lussier
(513) 569-7354

EPA
Office of Research Program Management,
Center for Environmental Research Information
Cincinnati, OH
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United Nations Environmental Program
Regional Office - Asia in the Pacific
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US Department of Commerce
International Trade Administration
Washington, DC 20230
Contact: Joseph Harrison
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US Department of Commerce
National Satellite Data & Environmental Information Service
Washington, DC
(202) 606-4594

US Department of State
Bureau of Oceans & International Environmental
and Scientific Affairs
2201 C Street NW
Washington, DC 20520
(202) 647-1555

II. Private Associations

Air & Waste Management Association
Pittsburgh, PA
(412) 232-3444

American Academy of Environmental Engineers
Annapolis, MD
Contact: Bill Anderson
(301) 266-3311

American Chemical Society
Washington, DC
(202) 872-4600

American Institute of Chemical Engineers
New York, NY
(212) 705-7338

American Institute of Chemists
Bethesda, MD
(301) 652-2447

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American Meteorological Association
Boston, MA
(617) 227-2425

American Petroleum Institute
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(202) 682-8000

American Public Power Association
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American Society of Civil Engineers
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American Society of Safety Engineering
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American Society of Sanitary Engineers
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American Water Resources Association
Bethesda, MD
(301) 493-8600

Applied Biotreatment Association
Washington, DC
(202) 546-2345

Asbestos Information Association/North America
Arlington, VA
(703) 979-1150

Association of American Pesticide Control Officials
Hardwick, VT
(802) 472-6956

Association of Environmental Consulting Firms
Chicago, IL
(312) 321-3320

Association of Petroleum Re-finers
Buffalo, NY
(716) 855-2757

Association of Groundwater Scientists and Engineers
Dublin, OH
(614) 761-1711

Association of Local Air Pollution Control Officials
Washington, DC
(202) 624-7864

Association of State and Territorial Solid Waste Management Officials
Washington, DC
(202) 624-5828

Automotive Dismantlers and Recyclers Association
Fairfax, VA
(703) 385-1001

Center for Environmental Information, Inc.
Rochester, NY
(716) 271-3550

Center for Plastics Recycling Research
Piscataway, NJ
(908) 932-4402

Chemical Manufacturers Association
Washington, DC
(202) 887-1100

Chemical Producers and Distributors Association
Washington, DC
(202) 785-2732

Chemical Waste Transportation Council
Washington, DC
(202) 659-4613

Coalition on Superfund
Washington, DC
(202) 393-4760

Council on Plastics and Packaging in the Environment
Washington, DC
(202) 331-0099

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Conservation Foundation
Washington, DC
(202) 293-4800

Electronic Industries Association
Washington, DC
(202) 457-4900

Environmental Defense Fund
New York, NY
(212) 686-4191

Environmental Federation of America
Washington, DC
(202) 537-7100

Environmental Hazards Management Institute
Durham, NH
(603) 868-5150

Environmental Studies Institute
Santa Barbara, CA
(805) 965-5010

Greenpeace USA
Washington, DC
(202) 462-1177

Hazardous Materials Advisory Council
Washington, DC
(202) 728-1460

Hazardous Materials Control Research Institute
Greenbelt, MD
(301) 982-9500

Hazardous Waste Treatment Council
Washington, DC
(202) 783-0870

Industrial Safety Equipment Association
Arlington, Va
(703) 525-1695

Institute of Environmental Sciences
Mt. Prospect, IL
(708) 255-1561

International Association of Environmental Testing Laboratories
Arlington, VA
(703) 524-2427

International Bio-Environmental Foundation
Sherman Oaks, CA
(818) 882-7128

International Hazardous Materials Association
Salt Lake City, UT
(801) 466-3500

International Sanitary Supply Association
Lincolnwood, IL
(708) 982-0800

Manufacturers of Emission Controls Association
Washington, DC
(202) 296-4797

National Academy of Sciences
Washington, DC
(202) 334-2000

National Air Toxics Information Clearinghouse
Research Triangle Park, NC
(919) 541-0850

National Asbestos Council
Atlanta, GA
(404) 633-2622

National Association of Corrosion Engineers
Houston, TX
(713) 492-0535

National Association of Environmental Management
Washington, DC
(202) 966-0019

National Association of Professional Environmental Communicators
Chicago, IL
(312) 321-3785

National Association of Chemical Recyclers
Washington, DC
(202) 463-6956

National Audobon Society
New York, NY
(212) 832-3200

National Coal Association
Washington, DC
(202) 463-2625

National Council for Solid Waste Solutions
Washington, DC
(202) 371-5319

National Council of the Paper Industry for Air and Stream Improvements
New York, NY
(212) 532-9000

National Council on Radiation Protection Measurements
Bethesda, MD
(301) 657-2652

National Environmental Development Association
Washington, DC
(202) 638-1230

National Environmental Training Association
Scottsdale, AZ
(602) 956-6099

National Lead Abatement Council
Princeton, NJ
(609) 520-1133

National Paint and Coating Association
Washington, DC
(202) 462-6272

National Safety Council
Chicago, IL
(312) 526-4800

National Recycling Coalition, Inc.
Washington, DC
(202) 625-6406

National Solid Waste Management Association
Washington, DC
(202) 659-4613

National Water Well Association
Dublin, OH
(614) 761-1711

National Wildlife Federation
Washington, DC
(202) 797-6800

Natural Resources Defense Council
New York, NY
(212) 727-2700

NETAC (Database)
National Environmental Technology Applications Corporation
Pittsburgh, PA
(412) 826-5511

North American Association for Environmental Education
Troy, OH
(513) 698-6493

Plastics Recycling Foundation Inc.
Kennett Square, PA
(215) 444-0659

Sierra Club
San Francisco, CA
(415) 776-2211

Society of Manufacturing Engineers
Dearborn, MI
(313) 271-1500

Technical Association of the Pulp & Paper Industry
Atlanta, GA
(404) 446-1400

The Economist Intelligence Unit
Business International Corporation
215 Park Avenue South
New York, NY 10003
(212) 460-0671

The Environmental Business
Association
Washington, DC
(202) 966-0006

The Freedonia Group
Environmental Technology Database
Cleveland, OH
(216) 921-6800

Water Environment Federation
Alexandria,VA
(703) 684-2400

World Environment Center, Inc.
New York, NY
(212) 683-4700

World Wildlife Fund
Washington, DC
(202) 293-4800

APPENDIX 2
PROJECT DESCRIPTIONS

July 25, 1991

OTA PROJECT DESCRIPTION:

AMERICAN INDUSTRY AND THE ENVIRONMENT:
IMPLICATIONS FOR TRADE AND U.S. COMPETITIVENESS

PROJECT DESCRIPTION: Industry throughout the world increasingly must take into account environmental issues such as ozone depletion and climate change. U.S. industry will face increasing environmental pressures, but also new opportunities, with different sectors affected differently. The challenge for American firms and the U.S. government will be to resolve the need for environmentally sound practices with the need to stay competitive internationally. The study will assess several issues, including:

-- How do environmental issues, trade and competitiveness concerns interact in the international arena? OTA will examine possible difficulties for U.S. industry in competing with firms in countries that have different environmental standards or that provide their firms more government help (e.g., technical assistance, financial incentives). The study will also discuss the changing institutional context facing policymakers. Among the questions they confront: how to address environmental concerns in bilateral or multilateral trade negotiations (e.g., Mexican trade, the GATT), and how to address trade and competitiveness issues in new environmental treaties or agreements. In addition, transfer of environmental technologies is emerging as a key concern as the United Nations and other bodies focus on environment and development relationships among industrialized and developing economies.

-- How can American business and the U.S. economy benefit from the rapidly growing global interest in controlling emissions, treating wastes and preventing pollution? The market for environmental technologies, products and services could grow to $300 billion per year by the end of this decade, reflecting heightened global environmental priorities. The study will assess whether American firms are well positioned to take advantage of these opportunities which are being aggressively pursued by Japanese and European firms. It will also examine the current and potential role of U.S. government to assist in the development of a strong "environment industry" through programs such as export promotion, foreign assistance, and research and development.

CONGRESSIONAL INTEREST: Environment/ trade/ manufacturing industry competitiveness issues surface often (e.g., the debate about fast track consideration of a North American free trade agreement, the debate in the last Congress on the Clean Air Act, etc.). Several bills on environment and trade issues have been introduced in recent Congresses.

RELATED WORK: CBO has done work on environmental regulations and economic efficiency in the past, but has nothing underway at this time. CRS plans workshops on some issues to be addressed by the UN Conference on the Environment and Development. GAO has work underway on compliance with international environmental agreements and on environmental issues related to a Mexican free trade agreement.

REQUESTERS: House Committee on Foreign Affairs, and House Energy and Commerce, and the Senate Committee on Finance.

SCHEDULE: The assessment would begin in late July 1991, and would be completed in the late Spring of 1993. An interim product is expected in the late spring of 1992; another interim deliverable is scheduled for January, 1993.

OTA STAFF CONTACTS: Wendell Fletcher, Project Director (228-6352), and Audrey Buyrn, Manager, Industry, Technology and Employment Program (228-6348).

WASTECH

A Cooperative Program Advancing the Use of Innovative Waste Treatment Technologies

130 Holiday Court, Suite 100
Annapolis, Maryland 21401
410 269 3311
FAX 410 266-7653

PROJECT PROFILE

WASTECH '92 is a cooperative project conducted by and for engineers and scientists and for the user community. The project seeks to further the application of innovative waste treatment technologies whose development is sufficiently advanced to warrant use. To this end, Project participants, technical and professional societies, individual engineers and scientists, and the waste management community at large will develop consensus-based monographs identifying the benefits, limitations, design criteria, and relative economic viability of selected innovative technologies.

Organization

The Project originated primarily from the substantial expenditures USEPA has made and continues to make to develop innovative methods for remediation of hazardous waste sites and contaminated soils and groundwater. The agency believes that several technologies offer improved performance and cost savings over traditional methods. To help foster use of these technologies, WASTECH '92 will develop eight authoritative, consensus-based monographs in the following general areas:

Bioremediation
Chemical Destruction
Chemical Extraction
Soil Washing/Flushing
Solidification/Stabilization
Thermal Desorption
Thermal Destruction
Vacuum/Vapor Extraction

This project is funded by the United States Environmental Protection Agency, Department of Defense, and Department of Energy and is being managed by the American Academy of Environmental Engineers operating under the direction of a Steering Committee chaired by Frederick G. Pohland, Ph.D., P.E., DEE, President-Elect of the Academy. The Steering Committee is composed of nationally recognized waste treatment experts who are also leaders in professional societies and associations with a strong professional interest in waste management including the Air and Waste Management Association, American Institute of Chemical Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers, Hazardous Waste Action Coalition, National Water Well Association, Society for Industrial Microbiology, and Water Environment Federation. The Project, representing a significant professional challenge and opportunity, has engendered exceptional interest and enthusiasm among all the early participants.

(over, please)

MANAGED BY THE AMERICAN ACADEMY OF ENVIRONMENTAL ENGINEERS

Project Methodology

The Steering Committee devoted considerable time and effort to planning the Project, selecting the technologies to be documented, and identifying experts to draft the monographs. The experts make up Task Groups, generally of five members, that will draft monographs on the selected technologies. The composition of each Task Group is designed to balance the interests of the various groups involved in waste treatment and site remediation -- industry, consultants, research, academe, and government. The Task Groups have access to a comprehensive data base compiled by EPA which will be supplemented from other sources. In addition, they may call upon other experts for their voluntary suggestions and contributions.

The development process will be fully public. A two-stage review will elicit comments by organizations and members of the professional community at large to ensure that the finished monographs represent a consensus on the state of the art of the selected technologies. Following the Steering Committee's review of the Task Groups' manuscripts, review and acceptance by professional and technical organizations having substantial interest and competence relating to the technologies addressed will be sought.

Schedule

The Project began in July 1991, and delivery of the completed monographs is scheduled for September 1993. The Project is being conducted in three phases. The first phase was dedicated to planning and organization. The second phase is devoted to preparation of the monographs and completing a two-stage peer review. The third phase consists of distribution of the completed work to practicing engineers and users; making revisions to incorporate continuing technological advances; and developing additional monographs as new technologies arise.

Summary

Remediation of hazardous waste sites and treatment of contaminated soils and groundwater is a major national problem of which the public is keenly aware. The public broadly perceives, as well, that remedies depend largely upon the efforts of engineers and scientists. The cleanup, then, is not merely one of the many problems facing our country in which engineers and scientists must take the lead, but it is also one in which their role in finding a solution is particularly visible.

Therefore, WASTECH '92 presents the professional community both a significant challenge and an opportunity. The challenge lies in the demanding task of forging truly consensus-based monographs that effectively identify the benefits, costs limitations, and design criteria for the selected innovative technologies. The opportunity lies in the chance to seize the lead in providing better, more cost effective remediation of hazardous wastes sites and soil and groundwater contamination.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
CENTER FOR ENVIRONMENTAL RESEARCH INFORMATION
CINCINNATI, OHIO 45268

March 3, 1992

Steven Livingstone,

In response to your request of February 28, 1992, I am providing herewith a description of a task, "Control of Air Toxics from Superfund Sites," that may meet your criterion of cross-(or multi-) media application of control technologies. The general objective of my study is to provide information to Remedial Program Managers and On-scene Coordinators, as well as others who may have a need for such information (e.g., consultants), on evaluating and selecting air emissions control devices at Superfund sites. A primary concern of RPMs and OSCs is for the control of air toxic emissions at these sites. Specific objectives of this assignment include the development of:

1. a concise description of available control techniques, factors that affect their performance, the relative advantages and disadvantages of each technique, and interactive effects of control techniques when used in combination;

2. information on the expected emission reduction (i.e., efficiency) for each control technique when used alone or in combination with another technique for both individual contaminants and mixtures of contaminants;

3. guidelines for selecting optimum control techniques and strategies, including possible alternatives to the remediation approach; and

4. cost information, or estimated total costs, for applying a given control technique (or combination of techniques).

As I mentioned, I have a draft of this document under review now. The final report should be available in late summer. Actual publication probably will not occur until the fall.

If you need further information, you may contact me at (513)569-7349, or write me at: EPA, MS-G75, 26 W. M.L. King Dr., Cincinnati, OH, 45268.

Justice A. Manning

APPENDIX 3
COMPETITIVENESS OF U.S. PRODUCTS

Competitiveness of U.S. Products
Wastewater Technology
Source: USAID EIP Project Paper 1/92 & Telephone Consultations

Technology	U.S. Competitive Data	Product Value	Service Value
Solids Removal:			
Clarifiers	C	M	L
Digestion	C	M	L
Incineration	C	H	H
Land Disposal	W	L	L
Composting	W	L	L
Dissolved Air	C	H	M
Physical/Chemical Treatment	C	H	M
Aerobic Treatment:			
Activated Sludge	C	M	M
Carbonaceous	C	M	M
Nitrification/ Denitrification	U	M	H
Contact Stabilization	W	M	L
Step Aeration	C	M	M
Extended Aeration	C	M	M
Sequencing Batch Reactors (SBRs)	C	H	H
Rotating Biological Disks (RBDs)	C	H	L
Oxidation Ditches	W	L	L
Pure Oxygen	S	H	H

S=Strong, C=Competitive, H=High, M=Medium, L=Low, W=Weak, U=Unknown

Competitiveness of U.S. Products
Wastewater Technology

Technology	U.S. Competitive Data	Product Value	Service Value
Biological Filters:			
Rock Media	W	L	M
Plastic Media	C	M	M
Redwood	C	M	M
Rubber Media	C	L	M
Granular Media Filtration:			
Sand/Gravel	W	L	L
Travelling Bridge	C	M	M
Activated Carbon:			
Granular	C	H	H
Powdered	C	H	H
Stabilization Lagoons:			
Facultative	C	L	M
Extended Aeration	C	L	M
Polishing	C	L	M
Land Application:			
Treated Effluent	W	L	L
Spray Irrigation	U	L	L
Sludge Application	W	L	L
Constructed Wetland	U	L	L
Flood Irrigation	U	L	L
Sludge Dewatering:			
Drying Beds	W	L	L
Screens	U	L	L
Belt Filter Presses	S	H	H
Centrifuge	C	H	H
Vacuum Filters	C	M	M

S=Strong, C=Competitive, H=High, M=Medium, L=Low, W=Weak, U=Unknown

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Competitiveness of U.S. Products
Wastewater Technology

Technology	U.S. Competitive Position	Product Value	Service Value
Sludge Lagoons	U	L	L
Anaerobic Systems:			
Anaerobic Lagoons	W	L	M
Anaerobic Digestors	C	L	M
Packed Beds	C	M	M
Fluidized Beds	C	M	M
Reverse Osmosis Filtration	S	H	H
Electrodialysis and Electrodialysis Reversal	C	M-H	M-H
Demineralization (Ion Exchange):			
Anionic	C	M	M
Cationic	C	M	M
Chemical Oxidation:			
Hydrogen Peroxide	C	M	M
Ozone	C	M	M
Chlorine	C	M	M
Chlorine Dioxide	C	M	M
Metal Absorption Compounds:			
GAC	C	M	M
Synthetic Resins	S	H	H
Zeolites/Clays	C	M	M

S=Strong, C=Competitive, H=High, M=Medium, L=Low, W=Weak, U=Unknown

Competitiveness of U.S. Products
Air Pollution Technology

Technology	U.S. Competitive Position	Product Value	Service Value
Electrostatic Precipitators	C	H	H
Cyclones	W	L	L
Scrubbers	W	H	H
Incinerators	C	H	H
HEPA Filters	S	M	L
Fabric Filters	C	M	L
Absorption Process	C	M	M
Source Controls	S	M	H
Electronic Sensing Equipment	S	H	H
Flaring	W	L	L

Competitiveness of U.S. Products
Solid Waste Technology

Technology	U.S. Competitive Position	Product Value	Service Value
Recycling	C-S	L-H	L-H
Compaction	C	H	M
Landfill	U	L	L
Incineration	C	H	M
Reuse	C	L-H	H
Energy Conversion	C	L-H	H

S=Strong, C=Competitive, H=High, M=Medium, L=Low, W=Weak, U=Unknown

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APPENDIX 4
TAXONOMY OF ENVIRONMENTAL PRODUCTS AND SERVICES

AIR/GASEOUS POLLUTION CONTROLS

- Acid Gas/SOx Controls
  - Wet Flue Gas Desulfurization
  - Spray Flue Gas Desulfurization
  - Dry Injection
  - Venturi Scrubbers
  - Other
- Aerators
- Coal Cleaning
  - Coal Washing
  - Physical Deep Cleaning
  - Chemical Cleaning
  - Biological Cleaning
- Combined NOx/SOx Controls
  - Slagging Combustors
  - In-Furnace
  - Post-Combustion
  - Other
- Filters
- Fluidized Bed Combusters
  - Bubbling
  - Circulating
- Fume Abatement
- Indoor Air Pollution Abatement
- NOx Controls
  - Low-NOx Burners
  - Flue Gas Recirculation
  - Selective Catalytic Reduction
  - Selective Non-Catalytic Reduction
  - Non-Selective Catalytic Reduction
  - Other
- Particulate Controls
  - Electrostatic Precipitators
  - Fabric Filters
  - Mechanical Collectors/Cyclones
- Soot Blowers
- Vehicles (Advanced)
  - electric
  - compressed natural gas
  - other vehicles
  - batteries

WATER/LIQUID POLLUTION CONTROLS

- Acid Handling/Recovery
- Potable Water Treatment
- Filtration
- Hazardous Liquid Waste Disposal
- Industrial Water Treatment
  - Air Stripping
  - Wet Air Oxidation
  - Clarification
  - Reverse Osmosis
  - Activated Carbon
  - Steam Stripping
- Chemical Coagulation
- Municipal Water Treatment
  - Primary treatment
  - Secondary treatment
  - Biological/chemical treatment
  - Aerobic/Anaerobic digestion
- Purification
- Sewer Systems
- Solvent Recovery
- Water Conditioning
- Water Treatment
  - Industrial
  - Municipal

SOLID WASTE POLLUTION CONTROLS

- Ash Handling
- Hazardous Waste Treatment/Disposal
  - Biological Treatment
  - Carbon Adsorption
  - Oxidation
  - Incineration
  - Irradiation
  - Other
- Recycling Systems
- Sludge Treatment
  - Mechanical Dewatering
  - Composting
  - Landfilling
  - Incineration
- Solid Waste Incinerators
  - Industrial
  - Mass Burn
  - Modular
  - Refuse-Derived Fuel

OTHER POLLUTION CONTROLS
Analyzers
Boiler Feedwater Treatment
Decontamination Equipment
Leak Detectors
Monitoring Equipment
- Radiation
- Other

Noise Abatement
Sampling Equipment
Stacks/Chimneys

CONTAINMENT TECHNOLOGIES
Capping
- Native Soil
- Clay
- Synthetic membranes
- Sprayed asphalt
- Asphalting concrete
- Concrete
- Multi-layered cap
- Chemical sealants/stabilizers

Vertical Barriers
- Soils slurry wall
- Cement-bentonite slurry wall
- Vibrating beam
- Grout curtains
- Sheet piling
- Injection of a permeability agent
- Ground freezing

Horizontal Barriers
- Block displacement
- Grout injection
- Injection of a permeability agent
- Ground freezing

Surface Controls
- Surface seals
- Grading
- Soil stabilization
- Revegetation
- Diversion and collection systems
  - Dikes and berms
  - Ditches and trenches
  - Terraces and benches
  - Chutes and downpipes
  - Seepage basins
  - Sedimentation basins/pond
  - Levees
  - Addition of freeboard
  - Floodwalls

Sediment Control Barriers
- Curtain barriers
- Cofferdams
- Capping

Dust Controls
- Water
- Organic agents

TREATMENT TECHNOLOGIES
Solids Processing
- Magnetic processes
- Crushing and grinding
- Screening
- Classification

Solids Treatment
- Neutralization
- Oxidation
- Reduction
- Other chemical modification
- Water leaching
- Solvent leaching

Solidification, Fixation and Stabilization
Sorption (Flyash, Zeolites, Kiln dust, Alumina, Lime, Carbon)
- Pozzolanic reaction (Lime-flyash, Portland cement)
- Encapsulation (Thermoplastics, Asphalt, Proprietary agents)

Solids Dewatering
- Sedimentation
- Air/Gas Flotation (Induced, Dissolved, Electrolytic)
- Gravity thickening
- Screens, hydraulic classifiers and scalpes
- Centrifuges
- Belt filter presses
- Pressure filters
- Vacuum filtration
- Dewatering and drying beds
- Thermal dryers

IN-SITU TREATMENT TECHNOLOGIES
Neutralization
Oxidation
Reduction
Precipitation
Bioreclamation
- Natural
- With bacteria augmentation
- With oxygen(air hydrogen peroxide)augmentation
- Other chemical modifications
- Immobilization
- Polymerization
- Photolysis

Permeable treatment beds
Solution mining
Vitrification
Vapor extraction from soil

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THERMAL TECHNOLOGIES
Incineration
- Rotary kiln / Molten salt
- Fluidized bed/ Liquid
- Rotary hearth/Landbased
- Multiple hearth/Shipboard
- Radiant heat furnace

Co-disposal processes
- Industrial power
- Power generation boiler
- Municipal sludge incinerato
- Cement kiln
- Lime kiln
- Municipal refuse incinerator
- Combustion byproduct recovery

Pyrolysis/controlled air combustion
- Conventional pyrolytic reactors
- Ultrahigh temperature reactors

Wet air oxidation
- Conventional U-tube
- Autoclave
- Vertical tube(deep well) reactors
- Supercritical water

Gaseous waste incineration
- Flares
- Direct flame combustion
- Catalytic combustion

DRUM AND DEBRIS REMOVAL

EXCAVATION
Solids
Semi-Solids(non-pumpable)
Sediments

BULK LIQUID REMOVAL
Pumps
Industrial vacuum
Gravity/siphon

GROUNDWATER COLLECTION/PUMP
Wells
- Well points
- Ejector wells
- Deep wells
- Function Options
  - Extraction alone
  - Injection alone
  - Extraction and injection

Drains (Subsurface or leachate injection/ collection points)
- French drains
- Pipe and media drains

GAS COLLECTION
Passive vents
- Pipe vents
- Trench vents

Active gas collection systems
- Onsite extraction wells
- Air injection system
- Interceptor trenches

GAS TREATMENT TECHNOLOGY
Condensation
Particulate removal
Adsorption
Absorption
Chemical reaction agents
Thermal destruction

TRANSPORATION TECHNOLOGY
Containers
- Bulk tanks
- Drums
- Bins
- Fabric bags

Vehicles
- Truck
- Railroad
- Barge
- Pipeline

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DISPOSAL/DISPERSAL OF FINAL PRODUCTS	ENVIRONMENTAL SERVICES
Reusable Product	Air Pollution Management
Sale at commercial value modifications	Air Quality Monitoring
Sale with a cost-of-processing support	Analytical Testing
Physical Separations	Bioassessments
Flow and strength equalization	Climate/Atmospheric Assessments
Coagulation/flocculation	Composting
Oil-water separation	Combustion/Incineration Systems Design
Chemical Treatment	Construction Services
Neutralization	Decontamination/Site Clean-Up
Precipitation	Nuclear
Ion Exchange	Asbestos
Oxidation (chlorine containing, Ultraviolet/Oxidant, Permanganate, Peroxide)	PCB
Reduction (Sulfur dioxide, Ferrous sulfate, Sodium boronyvinde, Sodium bisulfite, Sodium metabisulfite, iron powder, zinc powder)	Other
Organic chemical dechlorination	Design Services
Photolysis	Ecosystem Assessments
Irradiation	Effluent/Water Characterization/Monitoring
Electrochemical	Emissions Characterization/Monitoring
Other chemical	Environmental Auditing
Greensand	Environmental Impact Assessments
Land Application	Environmental Modeling
Deep Sea Application	Environmental Training
Deep Mine Application	Epidemiological Assessment
Wastewater Discharge	Groundwater Monitoring
To POTW	Hazardous Waste Management
To surface water	Indoor Air Quality
To(shallow)subsurface disposal	Permitting
To deep injection wells	Project Management
Atmospheric Discharge	Radon Abatement
Point sources	Recycling System Design
Area sources	Regulatory/Compliance Assessment
Fugitive emissions	Remote Sensing (Planes and satellites)
	Risk/Endangerment Assessments
	Site Inspection
	Solid Waste/Sludge/Ash Management
	Testing
	Toxic substances
	Other
	Toxicological Assessment
	Waste and Emissions Trading
	Waste-to-Energy/Resource Recovery Plant Design
	Water Pollution Management/Treatment

The Office of Energy and Infrastructure

The Agency for International Development's Office of Energy and Infrastructure plays an increasingly important role in providing innovative approaches to solving the continuing energy crisis in developing countries. Three problems drive the Office's assistance programs: high rates of energy use and economic growth accompanied by a lack of energy, especially power in rural areas; severe financial problems, including a lack of investment capital, especially in the electricity sector; and growing energy-related environmental threats, including global climate change, acid rain, and urban air pollution.

To address these problems, the Office of Energy and Infrastructure leverages financial resources of multilateral development banks such as The World Bank and the InterAmerican Development Bank, the private sector, and bilateral donors to increase energy efficiency and expand energy supplies, enhance the role of private power, and implement novel approaches through research, adaption, and innovation. These approaches include improving power sector investment planning ("least-cost" planning) and encouraging the application of cleaner technologies that use both conventional fossil fuels and renewable energy sources. Promotion of greater private sector participation in the power sector and a wide-ranging training program also help to build the institutional infrastructure necessary to sustain cost-effective, reliable, and environmentally-sound energy systems integral to broad-based economic growth.

Much of the Office's strategic focus has anticipated and supports recently-enacted congressional legislation directing the Office and A.I.D. to undertake a "Global Warming Initiative" to mitigate the increasing contribution of key developing countries to greenhouse gas emissions. This strategy includes expanding least-cost planning activities to incorporate additional countries and environmental concerns, increasing support for feasibility studies in renewable and cleaner fossil energy technologies that focus on site-specific commercial applications, launching a multilateral global energy efficiency initiative, and improving the training of host country nationals and overseas A.I.D. staff in areas of energy that can help to reduce expected global warming and other environmental problems.

The Office also helps developing countries speed their economic development through promoting technology cooperation between U.S. suppliers and developing country companies, institutions and governments. This effort involves Business Opportunity Identification to define and analyze the range of commercially viable trade and investment opportunities, technologies, and services that have a positive impact on the environment and are appropriate for developing countries; Venture Promotion to encourage the involvement of the U.S. private sector; Innovative Finance; and Policy Development assistance to developing countries as they pursue policy and regulatory changes to provide market incentives for environmentally beneficial technologies.

To pursue these activities, the Office of Energy and Infrastructure implements the following seven projects: (1) Biomass Energy Systems and Technology Project (BEST); (2) The Renewable Energy Applications and Training Project (REAT); (3) The Private Sector Energy Development Project (PSED); (4) The Energy Training Project (ETP); (5) The Energy Technology Innovation Project (ETIP); (6) The Global Energy and Environmental Managment (GLEEM); and (7) The Energy Efficiency Project (EEP).

The Office of Energy and Infrastructure helps set energy policy direction for the Agency, making its projects available to meet generic needs (such as training), and responding to short-term needs of A.I.D.'s field offices in assisted countries.

Further information regarding the Office of Energy and Infrastructure projects and activities is available in our Program Plan, which can be requested by contacting:

Office of Energy and Infrastructure
Bureau for Research and Development
U.S. Agency for International Development
Room 508, SA-18
Washington, D.C. 20523-1810
Tel: (703) 875-4052