Appendix A: Environmental Markets in Developing and Newly Industrialized Countries[1,2]

The largest markets for environmental goods and services (EGS) lie within the industrialized nations that are members of the Organisation for Economic Cooperation and Development (OECD). These countries will continue to account for most EGS expenditures for the next 10 or 20 years. However, there is likely to be rapid growth in EGS demand in non-OECD (developing, newly industrialized, and Eastern European and former Soviet) countries. Estimates of the current and prospective size of this non-OECD market vary widely. One study concluded that non-OECD countries accounted for $36 billion out of an estimated $200 billion global EGS market in 1990; by the year 2000, their EGS markets could grow to $55 billion (with the world total projected to be $300 billion).[3] Another source concluded that non-OECD markets amount to $37 billion (of a $270 billion world market); in 1996, the non-OECD market could reach $61 billion (the world total was projected to be $408 billion).[4] Yet, another source, the International Finance Corporation, suggests that one-third of the current global EGS market of $300 billion, which it projects will reach $600 billion in 2000, is found outside the United States, Canada, Europe, and Japan.[5]

Differences in the estimates reflect in part different definitions of the environmental industry. Some analyses include only goods and services for end-of-pipe control of air and water pollution and disposal and recycling of wastes (although some pollution prevention consulting may be included). Others include renewable energy and some energy-efficiency opportunities. Some estimates encompass markets for water supply, mobile source controls (such as catalytic converters), noise control, or construction work associated with environmental projects, while others do not.

Perhaps the greatest variable concerns so-called "cleaner technologies," including pollution prevention and energy-efficient equipment. These technologies are generally integrated into processes-such as industrial production processes, transportation systems, or heating or cooling systems for buildings. Yet cleaner production and improved energy-efficiency opportunities are often the most effective and most

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[1] This appendix draws on preliminary research from the OTA assessment, *Amen"can Industry and the Environment: Implications for Trade and Competitiveness. While this* appendix focuses on developing and newly industrialized country markets, the final report of the assessment will contain more in-depth analyses of global markets and U.S. competitiveness in the environmental goods and services sector.

[2] This appendix discusses environmental markets related to the industrial and utility sectors, including water supply, wastewatreatment, and refuse management. Environmental needs--and market possibilities-associated with land use management, agriculture, forestry, fisheries, biodiversity conservation, and ecotourism development are not addressed here.

[3] OECD, *The OECD Environment Industry: Situation, Prospects and Government Policies*, OECD/GD(92)1 *(Paris:* OECD, 1992).

[4] Grant Ferrier, President of Environmental Business International Inc., testimony to House Committee on Merchant Marine and Fisheries, Subcommittee on Environment and Natural Resources, Feb. 25, 1993.

[5] International Finance Corporation, Investin *in the Environment: Business Opportunities in Developing Countries* (Washington, DC: The World Bank and the IFC, 1992), p. iii.

cost-effective options for addressing pollution and waste. While often needed, end-of-pipe and remedial environmental controls are, by contrast, almost always a net cost to business and frequently shift pollution from one medium to another. (Per instance, wastewater treatment and some air scrubbing generates solid wastes that require disposal, while incinerators turn solid wastes into air emissions that require control).

Although now only a modest part of the global market, the environmental business opportunities in specific developing countries and newly industrialized countries (NICs) can be quite large. (Environmental technology opportunities in Eastern Europe and the former Soviet Union are not addressed here. They are the subject of a separate OTA assessment.)[6] As developing countries begin to address their environmental problems, environmental business opportunities could grow quickly. Of particular interest to environmental technology vendors are the middle-income and fast-growing countries in East Asia and Latin America such as the four NIC "tigers" (Hong Kong, South Korea, Singapore, and Taiwan), Mexico, Brazil, Chile, Malaysia, and Thailand. Opportunities are also growing in some lower-income countries, including India, Indonesia, and China.

In many developing countries, government funds for environmental protection will likely remain sparse. The availability of financing from private or mixed public-private sources could be a critical determinant for growth of environmental markets. The opening of various developing country economies to greater foreign investment and the loosening of state controls on energy, transport, and manufacturing industries-including privatization-provide growing possibilities for environmentally favorable investment.

Examples of the magnitude of developing country and NIC environmental markets include about $11 billion of environmental projects in Taiwan's current Six-Year Development Plan,[7] over $10 billion in South Korea's 1991-95 investment plans,[8] an annual environmental market of $1.8 billion (1993) in the six ASEAN nations? and a $2.4 billion annual market (1992) in six Latin American countries.[10]

The NICS and some developing nations produce some of their EGS market needs. The technical capabilities of EGS industries in Singapore, South Korea, Taiwan, Mexico, Brazil, and some other countries can be expected to increase. In fact, environmental goods are sometimes exported by these countries--often at lower prices than offered by firms in the United States, Europe, or Japan. Environmental firms from OECD countries face increased competition from developing country and NIC companies as well as from each other. However, OECD firms also are finding opportunities for branch operations and joint ventures in developing and newly industrialized countries.

SECTOR TRENDS

There are several trends in developing and newly industrialized countries which present vendors of EGS and cleaner technologies with growing markets:

- development of water and wastewater treatment infrastructure;
- electrification;
- growing transportation needs;
- development of solid and hazardous waste disposal capacity;
- increased industrial production; and
- development of environmental monitoring, standard making, and enforcement capability.

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6 The fist report of this other assessment is: U.S. congress, Office of Technology Assessment, *Energy-Efficiency Technologies for Central and Eastern Europe, OTA-E-562* (Washington, DC: U.S. Government Printing Office, May 1993).

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

s Republic of Korea Ministry of Environment, *White Paper 1990,1991,* in Tal Woo Lee, "Perspective of Environmental Industry in Korea," paper presented at GLOBE '92, Vancouver, BC, Canada, Mar. 16-20, 1S92.

9 Jonathan Menes, Acting Assistant Secretary for Trade Development, U.S. Department Of Commerce, testimony before the House Committee on Merchant Marine and Fisheries, Subcommittee on Environment and Natural Resources, Feb. 25, 1993. ASEAN is the Association of South East Asian Nations consisting of Brunei, Indonesia, Malaysia, Philippines, Singapore, and Thailand.

10 USAID, *Environmental Market Conditions and Business Opportunities in Key Latin American Countries*, Business FOCUS Series, October 1992 (available through USAID, Arlington, VA). The six countries are Argentina, Brazil, Chile, Colombia, Mexico, and Venezuela.

Water Supply and Wastewater Treatment Infrastructure

LDCS and NICS are expected to make major expenditures in the next few years to build and upgrade water supply and to provide sanitary services (see table A-l). As is discussed in chapter 2, hundreds of millions of people in the developing world lack potable tap water. Sewage treatment is rare. Both municipal and industrial wastewater treatment demand is growing. A market for smaller treatment systems serving individual apartment buildings and small groupings of businesses, and for improved septic tank systems, can arise in areas where centralized sewage treatment remains too costly. There may also be opportunities for developing "engineered wetlands" and similar biological systems as low-cost sewage treatment for smaller communities. Firms from many countries are involved in providing architecture/engineering and construction services, water and wastewater treatment equipment and chemicals, and control and monitoring instruments to meet these needs.

However, most expenditures in this sector will pay for locally provided goods and services. Construction labor and low-value materials like cement are obtained locally. Relatively simple equipment, such as pipes and sheetmetal products, can often be provided in-country or by regional low-cost international suppliers. Thus only a modest portion of water and wastewater related expenditures-primarily those dealing with project management and relatively sophisticated goods and services-would likely be significant for U.S. exports.

The export performance of U.S. and foreign competitors in this sector varies by country and subsector. The small size of the current market means that a few sales may substantially change the picture. In Brazil, American firms accounted for 20 percent of a $35-million (1991) industrial wastewater import market, edging out Germany (19 percent), Sweden (15 percent), the United Kingdom (15 percent), and Japan (7

Table A-l-Selected Water and Wastewater Markets and Expenditure Plans

Argentina[a]	
National water supply and sewerage program improvements	$250 million
Estimated 1992 water pollution control market	$100 million
Brazil:[a]	
Major water modernization projects (1992-97)	$3,105 million
Estimated 1992 water pollution control market	$345 million
Mexico:[a]	
Water supply and sanitation sector (1990-94)	$4,504 million
Estimated 1992 water pollution control market	$400 million
South Korea:	
Water pollution investments planned (1991 -95)[b]	$4,230 million
1991 Water pollution control expenditures by business[c]	384 million
Taiwan:[d]	
Taiwan six-year plan wastewater projects (1992-97)	$4,700 million
China:[e]	
Estimated 1991 water pollution control market	$433 million
Indonesia:[f]	
Multilateral development bank water/wastewater projects	$2,500 million

SOURCES: [a]USAID, *Enviromental Market and Business Opportunities in Key Latin American Countries, 1992;* [b]Rep. of Korea Min. of Env. *White Paper 1990;* [c]Yonhap (South Korean news agency) Mar. 9, 1992, in *JPRS Report: Environmental Issues,* May 5, 1992; [d]American Institute in Taiwan; [e]U.S. Department of Commerce; [f]U.S.-ASEAN Council for Business and Technology.

percent).[11] In Brazil's municipal sector, U.S. producers held 60 percent of a $135-million import market, ahead of Swedish and Japanese competitors. Complicating matters are a variety of licensing and joint venture arrangements between Brazilian and American, British, Finnish, French, Swedish, and Swiss firms. Mexico's water pollution control imports seem dominated by the U.S. with a 60 percent share (1989) versus 14 to 15 percent shares for Japan and Germany.[12] In contrast, Japan is the biggest player in China's water pollution control import market of $48.9 million (1991), accounting for 40 to 45 percent, while U.S. sales were 8 percent, behind Austria's 25 percent.[13] Austrian, Danish, and Canadian exports of water pollution control equipment to China have been supported by grants and credits from those countries. The U.S. is the largest exporter of water-related equipment to Egypt (36 percent in 1991), surpassing Japan (21 percent), Germany (17 percent), and Italy (15 percent) .14 But in Morocco, France dominates with 65 percent of the import market, high above U.S. and other European suppliers.[15] The point of this snapshot is that it is hard to say who dominates world trade in the water and wastewater sector except to note that the United States, Japan, and several European countries are the key players.

Electrification[16]

The World Bank estimates that electric power sector capital investment in developing countries, Eastern Europe, and the former Soviet Union during the 1990s may reach $1 trillion.[17] An analysis done for the 1991/1992 U.S. National Energy Strategy projects that during the years 1990 to 2010, electric power investments of over $1 trillion for 624 gigawatts of new capacity will occur in the developing countries (not including Eastern Europe or the former Soviet Union).[18] Whether or not growth in electricity demand and production occurs at this rapid pace, there is increasing recognition of the need for mitigating or preventing environmental impacts. Business opportunities will arise from the need for pollution abatement equipment, more efficient and cleaner power generating technologies, and improved energy end-use efficiency. Demand for architecture/engineering, construction, and project management services-areas in which U.S. firms are strong contenders but face growing foreign competition-will be increasing.

In the area of air pollution abatement, a relatively inexpensive initial option is particulate removal by electrostatic precipitators or fabric filters. U. S., Japanese, and European manufacturers are competitive in developing country markets and local environmental industry capacity is growing. End-of-pipe controls for sulfur dioxide and nitrogen oxides are more sophisticated and expensive and perhaps too expensive for some developing countries. U. S., Japanese, and German companies appear to be in the lead for these gas-cleaning technologies, although multinational arrangements can make national comparisons difficult. For instance, ASEA Brown Boveri (ABB), considered a Swiss-Swedish conglomerate, owns Combustion Engineering, a U.S.-based maker of air pollution control equipment, and Flakt, a Swedish provider of pollution controls. At the same time, ABB and various U.S. companies license Japanese technology for selective catalytic reduction (SCR) of nitrogen oxides. A variety of U.S. companies license or have adapted sulfur and nitrogen oxide control technologies from Japan and Europe. In fact, some U.S. air pollution control firms are concerned about the growing strength of German and Japanese gas-cleaning technology

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11 Ibid., p. 49.

12 Ibid., p. 112.

13 U.S. Department of Commerce National Trade Data Bank.

14 Ibid.

15 Ibid.

16 The OTA assessment *Fueling Development: Energy Technologies For Developing Countries*, OTA-E-516 (Washington, DC: U.S. Government Printing Office, April 1992) provides an extensive analysis of developing country energy and related environmental issues.

17 World Bank, "Capital Expenditures for Electric Power in the Developing counties, " IEN Energy Series Paper No. 21, February 1990, in World Bank, "The Bank's Role in the Electric Power Seetor," draft, Industry and Energy Department., box 5, p. 10.

18 U.S. Department of Energy, "National Energy Strategy Technical Annex 5: Analysis of Options to Increase Exports of U.S. Energy Technology," 1991/1992, DOE/S-0096P (Springfield, VA: National Technical Information Service).

suppliers. At the same time, some U.S. firms have their own proprietary technologies.

American firms are major providers of air pollution control equipment (for power generators and industrial facilities) in a number of markets. U.S. firms garnered a quarter of Brazil's 1992 air pollution control imports (Sweden, Germany, and France together accounted for half). U.S. firms also accounted for over 25 percent of 1989 Mexican air pollution control imports (versus 20 percent for Germany, 14 percent for Japan, and 7 percent for Switzerland) .19 In Singapore, American products earned nearly 40 percent of the 1991 import market share, with less than 15 percent from Japan and under 10 percent from Germany .20

Making environmental technologies affordable is critical to gaining markets in developing countries. Japan has embarked on a program to adapt power plant pollution control equipment to meet less rigorous emission requirements of developing countries at far less cost than would be required in Japan, America, or Western Europe.[21] Japan also plans to lease air pollution abatement equipment in Asian developing countries.[22]

Cleaner generation technologies can offer more cost-effective environmental performance than the use' of add-on pollution abatement technologies. A variety of ''clean coal''[23] technologies and combustion turbines (gas turbines) can allow developing countries to use their fossil fuel resources more cleanly and efficiently. In the clean coal area, the Department of Energy notes that the United States is at the technological forefront but that U.S. vendors have not been leaders in marketing abroad. DOE points to German, Japanese, French, Swedish, and Italian suppliers as the strong competitors.[24] Increasing competition to American suppliers is found in the combustion turbine business. General Electric is a major supplier in this sector. GE and its business associates abroad (various European and Japanese firms) who assemble turbines using key GE components supply roughly half the world's gas turbine market.[25] ABB, Siemens (Germany), Westinghouse, Pratt & Whitney, Rolls-Royce (UK), and Mitsubishi (Japan) are among others competing for this market. Licensing and joint ventures among competing manufacturers make competitiveness assessments difficult.

In the renewable energy sector, U.S. companies also face tough Japanese and European competition.[26] While the market is now small, it is likely to grow as renewable energy costs decrease and if increasing concerns about global climate change force changes in energy sources. Furthermore, some renewable energy technologies are well suited to developing country circumstances where settlements are far from existing electricity grids. German, Japanese, and Korean firms are among America's competitors in photovoltaic cell production. Siemens of Germany, which recently purchased ARCO Solar in the United States, is reportedly the world's largest photovoltaic cell manufacturer. Siemens exports 75 percent of its U.S. production.[27] Danish, Dutch, Japanese, and German companies are among those who make utility-scale wind turbines. U.S. Windpower has been active in seeking developing country markets.[28] Japan is noted

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19 USAID, *Environmental Market Opportunities. . . .* Op Cit., pp. 44,105.

20 U.S. Department of Commerce National Trade Data Bank.

21 ''Japan to Work with China in Developing Cheap Desulfurization Units for Plants,'' *International Environment Reporter,* July 29, 1992; Kawasaki Heavy Industries, Ltd., informationbooklet, 1992.

22 "JapaneseTradeM inistry To Lease Anti-Pollution Devices To Developing Nations, '' *InternationalEnvironmentReporter,* July 15,1992, p. 469.

23 Clean coal technologies refer to a variety of technologies including precombustion cleanin g of coal to remove polluting components, cleaner combustion technologies, andpostcombustion clean-up of stack gases. Stack gas clean-upwas referred to in the previous paragraph.

24 U.S. Department of Energy, "National Energy Strategy Technical Annex 6: Clean Coal Export Programs," 1991/1992, DOE/S-0095P (Springfield, VA: National Technical Information Service), p. 2. DOE's usage of the term "clean coal" also refers to end-of-pipe controls.

25 Eugene Zeltman, General Electric, personal communication, Feb. 3, 1993.

26 A forthcoming OTA assessment, *Renewable Energy Technology: Research, Development, and Commercial prospects,* will analyze technological and commercial aspects of renewable energy.

27 Mark Crawford, ''Seven Companies Awarded DOE Solar Grants,'' *Energy* Daily, Apr. 24, 1992, p. 3.

28 Jim Clarke, ''U.S. Firms Seek to Market Wind Power in LDCs,'' Energy Daily, Nov. 18, 1992, pp. 1-2.

as a leader in the hydroelectric sector.[29] Biomass, geothermal, and solar thermal are other renewable energy options for electricity production.

Improving energy end use efficiency through better motors, lights, appliances, controls, heating, cooling and ventilation, and insulation may lead to other environmentally preferable business opportunities. Improving energy efficiency can offer a "least-cost" option for meeting energy service demand by allowing countries to avoid installation of expensive additional electricity generation capacity as well as future fuel costs. As such, improved energy efficiency can present lower up-front costs and conserve capital for a country or utility.[30] However, efficiency investments often have a high first cost for consumers which dissuades investment. Innovative financing for improved energy or electricity use efficiency can help overcome the consumer first cost problems. Pioneered in the United States by utilities, regulators, "energy service companies,' and environmental organizations, such 'demand-side management" approaches are being adopted by developing country utilities (e.g., the Electric Generating Authority of Thailand) .31 The potential for exports of energy-efficient products to developing and NIC markets is large-perhaps $4.2 billion annually over the years 1990-2000 (for both electrical and nonelectrical energy conservation) .32 However, U.S. firms may not now be well positioned to tap this market because of tough competition from Japanese and European vendors already positioned in developing countries and low-cost Korean and Taiwanese competition.[33] In fact, the United States is a net importer of some energy-efficient products such as compact fluorescent bulb ballasts.[34] Efforts by American manufacturers and government export promotion officials to target energy efficiency export opportunities are in their early stages.

Transport

The growth of motorized transportation in developing and newly industrialized countries provides another business opportunity for U.S. environmental technology. The United States was the first major nation to institute strong vehicle emissions controls. The removal of lead from gasoline, installation of catalytic converters, and desulfurization of fuel were undertaken in the United States in the 1970s. Japan quickly adapted some of its requirements to U.S. standards, in part to qualify its automotive exports to U.S. markets. Several European countries, Australia, Canada, and South Korea followed in the 1980s.[35] However, only in 1993 has the European Community (EC) required the types of vehicle controls the United States has had for nearly two decades. As the United States continues to strengthen vehicle emission standards and several industrialized nations research electric, fuel cell, and hydrogen-powered vehicles, several countries in the developing world also appear to be following the initial U.S. path.

Mexico, Brazil, Taiwan, and South Korea are among fast-industrializing countries that are requiring catalytic converters on new gasoline-powered cars. Argentina, Chile, Venezuela, Egypt, Turkey, India, Singapore, and Thailand are expected to follow suit later in the 1990s. Brazil, South Korea, and Taiwan are projected to join the U. S., Canada, Japan, and Western Europe in requiring stricter control-including the use of filters and catalysto--of diesel vehicle emissions.[36] These requirements create markets for catalytic comverters and diesel emissions control devices. The

29 U.S. Department of Energy, "National Energy Strategy Technical Annex 5: Analysis of Options to Increase Exports of U.S. Energy Technology," 1991/1992, op. cit., p. 47.

30 U.S. Congress, Office of Technology Assessment, *Fueling Development: Energy Technology For Developing Countries*, OTA-E-516 *(Washington DC:* U.S. Government Printing Office, April 1992), p. 7.

31 International Institute for Energy Conservation, Seizing *the Moment: Global Opportunities for the U.S. Energy-Efficiency Industry*, December 1992, p. 4.

32 Ibid., p. 69.

33 U.S. Department of Energy, "National Energy Strategy Technical Annex 6," op cit.

34 International Institute for Energy Conservation op cit., p. 64.

35 H&W Management Science Co@@@ *International Mobile Source Emissions* Controls *Market Study: Update* No. *1*, prepared for the Manufacturers of Emission Controls Association August 1990.

36 Ibid.

largest producers of catalysts used in vehicle catalytic converters are Johnson Matthey (British headquartered with extensive U.S. operations) and U.S. companies Allied-Signal and Engelhardt; Degussa of Germany and a number of Japanese and Taiwanese firms have smaller shares of the market.[37] Allied-Signal has recently expanded operations in France and Mexico and has a joint venture in Japan. W.R. Grace may enter the market as it researches electrically heated catalysts to meet future California standards. The substrates on which catalysts lie inside catalytic converters are made by a number of U. S., Japanese, and European firms. Coming is a major manufacturer with manufacturing facilities in Germany and licenses to Japanese manufacturers.[38] American firms are competitive in the mobile source controls market.

Catalytic converters require unleaded gasoline. The technology for producing low-sulfur fuels and unleaded, reformulated, and oxygenated gasoline can also be a source of revenue for U.S. firms. For instance, Mexican refineries are being adapted to make less-polluting fuels. The U.S. companies HRI, Texaco, and Foster Wheeler are under contract to provide technologies for three Mexican refineries.[39] Refurbishment and replacement of public transit vehicles—including vehicles powered by natural gas-are yet another export chance created by environmental concerns; and another area where U.S. manufacturers face strong foreign competition.

Solid and Hazardous Waste Management

Many developing nations have limited capabilities for safe and efficient waste collection and disposal. For instance, there are no sanitary landfills in Pakistan.[40] Turkey, an OECD member, has neither sanitary landfills nor incinerators, and Mexico's landfill capacity is sufficient to meet the needs of only 21 percent of the population.[41] Modem facilities for the management of hazardous and specialized (for instance, medical) wastes are often lacking; these wastes frequently end up being left at municipal dumps if not in wetlands, quarries, or along roads. Recycling, however, can occur at relatively high rates within the informal sector of developing country economies as poor people salvage materials from the discards of others.[42]

As countries seek to develop waste handling infrastructures, business opportunities arise for architecture/engineering and construction firms to design and build landfills and incinerators; for suppliers to sell a range of products, from landfill liners and trash handling equipment to incinerator/waste-to-energy technologies and monitoring instruments; and for service companies to operate disposal sites and recycling centers. Among larger national waste management programs are Taiwan's plans to spend $3.5 billion on 23 solid waste disposal projects during the current Six-Year Development Plan and South Korea's 1991-95 plan to invest $2.6 billion by 1995 on waste management projects, including 55 incinerators.[43] South Korea also plans to construct 34 sanitary landfills over the next 20 years. Energy recovery and pollution abatement for existing refuse incinerators in places like China also present market opportunities.

American and European firms are establishing hazardous waste treatment facilities in developing countries. Waste Management International, subsidiary of Waste Management, Inc., operates hazardous waste facilities in Hong Kong and Singapore and is in the process of building such a facility in Java,

37 Stephen Lipmann, "U.S. Environmental Companies' Competitive Strategies: Eleven Case Studies," OTA Contractor Report, March 1993.

38 Clifton L. Smith, Corning Inc., presentation at "The Clean Air Marketplace," Tysons Corner, V' Apr. 22-23, 1992.

39 USAID, *Energy and Environment Market Conditions in Mexico*, Business Focus Series, March 1992 (available through USAID, Arlington, VA), p. 27.

40 Aban Marker Kabraji, Pakistan's representative to the International Union for the Conservation of Nature and Natural Resources, Presentation at GLOBE '92, Vancouver, BC, Canada, Mar. 16-20, 1992.

41 International Finance Corporation, *Investing in the Environment. . . .* Op cit., p. 16.

42 Ibid.

43 American Institute in Taiwan, Op cit.; Republic of Korea Ministry of Environment, Op Cit.

Indonesia.[44] The Danish company I. Kruger has won the contract to develop in Malaysia an integrated hazardous waste treatment and disposal facility along with three regional collection centers; facilities are expected to be on-line by 1995.[45] In Brazil, a $60-million facility featuring a $30-million Finnish incinerator will be built by Ecoclear (Italy) and Gestao de Empreendimentos (Brazil) in Rio de Janeiro.[46] American firms account for over 70 percent of Mexican imports of solid and hazardous waste equipment (1989).[47] U.S. opportunities in waste-to-energy facilities and hazardous waste incineration are strongly challenged by German, Japanese, Swiss, and Scandinavian firms.

As in the case of water and wastewater treatment infrastructure development, most expenditures for nonhazardous and hazardous waste management are likely to be spent on locally obtained labor and materials and on lower-technology components for which U.S. firms may not be the low-cost supplier. American companies can be competitive in design, management, and operation of private or govemment-contracted facilities, and in the supply of relatively sophisticated materials handling, treatment, incineration, and monitoring equipment. Incinerators and waste-to-energy plants present opportunities for supply of air pollution control equipment, while water pollution treatment technologies may be required for sanitary landfills.

Industrial Production

The success of the NICS, which other developing nations are trying to replicate, depended on rapid growth in manufacturing industries. Industrial growth brings increased pollution but also can contribute to the prosperity needed that can be used to battle pollution. Polluting industrial activities found in the NICS and developing countries are too numerous and heterogeneous to discuss succinctly. They range from myriad small metal shops and tanneries to large chemical, petroleum refining, and steel complexes. Textiles, primary metals, food products, electronics, automobile assembly, plastic and rubber products, paper and pulp, cement, and manyotherproducts made for domestic markets and for export generate varying levels of pollution when made.

These sectors are increasingly regulated or coming under other forms of pressure to control wastes and pollution. Thus, opportunities arise for purveyors of environmental goods and services to help retrofit, modernize, and develop newer and cleaner industrial facilities. For instance, state oil companies plan to make investments to improve the environmental performance of their refineries in Brazil, Mexico, and Taiwan.[48] Private and state-owned mining and smelting companies in Chile are making or plan to make investments in scrubbers and new smelting equipment to lower sulfur dioxide emissions.[49] Some U. S., European, and Japanese multinational corporations bring home-country or stricter-than-local corporate environmental standards to their developing country operations. Developing countries share with the U. S., Europe, and Japan the industrial challenge of phasing out chlorofluorocarbons (CFCS).

In many cases, the environmental equipment and services required is similar to that described above for wastewater, electric power, and waste handling. Dust and particulate control is often the initial air quality priority, as standard sewage treatment is for water. Scrubbing of sulfur and nitrogen oxides, odor and hydrocarbon emissions control, and control of heavy metals and other hazardous substances are other priorities. Designing and equipping wastewater and solid and hazardous waste facilities for industrial parks is a promising area. Such environmental facilities serving numerous industrial waste and effluent generators can effect pollution control at lower costs to enterprises than if each one had its own treatment facility.

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44 Patrick Heininger, waste Management International, presentation to the U.S. Environmental Technology Seminar, Jakarta, Indonesia, Oct. 27, 1992.

45 Environmental Management and Research Association of Malaysia (ENSEARCH) Briefing to U.S. Environmental Technology and Business Mission Participants, Oct. 30, 1992.

46 USAID, Environmental Market *Opportunities*. . . . Op. cit., p. 51.

47 Ibid., p. 118 and U.S. Department of Commerce National Trade Data Bank.

48 American Institute in Taiwan, "Listing of Taiwan's. . .", op. cit.; and USAID, *Environmental Market Conditions. . . . op. cit.*

49 USAID, ibid.

Despite certain economic advantages in centralized treatment and disposal of industrial wastes and effluents, there are also environmental business opportunities at the enterprise level. For instance, metal finishers and electronic plants generate wastewater containing heavy metals. Where effluent standards exist and are enforced facilities typically use chemicals to precipitate metals into a sludge which is then removed for disposal. In developing countries, as in the United States, Canada, Europe, and Japan, there is the possibility of removing and recovering metals from water by means of ion exchange. American, European, and Japanese firms produce ion exchange resins and apparatus and could be competitive suppliers to the NIC and developing nation markets. The first reported vendor of an ion exchange effluent control system in Malaysia is RMC Dornier, a subsidiary of Deutsche Aerospace (which is owned by Daimler-Benz).[50] Ion exchange is just one example of pollution control and prevention equipment applicable to particular industries at the plant level. Solvent and aqueous bath recovery, volatile organic compound recovery or destruction, odor control, and particulate control are among others.

U. S., European, and Japanese firms are also the leading actors in the development of cleaner industrial production approaches. Often pollution prevention approaches can save money and improve quality, whereas end-of-pipe control and disposal is almost always a cost to business. Opportunities arise for architecture/engineering firms to design and for American industrial firms to invest directly in cleaner production facilities in developing countries.

Finally, past industrial activities have resulted in contaminated sites from which a hazardous substance remediation market may arise. The United States is a leader in this area because of strict requirements under Superfund and the Resource Conservation and Recovery Act. Underground storage tank requirements and attention to contaminated Defense and Energy Department sites further propel the U.S. EGS industry. European and Japanese concerns over their contaminated lands have stimulated remedial activities in those countries, sometimes using American developed technologies but sometimes employing their own technologies (e.g., Dutch soil washing technology). However, remediation markets in developing and NIC economies are likely to remain quite modest for some time. Developing country environmental priorities generally lie in limiting additional environmental insult through establishment of wastewater treatment and waste disposal infrastructure, and requiring environmental controls on new and existing industrial facilities. Furthermore, many developing countries have had a relatively short history of activity in toxic chemical-intensive industries. Although there may be individual circumstances where contaminated sites present an extraordinary hazard or where leaked chemicals and fuels might be recovered for use, generally remediation will be a lower priority.

Environmental Monitoring

Although relatively small, the market for environmental monitoring and testing can be the linchpin for the development of environmental regulations, standards, and enforcement. As such, the use of development assistance and export promotion programs to target developing and NIC markets in environmental monitoring and testing instruments may yield long-term commercial dividends.

Countries developing an environmental regulatory capability need to be able to monitor the state of the environment, establish quantifiable standards, and monitor compliance. Pollution-monitoring devices, analytical instruments, fine chemicals and chemical test kits, and various laboratory supplies are required to perform such functions. Instruments and laboratory protocols adopted by a country's environmental agency might determine the types of instruments that will be used by state or provincial officials, municipalities, water and sewer authorities, private laboratories, and regulated industries. American instrument manufacturers compete with Japanese, German, and other European manufacturers. In southeast Asia, Australian instruments also compete. Cost as well as precision are important, so the best technology may not be the best seller. American technologies are often perceived as too expensive and overengineered. An advantage the United States does have is the good reputation the U.S. EEA and its standards have abroad, and the widespread

50 Malaysia Department of the Environment Briefing to U.S. Environmental Technology and Business Mission Participants, Kuala Lumpur, Oct. 29, 1992; and EnviroPro '92 Conference and Trade Show display, Kuala Lumpur, Oct. 30, 1992.

use of American Water Works Association, Water Environment Federation, and other U.S. industry and professional standards internationally. America's European and Japanese competitors are interested in promoting the use of their standards in developing country markets.

Japan's funding of environmental management centers in several Asian countries has the potential to strongly influence the choice of instruments and standards in those countries. For instance, Japan is financing and equipping the central reference laboratory for the Indonesian environment agency BAPEDAL.[51] The use of Japanese manufactured equipment for official standard-setting and monitoring may influence provincial and local authorities and private companies to purchase like equipment from Japan. The provision of equipment to standard-setting and enforcement agencies can be a gateway to further sales.

CONCLUSION

The trends point to increased environmental concerns in developing countries. Improvements in infrastructure, expanding industry, and growing environmental administrative capacity point toward an expanding market for environmental technologies and services. While much of the environmental expenditures will flow to local and regional providers of labor, materials, and lower-technology products, there will be important opportunities for American companies to export their equipment, instruments, and technical and managerial expertise. U.S. environmental companies face considerable competition from foreign firms, chiefly from Europe and Japan but also from developing and newly industrialized country companies with growing capabilities.

[51] BAPEDAL, Briefing to U.S. Environmental Technology and Business Development Mission Participants, Jakarta, Indonesia, Oct. 26, 1992.