THE ENVIRONMENTAL TECHNOLOGY INDUSTRY

The increase in the world's wealth and population means that the impact people will have on the environment will also increase. It can be restrained only in two ways: by changing people's behavior, or by changing the technologies they use.

Francis Cairncrosss, 1995[1]

OVERVIEW

Historically, the introduction of new and innovative technology has been detrimental to the environment. The refined use of fossil fuels help usher in the industrial age which introduced widespread use of plastics, man-made chemicals, automobiles and a host of other goods and properties that promoted wholesale destruction of much of the earth's natural resources. However, the use of environmental technology to manage, treat and protect our resources also has a long history. Human beings have always had need to channel and provide drinking water and dispose of their waste such as the aqueducts of Rome or waste collection by various Native American tribes. The modern environmental industry in the United States dates back to the early 1800s and the introduction of water systems management, sanitary engineering and waste management.

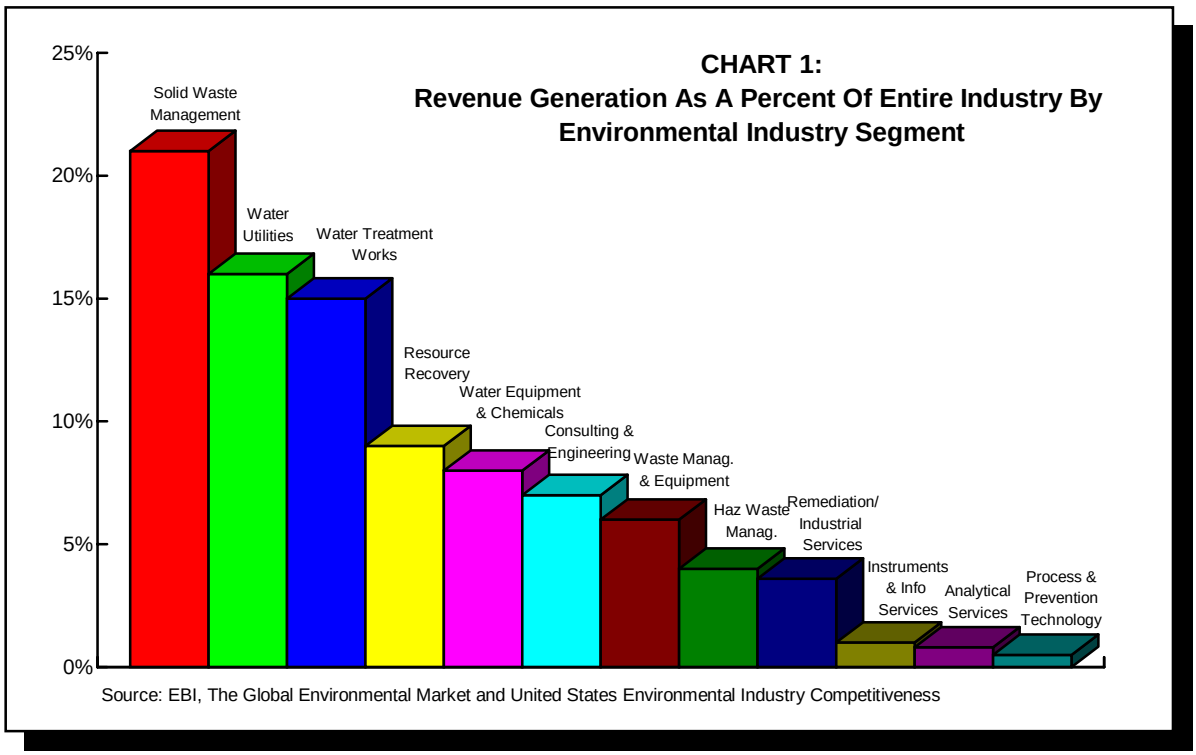
As the planet became more crowded and industry grew, treatment technologies came into being to help detoxify an increasingly polluted environment. In the US, the last century has seen industrial development grow at such a pace that government regulations became necessary to manage and treat the vast quantities of waste generated throughout the country. With the onset of the National Environmental Policy Act, the Clean Water Act, the Clean Air Act, Superfund and the Safe Drinking Water Act, as well as a host of other environmental regulations, a new industry was born to develop the technologies necessary to help businesses comply with these new laws. Yet, historically, the term "environmental technology" has had no meaning and no official definition. As a result, until recently, technologies and services that help the environment have never been indexed, they have never been economically assessed and revenues generated from the environmental industry have never been calculated. There was little thought given to innovative technology when environmental regulations were established, and there is still a great resistance on the part of the government to help a private industry that has been stamped with the undesirable label of "green."

Environmental technology and the environmental industry as a whole, is at once very easily defined and yet highly blurred at the edges. No one would debate that a new experimental water treatment facility in San Diego that converts wastewater to drinking water is environmental technology. Yet it can also be argued that a low cost incinerator on the banks of the Ganges that cremates bodies better than the old fashioned funeral pyre, is also environmental technology because it saves the river from accepting tons of partially burned human remains every year. As a result, the industry is in the process of being defined and catalogued in order to determine just how much revenue is derived from the industry on a yearly basis and what sectors are growing or declining. With no major organisation lobbying on the industry's behalf it is crucial to determine its impact on the US economy in order to

[1] Cairncross, Frances. *Green, Inc.* Earthscan Publications, London, 1995.

garner support from Congress and major agencies and departments such as the Environmental Protection Agency (EPA), the Department of Energy, the Department of Defense and others.

This chapter provides an introduction to environmental technology and provides a discussion of the barriers facing the industry. It starts with an overview and then provides the current accepted definition of environmental technology in the United States as defined by Environmental Business International, Inc. (EBI). Currently, the only country that gathers consistent data (size and types of environmental expenditures by industry) on the environmental industry is the United States. EBI has been working with the US Department of Commerce and the OECD to both standardise the definition of the environmental industry and to collect information on and survey environmental companies in the United States and around the world. Their definition and information on the industry is widely hailed as the best available. EBI has broken the industry into 14 segments. Chart 1 below presents those segments by revenue generation, with solid waste the largest segment and process and prevention technology the smallest. Following industry definition, this chapter briefly reviews the state of the industry and then concludes with a discussion of the barriers facing the industry.



INTRODUCTION

The US environmental Industry generates three percent of the nation's gross domestic product, and includes over 30,000 private companies.[2] The Organization for Economic Co-operation and Development (OECD) estimates the current worldwide market for environmental goods and services as $400 billion and the largest national market is the United States, accounting for roughly 40 percent of the world market. The domestic environmental technology industry is now larger than many other industries considered important to the growth of the US economy including computers, plastics and

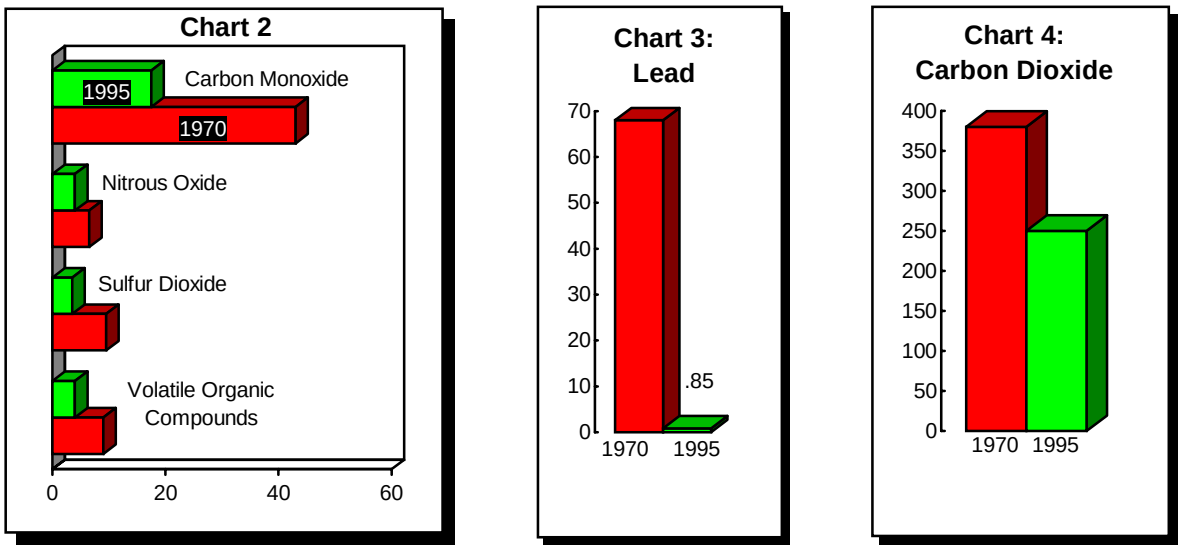
[2] Berg, David and Grant Ferrier. *Competitiveness of the US Environmental Products and Services Industry.* Environmental Business International (EBI). Draft Publication. March 25, 1997.

pharmaceuticals. However, the US market is starting to mature in most sectors of the industry, and is expected to grow at a slower rate than the rest of the world market.

As a whole, the environmental industry (approximately 70 percent) is dominated by service providers and is primarily focused on cleanup technology and services. Much of the services and cleanup sectors of the environmental industry have grown slowly over the past few years, however, the pollution prevention technology sector has increased by almost 15 percent. Other high growth areas include technologies for resource recovery and energy conservation.[3] The environmental technology industry is extremely diverse, covering a variety of high and low technologies and services. From precision monitoring instruments and consultancies, to recycling bins and waste transportation services, all are included in the environmental technology industry. As a result, there are relatively few barriers to entry for many sectors of the industry and it has provided a remarkably fertile ground for start-ups and entrepreneurs.[4] To date, there are over 60,000 small and medium-sized environmental firms in the United States, making up the bulk of the industry.[5] Most of these environmental enterprises are specialized, owner managed and offer a limited range of equipment and services.

Federal investments in environmental technology have increased from approximately $550 million in 1970 to $4 billion in 1994. According to the National Science and Technology Council (April, 1995), this investment has paid off through demonstrated success in dealing with many environmental problems. For example, as Charts 2, 3 and 4 below present, new technology has largely been responsible for often drastic reductions in hazardous air emissions from 1970 to the present. Since 1972, a national investment in water pollution control has helped restore water quality in a variety of United States underground and surface water resources. In other areas, however, environmental technology has not been able to offset increases in population and consumption which have made the United States the largest waste producer in the world.

Charts 2 - 4*:
Air Emissions
(grams/$ gross domestic product, 1987 dollars)



*Source: National Science and Technology Council, 1995.

[3] National Science and Technology Council. *Bridge to A Sustainable Future: National Environmental Technology Strategy.* US Government Printing Office, April, 1995.
[4] OECD, 1992.
[5] Karliner, Joshua. "The Environmental Industry: Profiting From Pollution." *The Ecologist.* Vol. 24, No. 2, March/April, 1994.

There are many more environmental problems to be researched, and a host of new technologies that need to be developed or introduced. Developing, commercializing and expanding new technologies requires capital, however, and the environmental industry attracts very little private investment. Because government regulations are the primary drivers of the market, the environmental technology industry is at the mercy of uncertain legislation and sporadic enforcement. The unintentional result is higher risk associated with investment in the industry and a reluctance on the part of lenders to underwrite significant environmental technology purchases. Exporters face additional challenges when looking for financial backing for entry into a foreign market. The financial and legal aspects of exporting tend to be far more complicated than domestic opportunities, and this expertise tends to be beyond the small and medium-sized businesses that comprise the majority of the environmental technology industry. In addition, in developing countries where need may be greatest, there is little government funding for environmental protection. [6]

THE ENVIRONMENTAL TECHNOLOGY INDUSTRY

As stated above, there is no universal definition of environmental technology, and the size of the industry depends on how it is defined. The industry includes companies that sell products and services in pollution prevention and pollution cleanup. Products may control hazardous air emissions or water quality. Services could include environmental assessment or regulatory advice. The environmental technology industry is pollution control equipment, solid waste recycling, hazardous and toxic waste technologies, sewage treatment, heavy construction and the wholesale trade of scrap and waste. In other words, environmental technology is a widely diverse industry.[7] However, according to EBI (1997), the US environmental industry can be broken into the following three segments:

- Service Segments: Operations that obtain their revenues by collecting fees for services rendered.
- Equipment Segments: Manufacturers that obtain their revenues from the sale of equipment.
- Resources Segments: Entities that obtain their revenues from the sale of resources (e.e., water or energy) or reclaimed materials (like steel or paper).

Table 1 below further breaks down and describes the various industry segments that make up environmental technology.

TABLE 1:
ENVIRONMENTAL INDUSTRY SEGMENTS

Segment	Description	Examples of Clients
Environmental Services		
Environmental Testing & Analytical Services	Provide testing of "environmental samples" (soil, water, air and some biological tissues).	Regulated industries, government, Environmental Consultants, Hazardous waste and remediation contractors
Wastewater Treatment Works	Collection and treatment of residential, commercial and	Municipalities, Commercial establishments and Industry

[6] Ibid.

[7] CTCA. *Industry Profiles: Environmental Technology.* California Trade and Commerce Agency, 1997.

TABLE 1:
ENVIRONMENTAL INDUSTRY SEGMENTS

Segment	Description	Examples of Clients
	industrial wastewaters.	
Solid Waste Management	Collection, processing and disposal of solid waste.	Municipalities and Industry
Hazardous Waste Management	Manage ongoing hazardous waste streams, medical waste, nuclear waste handling.	Chemical companies, Petrolium companies, Government agencies
Remediation Industrial Services	Physical cleanup of contaminated sites and buildings and environmental cleaning of operating facilities.	Government agencies, Property owners, industry
Environmental Consulting & Engineering	Engineering, consulting, design, assessment, permitting, project management, monitoring, etc.	Industry, Government, Municipalities, Waste management companies, Public works
Environmental Equipment		
Water Equipment & Chemicals	Provide equipment, supplies and maintenance in the delivery and treatment of water and wastewater.	Municipalities and Industry
Instruments & Information Systems	Produce instrumentation for the analysis of environmental samples. Includes information systems and software.	Analytical services, Government regulated companies
Air Pollution Control Equipment	Produce equipment and technology to control air pollution. Includes vehicle controls.	Utilities, Waste-to-energy industries, Auto industry
Waste Management Equipment	Equipment for handling, storing or transporting solid, liquid or hazardous waste. Includes recycling and remediation equipment.	Municipalities, Industry, Auto industry
Process & Prevention Technology	Equipment and technology for in-process (rather than end-of-pipe) pollution prevention and waste treatment and recovery.	Industry
Environmental Resources		
Water Utilities	Selling water to end users.	Consumers, Municipalities and Industry
Resource Recovery	Selling materials recovered and converted from industrial by-products or post-consumer waste.	Municipalities, Industry and Solid waste companies
Environmental Energy Sources	Selling power and systems in solar, wind, geothermal, small scale hydro, and energy efficiency	Utilities, industry and consumers
Source: EBI Inc., March, 1997		

At The Crossroads

Environmental technology is at a crossroads. According to EBI (1997), "the financial performance of the environmental industry has been substandard since 1991."[8] Much of the environmental industry is experiencing a consolidation of smaller firms into medium to large sized firms. Generally, many segments of the industry which rose in the 1970s and '80s, suffered overcapacity in the '90s. Simply put, there were too many small firms and not enough work as the recession took its toll. Indeed, even

[8] EBI. *Competitiveness of the US Environmental Products and Services Industry.* March, 1997, p.2-39.

major firms felt the "crunch" as evidenced by a number of mergers in the industry. Downsized government agencies and private businesses started looking for more comprehensive consulting services to keep themselves competitive. As a result, one company was often expected to take on a project from start to finish. Engineering firms were expected to perform environmental analyses and environmental firms were expected to build bridges. In response to these demands major engineering and construction firms such as Fluor Daniel, merged with environmental and remediation specialists like Groundwater Technology.[9] Unfortunately, as clients demanded more service, the smaller, single-purpose firms found that they could not compete. In California alone, of the approximately 250 environmental consulting firms, over 20 percent closed between 1994 and 1996, leaving fewer than 200 in the state. Even worse, about half of the environmental firms in US EPA Region 9 (Nevada, Arizona, Hawaii, and California) with ten employees or less, and approximately 30 percent with 11 to 25 employees also went out of business in the same time period.[10]

Environmental regulation has also become largely stunted as basic command and control standards have been met, and newer more innovative regulations have not been introduced. In general, command and control regulations take two forms: 1) "either the government specifies the technology an industry or factory must use to control pollution, or 2) it sets an emissions-rate cap that all pollution sources must meet regardless of the relative cost to each source."[11] Since the Republicans gained control of Congress in 1994, the anti-regulatory environment has intensified. Only a veto by President Clinton stopped a 21 percent cut in the EPA's enforcement budget that would have left the Agency unable to protect the environment.[12] As it is, there is currently a legislation limbo as reauthorization for important environmental regulations such as Superfund, the Clean Water Act, and the Endangered Species Act, have all been stalled in Congress.[13]

Overall the vast number of environmental businesses are devoted to cleaning up the "sins of the past" or controlling waste and emissions from oudated industries that will not last far into the next century. This market is finite and has already started leveling off. While still in its infancy, the move towards waste minimization and pollution prevention is already taking its toll on traditional end-of-pipe technologies and services.[14] Indeed, environmental services such as site remediation have seen their market shrink as contaminated sites are cleaned to federal standards or tied up in litigation. While the sheer number of contaminated sites means that the remediation business will remain strong into the next century, there will be little growth and little room for new players. In addition, for the many environmental segments that rely on municipal clients, such as water and waste water or waste management, only small steady growth is predicted as companies are faced with projects delays due to municipal budget problems.[15]

In general, environmental technology clients in the future will be demanding more for less. The most attractive technologies will most likely be those that reduce the cost of environmental protection. Technologies that minimize waste or prevent pollution will be in higher demand than those that treat waste at the "end of the pipe." This will be especially true in developing markets such as Asia and

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[9] Basta, Nicholas and David Veasey. "Environmental Firms React to A Cooler Market." *Chemical Engineering.* January, 1996.

[10] Lifsher, Marc. "Market Sags for Cleanup Consultants." *The Wall Street Journal, California.* Wednesday, July 2, 1997, p. CA2.

[11] Alper, Joe. "Protecting the Environment With The Power of the Market." *Science.* Vol. 260, June 25, 1993, p. 1884.

[12] Basta, Nicholas and David Veasey. "Environmental Firms React to A Cooler Market." *Chemical Engineering.* January, 1996.

[13] Basta, Nicholas and David Veasey. "Environmental Firms React to A Cooler Market." *Chemical Engineering.* January, 1996.

[14] Ferrier, Grant. "Pollution Prevention Will Reshape the Market." *Environmental Business Segments.* http://www.epa.gov/docs/epajrnal/fall94/05.txt.html. Fall, 1994.

[15] EBI. *Competitiveness of the US Environmental Products and Services Industry.* March, 1997.

Eastern Europe where environmental protection is currently seen as largely unaffordable by a majority of enterprises. In the United States, where the emphasis is traditionally placed on meeting regulations, the next generation of technologies will be expected to achieve the same or better results at a lower cost.[16] According to Environmental Business International, the future of the environmental industry lays in five distinct areas:[17]

- Water resources management, water delivery, wastewater treatment and water reuse and recycling systems;
- Transitioning waste management into resource management through resource recovery and recycling systems, as well as designing reusability and recyclability into all products;
- Energy efficiency and more sustainable energy systems from renewable sources;
- Industrial design for pollution prevention and efficiency in the form of life cycle analysis and design for the environment; and,
- The application of analytical and information technology for pollution prevention, process efficiency and operations.

Table 2 below reviews the growth projections for the various environmental industry segments discussed in Table 1 above, through 1998.

TABLE 2:
GROWTH PROJECTIONS FOR THE US ENVIRONMENTAL INDUSTRY

Industry Segment	Average Annual Growth (%) 1993-1994	Environmental Industry Revenues ($ billions) 1993	1994	1995	1996	1997	1998
Environmental Services							
Analytical	3.3	1.6	1.6	1.7	1.8	1.8	1.9
Solid Waste Management	4.1	29.4	30.6	31.9	33.4	34.7	35.9
Hazardous Waste	-0.8	8.6	8.6	8.6	8.6	8.5	8.2
Remediation	4.3	8.5	8.9	9.3	9.7	10.1	10.4
Consulting & Engineering	4.3	14.5	15.0	15.8	16.6	17.3	17.8
Environmental Equipment							
Water Equipment & Chemicals	5.0	13.2	13.8	14.6	15.4	16.1	16.8
Instrument Manufacturing	5.7	1.9	2.0	2.1	2.2	2.3	2.4
Air Pollution Ctrl Equipment	3.9	3.8	3.9	4.1	4.3	4.4	4.6
Waste Management	-2.7	11.2	11.1	10.9	10.6	10.3	9.8
Preventative Technology	15.0	0.7	0.8	0.9	1.1	1.2	1.4
Resource Recovery							
Water Utilities	4.7	23.1	24.3	25.5	26.7	27.9	29.1
Resource Recovery	5.8	15.2	16.1	17.0	18.1	19.0	20.1
Environmental Energy Sources	11.3	2.1	2.3	2.6	2.9	3.2	3.5
TOTAL US MARKET	**3.9**	**133.8**	**139**	**145**	**151.4**	**156.8**	**161.9**

Source: Chemical Engineering, January 1996.

[16] Mallet, Ed. "Challenges and Opportunities in the World Environmental Market." *Economic and Technology Development Journal of Canada.* 1997.

[17] Environmental Business International. *The Global Environmental Market and United States Environmental Industry Competitiveness.* San Diego, California, 1995.

It is difficult to calculate the exact number of environmental technology companies since many firms incorporate environmental consulting into their other services. Others maintain environmental divisions or units which are a small part of the entire company. However, some examples of companies involved in the environmental technology industry include:[18]

- Browning-Ferris Industries (waste management);
- Waste Management, Inc.;
- Romic Chemicals (recycling and resource recovery);
- Hewlett Packard (environmental instrumentation);
- Bechtel (consulting and engineering); and,
- ERM (consulting and engineering).

Path to Development

Like other technologies, environmental technology follows a familiar path from inception to commercialization. The following six steps help illustrate the basic stages of technology development.[19]

I. Idea Development. Refers to product conceptualization and initial drawings, calculations, and theoretical validation. The developer at this stage may construct a crude, inexpensive, non-functioning model for feedback from colleagues.

II. Proof of Concept. Refers to the construction of a rough, yet functioning model of the technology. This model may be less than full-scale. Its purpose is to test the most basic operating parameters and to aid in the design of a prototype (pilot).

III. Pilot Phase. Is an actual working version of the technology of adequate technical quality. It tests the technology's operating performance and gauges its production requirements and feasibility.

IV. Prototype Stage. Is the last model built before actual use of production machinery. It is a full-scale completely operational model built to conform as closely as possible with final production design standards. The prototype is used to determine the product's production requirements as well as the product's operational performance.

V. Application/Demonstration. Refers to the stage in which an actual market-ready model is manufactured in a limited production run. This stage tests the production process and produces a product that is used in third-party testing; e.g., for obtaining a federal or state government permit. This phase requires a great deal of private sector capital since very little government funding is available.

VI. Commercial Sales. Is the hopeful result of the first five stages and especially of extensive marketing and manufacturing activities (commercialization activities).

As an entrepreneur moves through the above stages, each step is usually characterized by the need for greater amounts of capital. However, as most entrepreneurs know, while the development progresses, the capital usually does not. Early stages of development are usually characterized by "sweat equity" financing, in which the technology producer builds on the investments of personal bank accounts,

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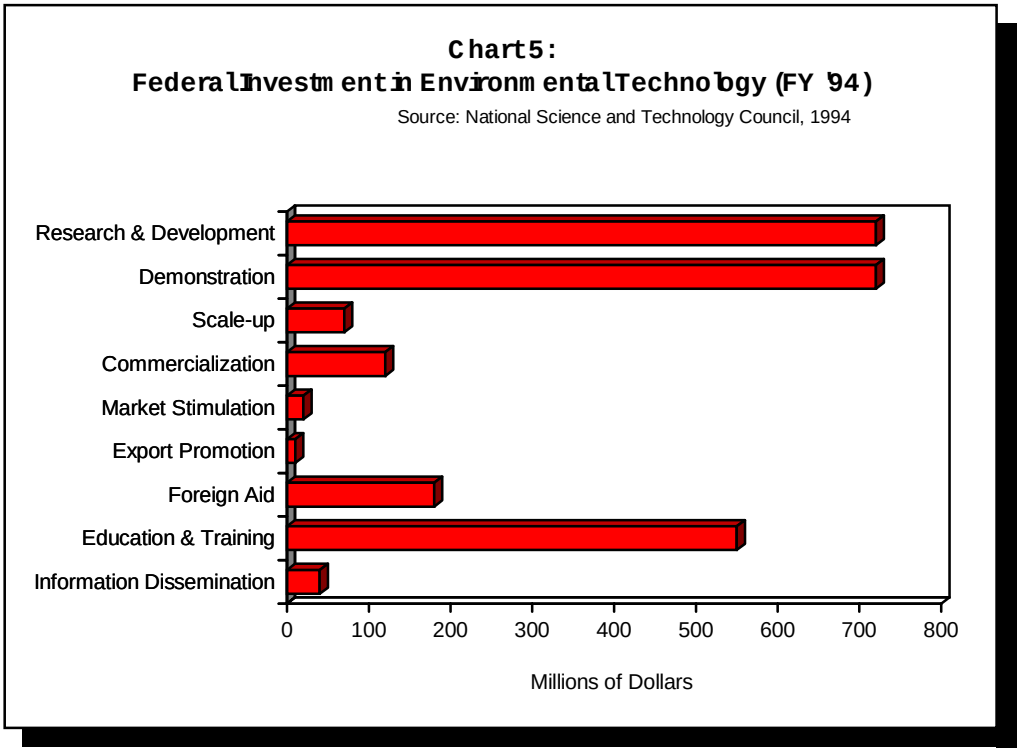
[18] CTCA. *Industry Profiles: Environmental Technology.* California Trade and Commerce Agency, 1997.

[19] Small Business Administration (SBA). *Bridging The Valley of Death: Financing Technology for a Sustainable Future.* US Environmental Protection Agency. December, 1994.

credit cards and the often meager finances of friends and family. Research and development funding from foundations, state and federal resources are also available, but not easily obtained.

Unfortunately, whatever funding is available to advance the product through the prototype phase, is usually exhausted by the demonstration and commercialization phases leaving the entrepreneur to either abandon the technology or sell it to the highest bidder (if someone is willing to buy). Furthermore, unlike the early R&D phases, government funding rarely covers later phases of development, and venture capitalists, prospective customers and investors, usually prefer to wait until a product has proven itself in the marketplace. As shown in Chart 5 below, which breaks down federal investment in environmental technology for fiscal year (FY) 1994, federal funding drops off steeply after the demonstration phase of development. Overall, only 10 percent of US investment in environmental technology comes from the public sector.[20]

In addition, federal expenditures to support environmental technology represent a small percentage of the overall US budget. In 1989, only one half of one percent was allocated for environmental technology while countries like Germany and the Netherlands devoted over three percent of their national budgets to environmental technology research and development. As Table 3 below presents, while the United States invests more money than any other nation except for Germany, it falls far behind most other OECD countries in public sector environmental R&D expenditures as a percent of the budget. Indeed, environmental technology innovation in the United States has been viewed as a secondary goal of the regulatory system, and programs to stimulate new technology barely exist. According to The National Advisory Council for Environmental Policy and Technology (NACEPT), the investment rate for environmental technology is so low that the national ability to make environmental improvements is limited by lack of technology.[21]



[20] Interagency Environmental Technologies Office (IETO). *White House Conference on Environmental Technology: Working Papers From the Conference Held in Washington, DC, December 11 - 13, 1994.*
[21] National Advisory Council for Environmental Policy and Technology. *Permitting and Compliance Policy: Barriers to US Environmental Technology Innovation.* Environmental Protection Agency, January, 1991.

TABLE 3:
PUBLIC SECTOR ENVIRONMENTAL R&D EXPENDITURES, 1989

Country	Environmental R&D Expenditures ($US mil)	% Share of Total Government R&D Expenditure
Netherlands	75	3.8
Germany	420	3.4
Denmark	28	3.0
Norway	27	2.7
Sweden	65	2.5
United Kingdom	170	2.3
Switzerland	85	2.0
Italy	120	1.9
Finland	15	1.7
Canada	50	1.6
Austria	11	1.4
Japan	150	1.4
Australia	20	1.3
France	95	0.7
United States	420	0.5

Source: OECD, 1992.

According to the Environmental Law Institute (1998), there is an obvious need for expanded investment in R&D in the environmental industry. Indeed, "[t]here is a particularly compelling rationale for government support of R&D in the environmental area, because private capital markets do not place adequate value on the social benefits of improved environmental performance and thus will not provide adequate funding for innovative environmental technologies."[22] Of total investment in research and development by the US government, which amounted to over $70 billion in 1992, less than seven percent was devoted to environmental technology.[23] In response to cries for more support for the environmental technology industry, President Clinton announced the Environmental Technology Initiative (ETI), an interagency effort led by the U.S. Environmental Protection Agency, in 1993. The initiative was created to promote improved public health and environmental protection by advancing the development and use of innovative environmental technologies. By 1995, $104 million had been invested in over 250 projects which promoted the introduction of environmental technologies in both the public and private sectors.[24] ETI projects in California included:

- Promoting cleaner processes in plating and metal finishing;
- Advancing plastics recycling;
- Researching ways to reduce barriers to innovative waste treatment technologies;
- Researching light color surfaces as heat island mitigation; and,
- Applying innovative techniques to destroy organic pollutants in air and water.

However, the present administration soon lost interest in the Initiative and during the 1996 election, environmental technology was no longer in a prominent place on the agenda. Funding dropped off,

[22] Environmental Law Institute. *Barriers To Environmental Technology Innovation And Use.* Washington, DC, 1998.
[23] Carnegie Commission. *Environmental Research and Development: Strengthening The Federal Infrastructure.* Carnegie Corporation, New York, December, 1992.
[24] Environmental Protection Agency. *About the Environmental Technology Initiative.* http://www.epa.gov/oppe/eti/eti.html.

and by 1997, the Environmental Technology Initiative had been pretty much abandoned by the Agency.

Government Funding

When considered by the federal government, the environmental technology industry is usually divided into four different categories — prevention, monitoring, control, and remediation. Each category has unique characteristics and is funded differently by the Federal Government. As shown in Chart 6 below, while control technologies dominate the US marketplace, the largest area of research investment is in prevention technologies. Like other western nations, the environmental technology industry in the United States is shifting to a higher investment in prevention technology. According to the *National Science and Technology Council* (1994) the reasons for this are threefold: 1) regulations in the developed countries are increasingly focusing on prevention rather than cleanup, 2) new international environmental standards developed by the International Standards Organization and, 3) economic benefits realized from efficient and preventative manufacturing processes.

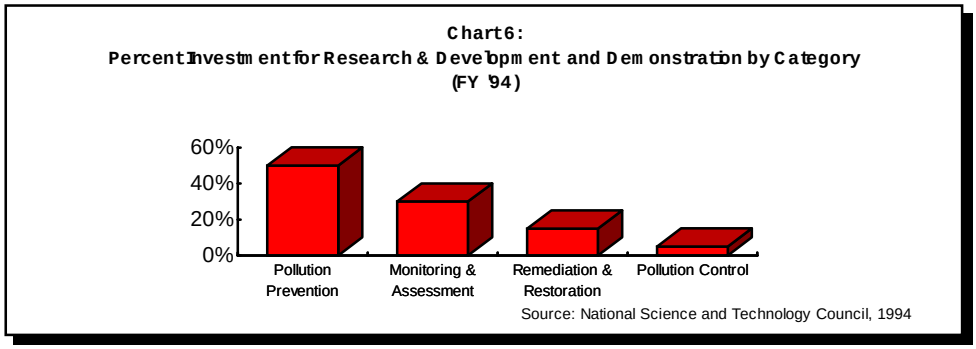
The *National Science and Technology Council* defines the four environmental technology categories as follows.

Prevention Technologies avoid the production of environmentally hazardous substances, or alter human activities in ways that minimize damage to the environment. These technologies include equipment, processes and process sensors and controls designed to prevent or minimize the generation of pollutants, hazardous substances, or other damaging materials. Prevention technologies also include those technologies used in product substitution, or in recycling and recovery of useful raw materials, products, and energy waste streams.

Monitoring and Assessment technologies are used to establish and monitor the condition of the environment, including releases of pollutants and other natural or anthropogenic materials of a harmful nature. These technologies include the design, development and operation of monitoring instrumentation with associated quality assurance and risk evaluation aspects.

Control technologies render hazardous substances harmless *before* they enter the environment. These technologies include the treatment of pollutants or other natural or anthropogenic materials to eliminate or reduce environmental and human health hazards. Control technologies also include those technologies which reduce pollutant/waste material volume or mobility to make subsequent management more effective.

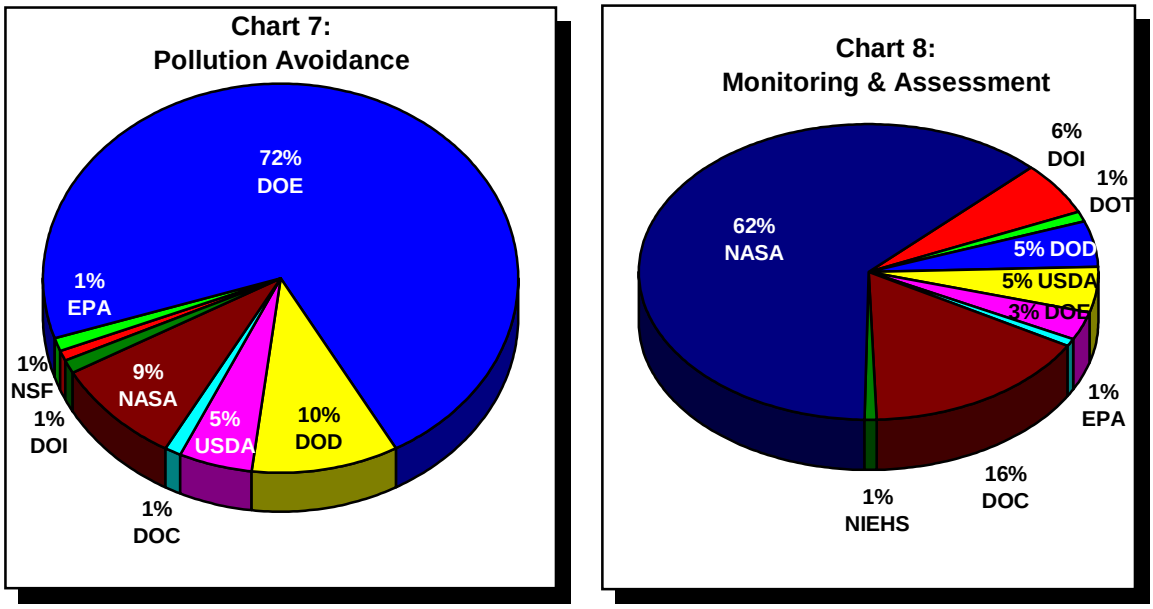
Remediation and Restoration technologies are those that render harmful or hazardous substances harmless *after* they enter the environment. These technologies include eradication, encapsulation, and other cleanup technologies that either remove the risks associated with harmful wastes or make them more manageable.

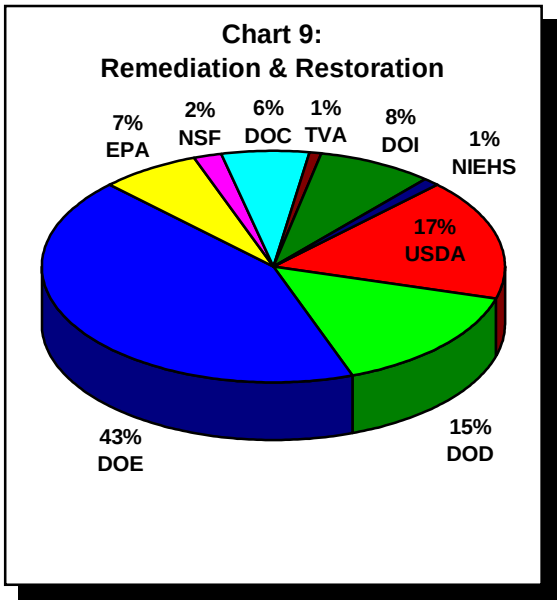


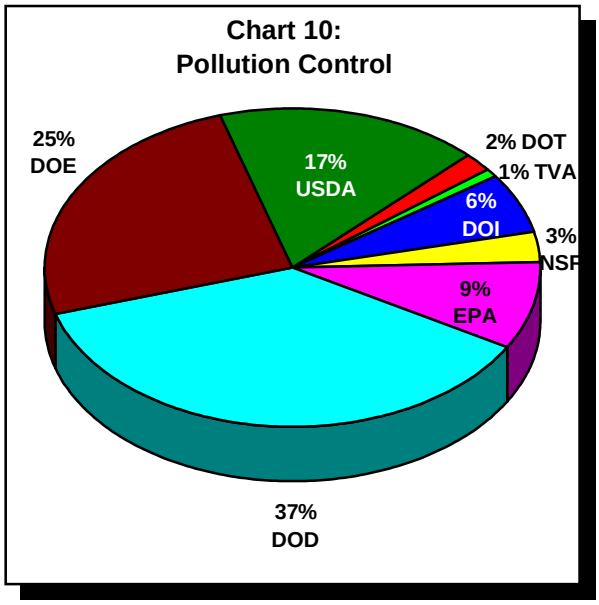
As stated above, different categories of environmental technology receive different levels of funding from various US agencies. Overall, as shown in Charts 7 through 10, the Department of Energy (DOE) and NASA provide the greatest amount of funding for environmental technology, primarily for pollution prevention and monitoring and assessment equipment.

The energy efficiency and clean energy programs at the DOE account for more than 70 percent of the total funding for pollution prevention technology. The high proportion of NASA funding for monitoring and assessment equipment is largely due to sizable programs for development of space, aircraft, and ground observational technology designed to monitor the state of the environment. DOE programs which fund more than 40 percent of the work in the area of remediation and restoration include remediation of high-level waste tanks, and mixed waste characterization, treatment and disposal. DOE and Department of Defense (DOD) control technology programs include technology for controlling pollutants from fossil fuels, and new equipment and procedures for complying with environmental regulations.

Charts 3.7 - 3.10:
Federal Research & Development and Demonstration Funding (FY '94)







Source: National Science and Technology Council, 1994.
Legend: DOC (Department of Commerce); NASA (National Aeronautics and Space Administration); DOI (Department of Interior); USDA (US Department of Agriculture); DOD (Department of Defense); DOE (Department of Energy); EPA (Environmental Protection Agency); NSF (National Science Foundation); TVA (Tennessee Valley Authority); NIEHS (National Institute for Environmental Health and Safety).

Barriers to Environmental Technology - Producers

In 1994, the US Environmental Protection Agency sponsored a survey of the environmental industry to determine some of the barriers that entrepreneurs face when trying to find capital for new technology.[25] Some barriers are typical of all new startups including unseasoned management, lack of liquidity, and higher interest rates on loans (if they can get them) due to the uncertainty of young companies introducing new and untried technologies. However, unlike most other new technologies, the environmental technology industry is driven more by state and federal regulations than the marketplace which causes a new host of obstacles that inhibit bankers and would be investors. Some of these obstacles are presented below.

Oudated Regulatory System
Pollution is controlled in the United States primarily through time honored methods such as "command and control" which favors setting standards and then defining which technologies are required to meet those standards. "[E]mission limits or discharge standards based on a single best technology create practical barriers to innovation by limiting permissible technologies to available ones that meet the standards."[26] This type of legislation leads to a virtual monopoly for one or a few types of technologies and discourages the creation of better and more innovative technologies, or even further improvements on already approved technologies. In addition, command and control legislation fails to create an atmosphere of "continuous environmental improvement" which is necessary to promote a constant investment in research and development that leads to innovation.[27]

[25] Ibid.
[26] Environmental Law Institute. *Barriers To Environmental Technology Innovation And Use.* Washington, DC, 1998.
[27] Ibid.

Because the environmental industry is driven by regulations, there is no natural market which promotes innovation. If technology users are given no regulatory incentive to try new and better methods of prevention or treatment then there is no market for advanced environmental technologies. Indeed, according to the Technology Innovation and Economics Committee which was created by the EPA, "the emphasis in the environmental management system on single-medium pollution control strategies is rapidly reaching both technological and cost limits" and that "existing permitting and compliance authorities at all levels of government lack the flexibility necessary to encourage technology innovation for environmental purposes."[28] This approach to pollution control leads to a "stutter-step" approach to research and development, where new technologies are needed intermittently as new standards are tightened or new regulations introduced.[29] According to the Environmental Law Institute (1998), as a result of an overwhelming use of command and control regulations, environmental R&D is extremely low with only three percent of annual revenues from firms which develop and sell environmental technologies devoted to research.

In addition, by relying on emission standards to control pollution, there is little incentive to incorporate environmental management and pollution prevention programs in industries that are regulated by command and control regulations. Discharge rates and emission standards are end-of-pipe solutions which leave no room for investment in programs which promote prevention as opposed to waste treatment.[30] According to the Technology Innovation and Economics Committee, "[t]he current system of single-medium permitting has achieved significant environmental gains primarily by stimulating a pollution control response, rather than by encouraging pollution prevention."[31] By comparison, when standards regulating SO_2 emissions from individual companies were exchanged for an overall industry emissions cap, a variety of alternatives to the traditional scrubbers were introduced to the industry including low-sulfur coal, fuel blending, demand side management and emissions trading. Soon after, significant improvements in scrubbers were introduced when companies began to adopt some of these other alternatives and scrubber manufacturers felt the "pinch" of competition .[32]

Permitting Processes - Financial Uncertainty

While the US environmental industry is a $140 billion business, it was founded largely on the heels of government laws and regulations and, as a result, it is susceptible not only to the whims of the national and international economy but upon the willingness of the government to enforce its own laws. During the recession of the early 1990s, federally mandated programs such as Superfund saw reduced funding, enforcement was reduced and the industry contracted. As a result, in 1993, industry revenues rose only by 2.7 percent and Green mutual funds ranked last in performance.[33]

Furthermore, according to a California venture capitalist who has invested in environmental technology, nearly every investor and developer in the environmental arena has suffered losses due to multiple permitting requirements at various levels of government, lack of materials that explain the permitting process, and multi-year permitting delays.[34] Small companies are at an even greater risk because they often do not have the resources to survive the time delays brought on by the

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[28] USEPA. *Removing Barriers and Providing Incentive To Foster Technology Innovation, Economic Productivity and Environmental Protection.* EPA 100-R-93-004, p. iv, April, 1993.

[29] Environmental Law Institute. *Barriers To Environmental Technology Innovation And Use.* Washington, DC, 1998.

[30] Ibid.

[31] USEPA. *Removing Barriers and Providing Incentive To Foster Technology Innovation, Economic Productivity and Environmental Protection.* EPA 100-R-93-004, p. vii, April, 1993.

[32] Environmental Law Institute. *Barriers To Environmental Technology Innovation And Use.* Washington, DC, 1998.

[33] *Business Week*. "A Green Industrial Policy Takes Root." July 25, 1994.

[34] SBA, December 1994.

uncertainties of permit processing. In addition, for investors, the uncertainty of whether or not the investment will ever actually be put to use before regulations change is a major deterrent.

Permitting Process - Market Fragmentation

While all states must adopt federal statutes and regulations regarding the use of environmental technology, most states have also adopted there own, often more stringent laws. Therefore, new technologies must comply with a variety of different state laws as well as federal laws if they are to be viable in more than one state. Moreover, most permits are granted on a site specific basis, not by technology, creating a market partitioned into hundreds of regional and local regulatory districts. By having vast numbers of separate regulatory districts, each requiring new testing and demonstration procedures independent of one another, significant costs are generated.

Environmental technology must also be tested by potential users to assure compatibility with their particular operations, adding another layer to the process. Another major disadvantage of current permitting procedures is that they take exorbitant amounts of time. Not only does this stymie investors, but often projects which may require environmental technology, such as a waste treatment facility, are under a tight deadline, and project engineers are more likely to choose a proven and permitted technology over a new and innovative one.[35] In addition, the time required to permit a new technology will most likely add to the cost making it more expensive to implement than conventional technology. Overall, adopting new environmental technologies is perceived as a risk and most firms have a strong aversion to risk.[36]

Regulatory Uncertainty

Producers looking for a competitive edge will often design a new technology based on anticipated regulations. However, in the case of the environment, regulations are often rescinded or altered so that the promulgated standard is set at a different level than originally proposed. As a result, the producers product may ultimately turn out to be unnecessary. Since it is difficult to synchronize innovation and production with uncertain demand, the financial community is unable to calculate the risks of investment. In addition, many companies end up jumping from problem to problem to capitalise on new regulations rather than gaining strength in one particular area. According to EBI (1997) "[T]his reactive approach has made companies well fit to respond to the latest regulatory whim, but not so fit to thrive in an environment without regulations."[37]

Indeed, my 10 years personal experience in the environmental consulting industry has shown that consultants closely monitor new environmental regulations, but will do nothing towards capitalising on the legislation until it will likely be signed into law. Once the legislation looks as though it will pass however, consultants slip into high gear, learn the regulation, find their niche, and then sell themselves to potential clients, hopefully beating their competitors in the process. This type of approach does not allow for long term planning, and the majority of the work gets "sewn up" quickly by a small number of firms, leaving those who were either slow or cautious in the wake. However, if the legislation changes, or if it does not pass, a number of firms will have wasted significant amounts of time, staff and money, leaving them to question whether they will pursue other new legislation that may be passed in the future, or simply nurture their current, safer niche. The danger in that of course, is that the existing niche may change or disappear with upcoming regulation. This persistent uncertainty leaves consulting firms, like other segments of the environmental industry, in a constant state of flux, with new internal company divisions created and old ones deleted based on new regulations that come down the pipe. As a result, most consulting firms are focused on the short term, and experience significant bouts of retraction and growth on a regular basis. According to R.

[35] Environmental Law Institute. *Barriers To Environmental Technology Innovation And Use.* Washington, DC, 1998.

[36] Ibid.

[37] EBI. *Competitiveness of the US Environmental Products and Services Industry - Draft.* March, 1997.

Steven Maxwell with Techknowledgey Marketing Services, "[i]t is very difficult to develop sound long-term marketing strategies when whole markets can be created or destroyed by the stroke of a legislative pen."[38]

Enforcement

Enforcement of EPA standards and other environmental regulatory entities is also extremely important to technologies, especially those technologies designed to meet a demand created by regulation. However, producers claim that environmental regulations are weakened due to poor enforcement. Many companies would like to comply with environmental regulations, but they fear that their competitors may not. In general, industry would prefer tighter enforcement of environmental regulations since that would place all business on a more level playing field. Unfortunately, many small businesses find it difficult to survive as the market stagnates from weak enforcement. In addition, the variation in enforcement from one presidential administration to the next has led to serious growth fluctuations within the industry.[39]

Testing

Without testing and demonstration, a technology will never be commercialised. Indeed, the demonstration phase of development is a critical step for an environmental technology since demonstration is needed not only for government permitting, but also for potential investors and customers. Ideally full-scale testing should occur under real world conditions at a site where environmental problems exist. Unfortunately, because regulations vary from state to state, new technologies must be tested and retested at multiple sites in multiple states. This cost is often compounded by the lack of sites to test a product. Current regulations do not encourage industries to test promising technologies while maintaining compliance with existing standards. As a result, due to the penalties for non-compliance, potential customers rarely allow unproved technologies to be used on their premises.

In addition, there is little financing available for demonstration. Most lenders and investors will not back an unproved product, preferring to wait until the technology is verified and commercialised. Yet the technology producer cannot commercialise his technology until it has been fully demonstrated. Bankers and investors are also unlikely to offer funding to small environmental entrepreneurs if they have no confirmed customer base for their technology. However, customers are unlikely to hire the entrepreneur if he lacks a permit for his technology, but the entrepreneur is unlikely to receive a permit until he can identify sites (i.e., customers) where his technology will be implemented.[40] This "Catch 22" situation is prevalent throughout the industry and can only be resolved through a formalised permitting process at both the state and federal level.

Technology Lock-In

Customer's fear of non-compliance for using innovative, untested technologies creates a tremendous marketing barrier for environmental technology producers and leads to "technology lock-in." Regulated industries are reluctant to part from using the technology upon which a standard is based and which the EPA describes in control technology guidance documents accompanying the regulation. Therefore, even the entrepreneur with a less expensive or more effective technology often finds it difficult to penetrate the market.

Furthermore, permitting officials are also reluctant to risk the potential environmental consequences of approving an innovative technology. Enforcement personnel do not normally grant exceptions for businesses that make real attempts to comply using innovative approaches, but fall just short of

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[38] Maxwell, R. Steven. "The Challenge of Environmental Technology Development." *GMI*. April, 1994, p. 58.

[39] Interagency Environmental Technologies Office (IETO). *White House Conference on Environmental Technology: Working Papers From the Conference Held in Washington, DC, December 11 - 13, 1994.*

[40] Ibid.

regulatory levels. There is no incentive to try anything new when previously approved technologies will result in full compliance with no hassles or headaches. Technology users know that they receive no rewards for exceeding regulatory requirements so they have no reason to try better methods of prevention and treatment. As a result, the same old technologies are used year after year and newer more innovative technologies are frozen out of the market.[41]

Lack of Information

Accurate and current information is critical to investors and producers to assess the market's needs. However, such information is not readily available in the environmental industry. Standard Industrial Codes (SIC) have only just recently been applied to the industry, so overall industry performance is still widely unknown. In addition, the reluctance of the industrial community to publicize (as opposed to hide) its environmental difficulties means that there is a slower response from the marketplace to improve the problem. Consequently, industries that actually develop effective responses to their own environmental problems will rarely disclose these new environmental technologies, thus hiding promising solutions from the marketplace.

Government Technology Programs

As discussed above, government technology programs focus on R&D and then leave the technology financially hanging when it comes time to commercialize the product.

Lack of Financial Investment

Since the industry is new, there are few success stories. Indeed, most venture capital firms experiences with early stage environmental technologies has been negative, which has set a poor precedent for other investors to follow. According to a report from a 1994 Environmental Industry Summit Meeting, one of the problems facing the industry is that there is no textbook study on how to make money in the environmental industry.[42] The financial community is highly wary of investing in the industry. Dag Syrrist, a venture capitalist with Technology Funding, Inc. stresses the importance of "strong standards which are predictable and enforceable, and flexibility in meeting those standards.[43] He states that the non-investment in environmental technology is not a "cash problem." There is plenty of funding to go around, but investors prefer an industry with a high rate of return that is not subject to the whims of government regulation. Bankers have also emphasised the need for a predictable and stable market.

Unfortunately, the environmental technology funds (i.e., green funds[44]) that were set up in early '90s to attract investors interested in capitalising on the growing international need for pollution management, have mostly failed. As of 1997, there are roughly four funds left in the United States after a high of twelve only three years before. Not surprisingly, analysts have attributed the decline in green funds to an overall weakening of demand for environmental products and services, poor enforcement of environmental regulations, and a waning of public interest in environmental issues.[45] Since 1994, the average environmental fund in the United States provided a return of 37.7 percent as opposed to non-environmental or ethical funds which provided a return of 65.4 percent.[46] While 37.7

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[41] Environmental Law Institute. *Barriers To Environmental Technology Innovation And Use.* Washington, DC, 1998.

[42] Environmental Business Council. *1994 Environmental Industry Summit Meeting*. US Environmental Technology Council, JW Marriot Hotel, Washington, DC, September 12-13, 1994

[43] Ibid.

[44] Green funds should not be confused with Ethical or Socially Responsible funds. Ethical funds may include environmental technology, but they also screen out technologies or services that are incorporated in unfavorable industries such as hazardous waste or oil.

[45] Brocklehurst, Ann. "Sapling Green Funds Failing to Bear Fruit." *International Herald Tribune.* Saturday-Sunday, June 7-8, 1997, p.17.

[46] de Aenlle, Conrad. "Eco-Friendliness is Not the Business of Business." *International Herald Tribune.* Saturday-Sunday, June 7-8, 1997, p.19

percent is not a bad return, given the choice, investors have inevitably turned to the more profitable funds. According to Harch Gill, with Envirogen, a company that specialises in waste treatment and cleanup, "Wall Street appears to have a lack of interest in the environmental market in general, and that is warranted due to the lackluster performance shown by most environmental firms."[47]

Other barriers to investment include the majority of barriers mentioned above. Because of the uncertainty of the permitting process, lack of enforcement, fragmented markets, and difficulties with testing, inventory are rarely interested in a new technology until it has been tested, permitted and commercialised. Market size is a particular concern. Whereas a new drug certified by the Food and Drug Administration receives instant access to the entire country, a permitted environmental technology can, at best, corner the market one state at a time, with each state escalating the cost and time of commercialisation.[48]

Financial Institutions Lack of Familiarity

Some financial institutions have shied away from environmental technology because they do not know or sufficiently understand the industry. The industry is often perceived as high risk (for reasons discussed above) with low returns. In addition, according to Paul Hardiman with the Bank of Boston, many lending institutions are concerned about the regulatory environment surrounding the industry, and they are wary of the amount of time it normally takes a new technology to be licensed or approved. Hardiman also notes the lack of willingness on the part of users to implement new technologies and the slow growth rate of most environmental technology industries.[49]

Finally, technology producers also suffer a general mistrust of their new technologies due to;

- Lack of consistent and credible testing protocols and performance data;
- Lack of an independent review and verification of vendors' performance claims; and,
- Inadequate mechanisms for the dissemination of information among individuals, businesses and Federal agencies on the availability, applicability, costs, and performance of new environmental technologies.[50]

Opportunities and Problems in Technology Transfer

Technology transfer from a public or private resource to a small business can occur in several forms ranging from providing informal information, to licensing, joint development ventures and outright sale of technology. There are numerous federal laboratories and large universities carrying out research in environmental technology. There are also a number of small, entrepreneurial businesses that would like to capitalize on this research and commercialize the new technology.

However, while detailed technology transfer procedures normally exist which are intended to simplify and direct the process, completing a final legal arrangement is a very lengthy, expensive and ultimately unlikely proposition for small businesses. The laboratories have tacitly recognized this and some now have small business initiatives for technical assistance in addition to the other legal transfer forms. Ultimately, though, the process is still uncertain, and successful technology transfer usually results from initiative, persistence, and good timing. Generally no rules or guidelines exist and everything is negotiable. In all cases, person-to-person interaction is mandatory and is the ultimate arbiter of success.

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[47] Fitzgerald, Patrick. "Big Investment Chill." *Chemical Marketing Reporter.* v. 249, n22, May 27, 1996.

[48] Environmental Law Institute. *Barriers To Environmental Technology Innovation And Use.* Washington, DC, 1998.

[49] Interagency Environmental Technologies Office (IETO). *White House Conference on Environmental Technology: Working Papers From the Conference Held in Washington, DC, December 11 - 13, 1994.*

[50] Economic Barrier Group. *Economic and Institutional Barriers to Innovative Environmental Technology.* Environmental Protection Agency, July, 1993.

Barriers to Environmental Technology - Users

While the primary focus of this Chapter is on producers of environmental technology, it must also be concerned with users, since both face serious barriers to financing. The environmental technology entrepreneur has little chance for success if he has no customer who can afford to purchase his product.

In addition to the difficulty that manufacturers experience introducing new technology, potential buyers are reluctant to try new technology and more often than not begrudge the regulations that make them purchase environmental technology in the first place. Companies in the market for environmental technology are often unaware of the potential advantages, particularly in financial terms. Traditionally, environmental technology investments have been seen as a drag on corporate productivity and competitiveness and have, at best, been viewed as simply a cost of complying with environmental regulations.[51] The information on the financial advantages of environmental technology is often not fully available, since in some cases, accounting systems do not fully capture those benefits (i.e., money saved in the long-term due to reduced clean-up costs after incorporating pollution prevention technology into the production process). Thus, it becomes more difficult to make a financial case to the buyer and the providers of capital.

Some of the other barriers facing environmental technology users are presented below.

Small and Medium-Sized Firms
Small and medium-size enterprises, in particular, are frequently inhibited from making environmental technology investments for a variety of financial reasons, ranging from the cost of capital for such investments to the absence of appropriate funding instruments. Smaller companies are typically highly leveraged and thus in a weak position to seek long-term financing for capital expenditures. Indeed, a recent Dun and Bradstreet survey found that most small businesses depend on credit from suppliers as their most popular source of financing which puts additional capital pressures on poorly funded environmental technology producers.[52]

Competition for Capital
Another important obstacle to the diffusion of environmental technology is that, in a wide range of situations, the benefits of environmental technology investments are less immediately important to enterprises than competitiveness-boosting alternatives. In other situations, the gains from resource-efficiency and cleaner production are more attractive in the aggregate than they are at the micro level. A more energy-efficient economy, for example, may boost national competitiveness, yet the immediate financial benefits may be insufficient for a particular organization when it is more interested in, say, investing in product quality improvement due to rapidly changing export market conditions.

Lender Liability
When considering providing a loan to a small businesses which generate pollutants, a lender is most concerned with the three following possibilities:[53]

[51] Commission on Sustainable Development. *Environmentally Sound Technology Transfer.* United Nations, 1994.
[52] SBA, December 1994.
[53] Pugin, Catherine M. *P2 Financing: The Banking Outreach Project.* Environmental Protection Agency, Environmental Services Division for Region III, Philadelphia, November, 1993.

- The costs of compliance or fees for cleanup that the small business must pay can severely impact its cash flow and potentially put the company out of business, thereby impairing the borrowers ability to repay the loan;
- Property held as collateral which becomes contaminated loses its value; and,
- If the bank forecloses on contaminated collateral, it may be liable for cleanup costs.[54]

In general, banks are unwilling to lend to any business that has environmental problems. Because of potential liability, lenders are extremely reluctant to provide loans to those industries that cause or may cause environmental problems. They are especially reluctant concerning those industries that generate hazardous waste such as petroleum or chemical producers. For these industries, a financing problem can be particularly acute since banks will most likely not accept real estate as collateral for fear that a default will mean the bank inherits potentially contaminated lands. For small businesses that have little more than the land on which they operate, establishing a source of capital becomes almost impossible - even to purchase cleanup or pollution prevention technology.

Increasing the Debt Burden

One of the most difficult obstacles in obtaining a loan for environmental technology, is that the equipment for which the loans are requested does not increase business operating revenue. Instead, it effects cash flow negatively and the debt burden is increased. In addition, most banks question the validity of the intrinsic value of environmental technology as collateral. A lack of familiarity with the industry makes it difficult for lenders to estimate the resale value of the technology. Bankers and borrowers alike are concerned that a technology or standard which is required today may change within a few years, wasting money, and possibly requiring another investment in equipment.

Regulatory Awareness

Many small businesses are unaware of environmental regulations, and companies that seek to conform with environmental regulations do not always know how to comply. Often small business owners, because of limited temporal, financial, legal, and technical resources, are unable to comprehend overly complex regulations and those that are overlapping, inconsistent and redundant. In other cases, many small businesses are reluctant to contact regulatory agencies for advice on regulatory compliance out of fear that the agency will send inspectors to the inquiring business and punish any violations uncovered.

Pollution Prevention Technology Barriers

The environmental industry has grown by leaps and bounds in the last three decades, and much of that is due to the significant increase in environmental legislation since the National Environmental Policy Act was past in 1970. With national outrage focused on pesticide ridden soils, burning rivers, and smog-filled cities, early legislation focused on cleanup and remediation. This first phase of environmental policy was quickly followed by end-of-pipe, command and control legislation that stressed prevention and abatement - keeping industrial wastes from entering the local air, soils or water. Now , as we approach the next millennium, there is a movement towards stopping pollution at the source which places the promotion of pollution prevention technologies as the next logical step in

[54] According to a January 2, 1997 article in the *American Banker*, the Federal Appeals Court in Cincinnati has recently ruled that amendments to the Superfund law prevent litigants from suing banks that hold mortgages on contaminated sites. However, this ruling may or may not be of value for environmental technology users seeking bank loans to finance pollution prevention or cleanup. While banks are no longer liable for foreclosed contaminated lands, they would still be the owners of contaminated lands and would therefore, experience a loss when trying to sell the polluted property. As a result, most banks will probably still be reluctant to accept potentially polluted real estate as collateral in the future. (See: Seiberg, Jaret. "Court/Banks Not Liable for Clean-Up Costs." *American Banker*. January 2, 1997.)

environmental regulation.[55] Table 4 below describes the logical progression of generations of environmental technology.

TABLE 4:
GENERATIONS OF ENVIRONMENTAL TECHNOLOGY

Technology	Point of Application	Characteristics	Examples
Remediation Technologies	▪ Symptoms ▪ Damaged Resources or Environments	▪ After the Fact ▪ Costly ▪ Range from low tech to high tech	▪ Soil Remediation ▪ Toxic Site Cleanups ▪ Water Treatment
Abatement Technologies	▪ Pollutant Capture ▪ Treatment at End-of-Pipe	▪ Captures or treats pollutants before release ▪ Consumes capital, energy and resources ▪ Generates a waste stream ▪ Fairly costly	▪ Flue Gas Desulphurisation ▪ Sewage Treatment Plants ▪ Catalytic Exhaust Pipes
Pollution Prevention Technologies	▪ Industrial Process Design ▪ Product Design or Composition	▪ Changes product or process to reduce or prevent pollution ▪ More cost effective than abatement ▪ Reduced waste stream	▪ Chlorine-Free Paper ▪ Cyanide-Free Electroplating ▪ Lead-Free Gasoline ▪ Industrial Process Design

Source: Ekos Research Associates, Inc., April, 1997.

As stated above, pollution prevention technology is the fastest growing and most innovative sector in the industry. Because it reduces or eliminates waste production, it is considered by most experts to be the future and natural path of the industry. Yet the vast majority of environmental spending in the United States, amounting to approximately $150 billion per year or roughly 2.4 percent of the gross domestic product, goes towards end-of-pipe technology that responds to oudated command and control legislation.[56] As a result, the United States is not taking significant steps towards promoting clean production processes, but instead is allowing industry to carry on with traditional approaches to pollution and waste including treatment, remediation and cleanup at the end of the production line. Indeed, by promoting pollution control as opposed to overall improved environmental performance, the United States is squandering the opportunity to take greater advantage of the pollution prevention innovations emanating from the private sector.[57]

Pollution prevention faces its own host of barriers which inhibit its production and use both in the United States and abroad. While pollution prevention technology's promoters see it as the answer to costly clean-ups and wasteful use of resources, industry has been hard pressed to adapt pollution prevention technology to production. The National Advisory Council for Environmental Policy and Technology has determined that the current environmental regulatory system emphasizes pollution abatement, end-of-pipe technology, and offers little incentive to implement pollution prevention

[55] Ekos Research Associates, Inc. *National Capital Region Technology Forecasts for the Telecommunications, Software, Life Sciences and Environment Industries.* Regional Economic Diversification Opportunities, Hull, Quebec, April 30, 1997. (http://www.inasec.ca/redo/ekos/finrep_1.htm)

[56] Davis, et. al. "Extended Product Responsibility: A Tool for A Sustainable Economy." *Environment.* v. 39, n. 7, September 1997.

[57] Beardsley, et. al. "Improving Environmental Management: What Works and What Doesn't." *Environment.* v. 39, n. 7, September 1997.

procedures.[58] There are a number of factors that tend to favor investment in more traditional "end-of-pipe" approaches including:[59]

- End-of-pipe approaches tend to be cheaper — implementing a pollution prevention program means altering the entire industrial process from start to finish;
- End-of-pipe technologies tend to have a higher profile and are more visible examples of a company's commitment to the environment;
- End-of-pipe technologies are usually much less disruptive to the current production and working processes; and,
- The market for end-of-pipe technologies is much better developed.

Other more general factors which inhibit the growth and use of pollution prevention technology include:[60]

- Corporate regulatory strategies tend to focus on emission and engineering standards, which leaves little motivation for more long term restructuring of the underlying technological process;
- Adopting a commitment to pollution prevention is a long-term process and many companies fear the costs over time that may be incurred — especially in a recessionary economy;
- The pollution prevention process literally may not be cost effective if raw materials and natural resources continue to be undervalued; and,
- There tends to be a fairly high learning curve as most companies are forced to step outside of their normal practices — there is often little "in house" expertise in pollution prevention technology.

In addition, pollution prevention technology is relatively new and untried, while end-of-pipe technology is widely accepted, well-proven and readily available. Regulatory officials accept the purchase of end-of-pipe technology as a strong commitment towards pollution reduction. Indeed, according to a 1997 Environmental Technology Evaluation Center (EvTEC) survey of small businesses, constraints by regulations or permits were seen as the greatest barrier to the introduction of pollution prevention technology. Other barriers mentioned in the EvTEC survey, including liability concerns and inadequate technological evaluations are listed in Chart 3.11 below.[61] Finally, end-of-pipe technology is also well-suited and non-disruptive to the production process, while pollution prevention technology becomes part of the production process and can slow or shut down an entire production line while the technology is being tested and adopted.[62]

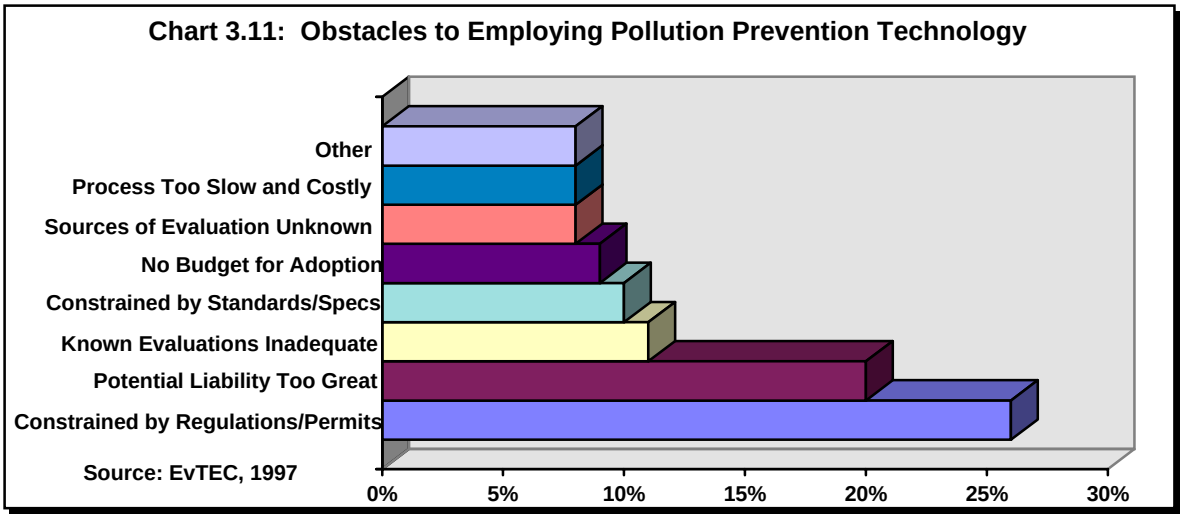
[58] NACEPT, 1991.

[59] Irwin, Alan and Paul D. Hooper. "Clean Technology, Successful Innovation and the Greening of Industry: A Case Study Analysis." *Business Strategy and The Environment.* Vol. 1, Part 2, Summer, 1992.

[60] Ibid.

[61] Environment Technology Evaluation Center. *Acceperating Environmental Technology Implementation.* Civil Engineering Research Foundation, Report #40288, September 1997.

[62] Rawat, Anil. "Technological Change and Environmental Management in Industry." *International Journal of Environment and Pollution.* Vol. 6, Nos. 2/3, 1996.



Clearly there are numerous barriers to the implementation of pollution prevention technology. Ultimately, the growth of pollution prevention technology depends on changing management's focus away from the traditional end-of-pipe approach. In many cases pollution prevention is ignored because of informational, institutional or attitudinal problems. Pollution prevention technology is often viewed a s a drag on the bottom line, and its implementation is rarely seen as working in management's favor. In most companies, neither career incentives nor accounting practices make pollution reduction appear worthwhile.[63]

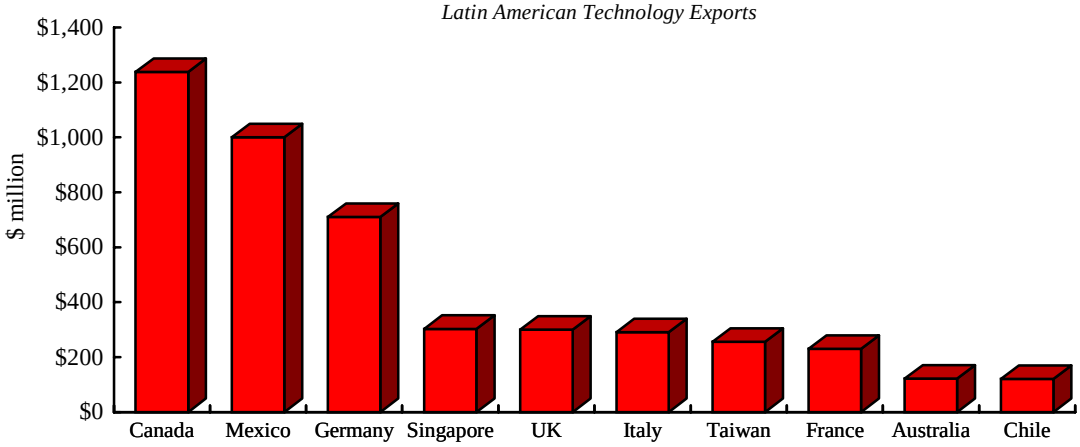
The International Market for Environmental Technology

The Organization for Economic Co-operation and Development (OECD) estimates the current worldwide market for Environmental Goods and Services (EGS) as 400 billion, with non-OECD countries accounting for 36 billion, rising to 300 billion in 2000 (non-OECD 55 billion). The largest national market is the United States, accounting for over 40 percent of the world market. However, the US market has largely matured in most sectors of the industry, and is expected to grow at a slower rate than the remainder of the world market.[64] As Chart 11 below presents, Canada is the leading importer of US environmental technology, followed by Mexico and then Germany and Singapore. Other large importers include the UK, Italy, Taiwan, France, Australia and China. According to EBI (1997), while the largest environmental markets are in the developed countries, the growth rate for the environmental industry will be much higher in newly industrialized countries.

[63] Heaton, George, et. al. *Transforming Technology: An Agenda For Environmentally Sustainable Growth in the 21st Century*. World Resources Institute. April, 1991.
[64] OECD, 1992.

Chart 3.12: Top Ten Environmental Technology Importers From the US (1993)

America University Webserver. Trade & Environment Database.
Latin American Technology Exports



Currently the US Government is promoting stronger markets for US environmental technology exports in Asia, Latin America and the newly independent states of the former Soviet Union. Some examples of market size in these developing regions include:

- Thailand, where the private sector market for pollution-control equipment is estimated at 120 million/year and is projected to grow to 1.5 billion by 2000. Public sector investment is expected to run at 690 million over the next few years.

- Taiwan, where the environmental market is expected to be worth 35 billion over 1992-95.

- Eastern Europe and the former Soviet Union where expenditure on the environment was 15 billion in 1990 and is set to grow at 4.0% a year to reach 21 billion by 2000, roughly the same size as the current and projected German market.

- Poland where 1.0 billion on environmental protection projects was spent in 1991, and plans to spend a further 7.0 billion by 1996. The country's full environmental program is estimated at 260 billion over 30 years.

- Mexico, where the pollution control market is growing at 10% annually to a 1990 level of 250 million, and is expected to reach 10 billion by the year 2000, although the overall environmental market is forecast at 19 billion by 2000.

US Competitiveness

As stated above, the largest export markets for the United States are in Canada and Western Europe. However, over the next few decades markets in the developing countries, especially in Asia and Latin America, will become as large as in the developed world.[65] As a leader in the industry, the United States is naturally poised to capture a large percentage of the new world market. The largest exporters of environmental technology are those countries with the most advanced environmental policies and frameworks. Hence, Germany is the world's leading exporter of pollution abatement

[65] National Science and Technology Council. *Technology For a Sustainable Future: A Framework for Action*. US Government Printing Office, 1994.

equipment, Japan is a major exporter of air pollution control equipment, and the United States is a leader in waste management techniques.[66] The top five competitors are the United States, Germany, Japan, France and the United Kingdom. As presented in Table 5 below, each nation excels and falters in a variety of areas, but it is generally believed that the market, as a whole is wide open for the near future.

TABLE 5:
Relative Competitiveness of Environmental Industries

Equipment	**US**	**Germany**	**Japan**	**Frnc & UK**
Water Equipment and Chemicals	G	E	E	O
Air Pollution Control	O	E	E	M
Instruments & Information Systems	E	O	G	O
Waste Management Equipment	O	G	O-G	O
Process & Prevention Technology	P	P	M	P
Services				
Solid Waste Management	G-E	O-G	M	O-G
Hazardous Waste Management	G	O	O	O
Consulting & Engineering	G-E	G	M	O
Remediation/Industrial Services	G	O	M	O-M
Analytical Services	G	O	O	O
Water Treatment Works	M-P	M	M-P	G-E
Resources				
Water Utilities	P	M-P	P	G-E
Resource Recovery	O	O-G	O	O
Environmental Energy Sources	G	G	G	O-M

Source: Environmental Business International, Inc., San Diego, CA.
E-excellent, G-good, O-OK, M-mediocre, P-poor

However, due to a large domestic market and the limited financial strength and export experience of environmental technology businesses in the United States, the industry as a whole has made few in-roads into the foreign market. Indeed, only eight percent of total revenues for the US environmental industry are generated outside the country.[67] As a result, other countries such as Germany, Japan, England and France are building a strong competitive edge in the developed and developing world through efficient, government supported export strategies. Japanese companies, for example, are encouraged to develop and commercialize cleanup and pollution prevention technologies through a variety of government incentives. Germany is moving aggressively to capture a larger share of global markets, and England and France already dominate the international market for water and wastewater treatment technologies.[68]

As stated earlier, generally those countries with the most comprehensive environmental regulations, standards and policies tend to maintain the most competitive environmental industries. However, clearly the Unites States is not taking advantage of its position. According to EBI (1997), the US complacency in the international market is to a host of factors including the following.

- With the largest environmental market in the world, almost twice that of its nearest competitor Japan, the US industry has had no reason to venture outside of its home market.

[66] OECD. *The OECD Environment Industry: Situation, Prospects and Government Policies.* Organization for Economic Co-operation and Development, Paris, 1992.
[67] EBI. *Competitiveness of the US Environmental Products and Services Industry*. March, 1997.
[68] National Science and Technology Council. *Bridge to A Sustainable Future: National Environmental Technology Strategy.* US Government Printing Office, April, 1995.

- The majority of the US industry is populated by small and medium sized firms which have difficulty competing with the larger, foreign firms from Western Europe and Japan.

- These smaller US firms are reluctant to enter the international market where business development costs are three to five times those at home.

- US business has maintained a traditional wariness of exporting due to concern over issues related to culture, currency, inconsistent regulations, insurance, corruption etc., and due to the large home market, US firms have not needed to overcome these fears.

- Lack of available finance and business support from the government compared to foreign competitors has been cited by environmental firms as a barrier to export.

In general, the overall performance of the US industry in international markets varies. EBI's (1997) research has determined that because the US economy is much more service-based than its competitors, the US has exhibited a strong export advantage in the service segment of the environmental industry, especially in areas such as consulting and engineering. Due to strict national regulations on waste, the US has also displayed an advantage in solid and hazardous waste management. However, in areas such as water and wastewater, the United States lags far behind countries such as Britain which have privatised their water systems. The United States has also lost their advantage in areas like air pollution control. Once on the forefront of air quality legislation, US standards and regulations have stagnated while other countries in Western Europe and Japan have implemented far more strict air quality legislation. As a result, the most innovative technology no longer comes out of the United States. When the US Clean Air Act was amended in 1990, the first contract for installation of clean air technology in the United States was filled by Mitsubishi.[69] Indeed, in 1990, there were no US air pollution control firms in the top five. The top two were Japanese (Mitsubishi was number one) followed by Sweden and two from Germany.[70]

Global marketing ability becomes more important as the US market slows and global opportunities grow. Smaller firms especially need to determine the best way in which they can capture a share of the global market which is traditionally dominated by larger firms. In addition, the predominantly smaller size of firms in the industry means that venture capital or some other external financing is crucial to entering the market. Access to financial resources that can help support development and demonstration as well as commercialization, is mandatory to the ultimate success of the US industry at a global level. Indeed, according to Bosworth Dewey with the Overseas Private Investment Corporation, "most US companies who break into the international marketplace are usually not companies with the best technologies, but are ones with the best financial packages."[71] Chart 12 below presents the factors contributing to worldwide competitiveness, as identified by the OECD (1992), and how the United States compares to Germany and Japan.

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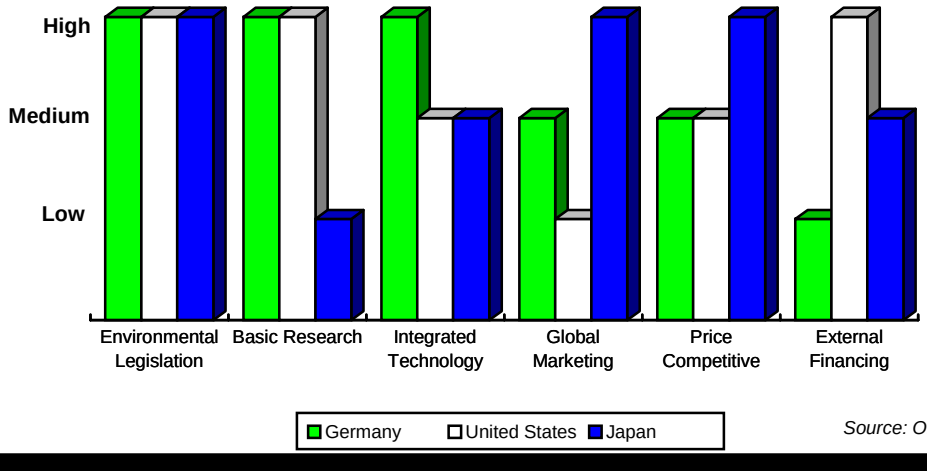
[69] Environmental Business International. *The Global Environmental Market and United States Environmental Industry Competitiveness.* San Diego, California, 1995.

[70] OECD. *The OECD Environment Industry: Situation, Prospects and Government Policies.* Paris, 1992.

[71] Interagency Environmental Technologies Office (IETO). *White House Conference on Environmental Technology: Working Papers From the Conference Held in Washington, DC, December 11 - 13, 1994.* p.61.

Chart 3.13:
Competitive Factors In The Environmental Industry



Source: OECD, 1992