

**THE GLOBAL
ENVIRONMENTAL
GOODS
AND SERVICES
INDUSTRY**

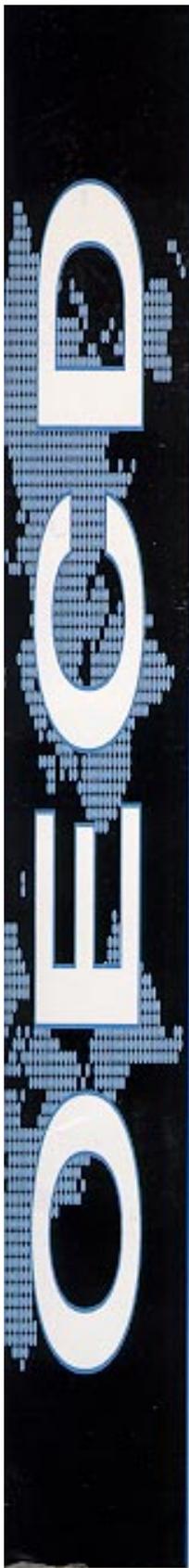
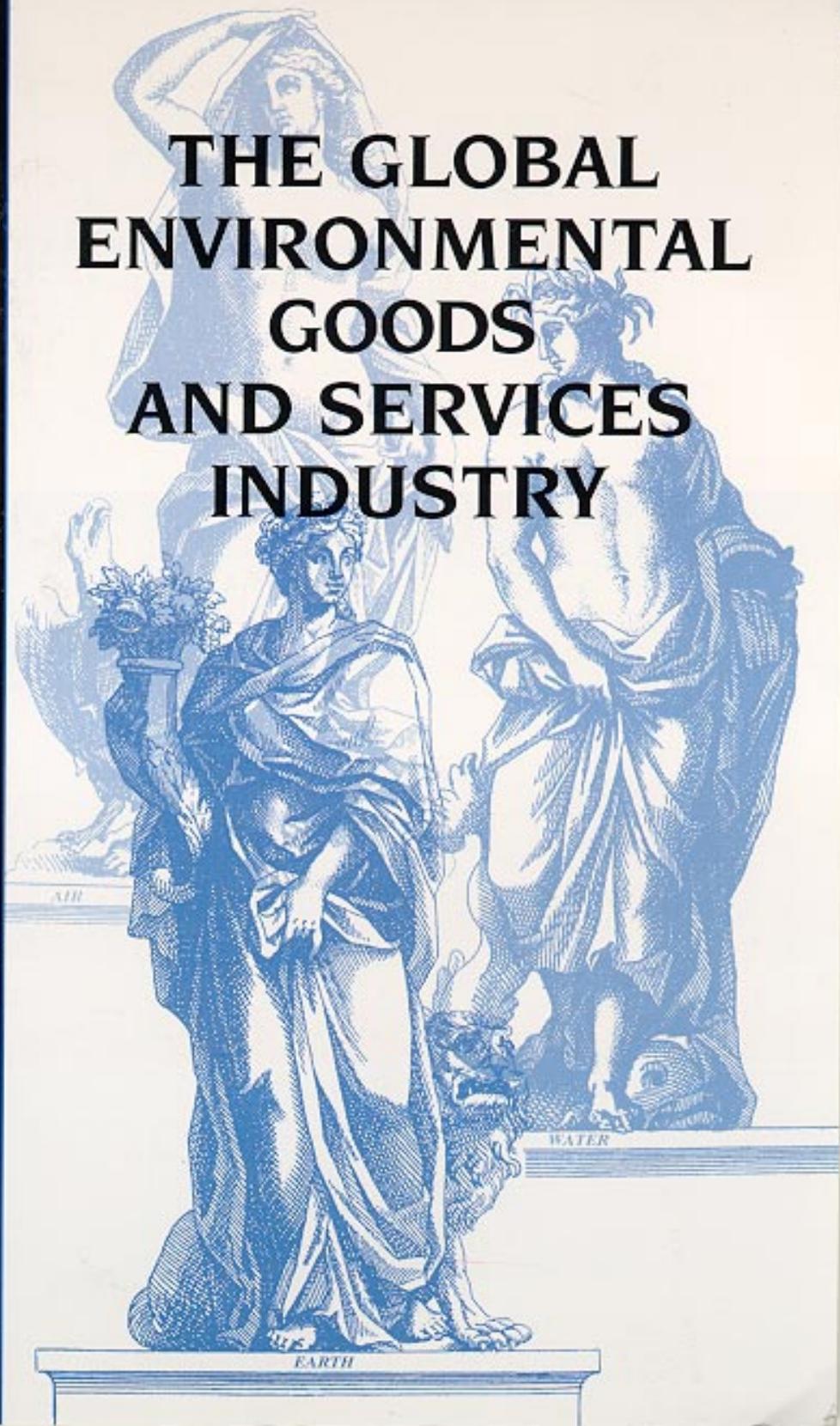


TABLE OF CONTENTS

SUMMARY	3
The Environment Industry	4
Defining the environment industry	4
Environment industry products	5
Environment industry by field of activity	7
Environment industry structure	10
The Environment Industry: Growth, Trade and Employment.....	10
Markets.....	10
International competitiveness	18
International trade	18
Employment.....	21
Environment Industry Development	23
Factors affecting the environment industry	23
Barriers to development	24
Policies for the Environment Industry	25
General policies	25
Specific policy measures.....	26
<i>Annex:</i> Selected definitions and classifications of the environment industry	31
Bibliography	33

List of tables

1.	Global environment market	6
2.	OECD environment industry output: 1990.....	9
3.	Forecast of market trends for the global environment industry	9
4.	Western Europe environment market growth by segment	9
5.	Distribution of environment industry firms by number of employees	10
6.	The principal environmental markets	11
7.	Pollution abatement and control investment expenditures	11
8.	Environment investment expenditures by sector: France 1991	12
9.	Environment industry growth: United States (percentage growth)	13
10.	Domestic production and trade in environmental equipment: Canada 1990	14
11.	Environmental markets: Mexico.....	14
12.	Estimated environmental expenditures needed in eastern Germany	15
13.	Foreign environmental licenses acquired by the top 30 Italian firms	16
14.	Growth prospects and potential advantages	19
15.	Environmental industry trade balances for selected countries: 1992	20
16.	Latin America environment markets and imports: 1992	20
17.	Environment industry employment: 1992	22
18.	Estimates of environment industry employment growth.....	22
19.	Government budget appropriations for environmental R&D	28

SUMMARY

The environment industry supplies pollution control, reduction, clean-up and waste handling equipment and related services, and a growing range of other environmental services. The industry's market is estimated to be of the order of US\$250 billion (between the pharmaceutical industry and information technology industry in size, excluding most clean technologies), and is growing at around 5 per cent per year. The boundaries of the industry are blurred and they are not easily defined. "Clean" technologies and processes which minimise pollution and material use and clean products which are less environmentally-damaging are increasingly important, but difficult to account for. The industry is becoming increasingly trade-oriented, but is considerably less trade-intensive than industries selling standardised mass market products such as automobiles and computers. Internationalisation has been hampered by differences in national regulations, by the size structure of the industry (many small specialised firms and few large firms), and by the importance of government procurement. Employment in the environment industry is probably growing, and is around 1 per cent of total employment in most OECD countries.

Environmental regulations and standards set the broad framework for demand for environmental goods and services. There is a shift in regulatory focus towards economic instruments, incentives and voluntary agreements which concentrate more on overall environmental performance, and give greater flexibility in achieving environmentally-satisfactory solutions. This has been coupled with greater emphasis on clean technologies and products. Both provide new impetus to the supply industry.

Uncertainties regarding both environmental regulations, and in the supply of and the demand for new technologies, have proved to be important barriers to the development of the industry. Poorly developed markets, differences in the regulations from country to country, technical regulations and specifications which inhibit flexibility and innovation of the supply side have also posed considerable problems. Development of the industry can also be inhibited by financial restraints. This is a principal hurdle for start-ups and small businesses in new areas which combine a range of technologies aimed at providing improved environmental solutions.

The industry has benefitted from general industrial policies and programmes in the R&D and technology areas, investment incentives to stimulate demand, support for small firms and export incentives. Specifically, targeted support for environmental R&D has proved to be an important tool for the development of the industry. Pollution control and environmental improvement have been singled out by all OECD countries as important socio-economic objectives, and have therefore received substantial R&D resources. Since about one-half of all investment in the field comes from government expenditures, governmental purchasing and procurement has a major impact on the industry in many countries. Certain countries also have specific programmes to support development in such areas as environmental exports and small firms, which helps to overcome market failures and information gaps.

The Environment Industry

Defining the environment industry

In analysing the environment goods and services industry, the main obstacles are related to the definition of the industry, its extent and boundaries. This is due in part to the complexity of definition, and to the lack of information in some of the newer, rapidly growing areas.

A number of studies have tried to define, delimit and describe the environment industry, but there is little agreement among them. There are several reasons for these divergences. First, the industry covers a heterogeneous set of goods and services. At the core of the industry, there is a group of identifiable goods and services which are used to clean-up existing processes and production (“end-of-pipe” equipment and/or technologies), treat water and effluent, control air pollution and reduce noise. There is also a set of waste management and re-cycling technologies and services to recuperate waste for re-use, and deal with past environmental damage, as well as a growing range of environmental services such as research, design and engineering services. Most of these equipment production, technological and service activities can be identified and measured, but they are heterogeneous, making data collection complicated and comparisons difficult.

Second, there is no agreement on criteria to establish the boundaries of the industry. In particular there is growing interest in including renewable energy, clean technologies and products. In the long run, while they are difficult to account for, “clean” technologies, production processes and products will reduce the need for clean-up and “end-of-pipe” solutions, changing the structure of the environment industry and the relative importance of its core group of activities.

Third, many producers of pollution abatement and control equipment and services have a low degree of specialisation in these products. Environmental goods and services may be classified with other goods and services which are the main line of business and are therefore not readily separable for inclusion in measures of the environment industry. Finally, different studies have focused on broader or narrower groups of activities or products, producing divergent results, depending on whether they have been developed for environmental jobs surveys, eco-product surveys, general statistical surveys, etc. Values may also depend on whether estimates are made from the supply or the demand side.

Overall, there are a group of measurable goods and services and industrial and service activities which are widely agreed on as forming the “core” of the environment industry. But beyond this core the boundaries of the industry are fluid, and there are difficulties in measuring many environmental goods, services and activities with any precision.

The following general definition can be used as starting point: “Eco-industries... may be described as including firms producing goods and services capable of measuring, preventing, limiting or correcting environmental damage such as the pollution of water, air, soil, as well as waste and noise-related problems. They include clean technologies where pollution and raw material use is being minimised...” (European Commission, 1994).

This wide definition includes clean technologies. These technologies need to be considered as part of the industry, despite definition and measurement problems. Cleaner technologies are difficult to measure because improvements which are less polluting cannot be separated from general improvements which are more efficient, use less resources and produce less waste or harmful by-products. Hence the share of costs related to environmental improvement cannot be clearly separated from the cost of general efficiency improvements. For these reasons, other definitions, including that

used in the previous OECD study (1992), tend to exclude clean technologies (see Annex). They are excluded from much of the data discussed below, except where indicated.

However, description and discussion of the industry which focuses mainly on “end-of-pipe” technologies and clean-up services will not capture structural change in the industry as regulation and incentives move towards reducing resource use, minimising waste, and adopting cleaner technologies and production processes. Hence clean technologies are discussed qualitatively to the extent that this is meaningful.

Table 1 reproduces estimates of the global environmental market. These data show different values for the size of the industry, although they all show rapid growth over the next 5-15 years. Differences are mainly due to different definitions of the industry.

Environment industry products

The environment industry includes activities producing goods and services that range from “end-of-pipe” equipment pollution control and clean-up technologies, to recycling and technical and professional services. Clean production technologies, while important in re-structuring the industry, are more difficult to measure, as are eco-products (such as clean cars, efficient refrigerators and washing machines, biodegradable soaps). One way of describing the industry is to include goods and services which provide environmental protection in different domains: water, solid waste, air, soil, noise, natural resources, miscellaneous services, etc. The result of this classification is:

Environmental equipment

- waste-water treatment equipment;
- waste management and recycling equipment;
- air pollution control equipment;
- noise reduction equipment;
- monitoring instruments, scientific, research and laboratory equipment;
- natural resource conservation/protection and urban amenities.

Environmental services

- waste-water operations;
- waste handling and facility operations;
- air pollution control operations;
- noise reduction operations
- analytical, monitoring and related conservation and protection services;
- technical and engineering services;
- environmental research and development;
- environmental training and education;
- accounting and legal services;
- consulting services;
- other environmental business services;
- other: eco-tourism.

Table 1. Global environment market

(US\$ billion)

	OECD		ECOTEC			ETDC		Environmental Business International	
	1990	2000	1992	2000	2010	1990	2000	1992	1998
North America									
-- United States	78	113	85	125	200	115	185	134	180
-- Canada	7	12	14	18	30	7	14	10	17
-- Mexico	-	-	1	5	10	3	18	1	2
Sub-total	85	125	100	147	240	125	217	145	199
Latin America	-	-	2	5	15	-	-	6	10
Europe									
-- France	10	15				10	30	-	-
-- Germany	17	23	60 ¹	89 ¹	144 ¹	21	65	94 ¹	132 ¹
-- United Kingdom	7	11				11	28	-	-
-- Rest of European Union	12	20				15	48	-	-
-- Rest of Western Europe	5	9				6	17	-	-
-- Eastern Europe/NIS	15	21	5	9	23	15	25	14	27
Sub-total	66	99	65	98	167	78	213	108	159
Asia Pacific									
-- Japan	24	39	30	44	72	24	65	21	31
-- Australia/New Zealand	2	3				2	4	3	5
-- Taiwan	-	-				5	30	-	-
-- Hong Kong	-	-	5 ²	12 ²	50 ²	-	3	-	-
-- South Korea	-	-				1	8	-	-
-- Rest of Asia Pacific	-	-				14	28	6	13
-- China	-	-	2	5	20	-	-	-	-
-- India	-	-	1	2	7	-	-	-	-
Sub-total	26	42	85	63	149	46	138	30	49
Rest of World	21	34				6	12	6	9
Total World	200	300	210	320	570	255	580	295	426

All Western Europe.

East and South-East Asia.

Source: OECD (1992), excluding "clean" technologies; ECOTEC (1994) excluding "clean" technologies; ETDC (Environmental Technologies Development Corporation, in Higgins, 1994) including replacement "clean" technologies only, excluding entirely new "clean" processes, "clean" and alternative energy generation, and "clean" products; Environmental Business International, in OTA (1994) including some "clean" technologies, such as alternative energy sources.

Integrated environmental technologies in industrial processes and cleaner products (optional):

- clean production equipment;
- efficient energy generation and conservation equipment;
- eco-products.

Environment industry by field of activity

In order to better understand the structure of the environmental goods and services industry, it may be divided into eight fields of activity. These are the “core” activities of the industry. They are in most lists describing the industry, and underlie much of the quantitative data presented in this report.

These are:

Water and effluent treatment: This includes activities providing products, systems and services for the removal of pollutants from sewage and the purification of pollutants and contaminated drinking water and industrial waste-water. It provides the equipment and services related to the analysis and assessment of needs, design and installation, and is moving towards providing more complete products and water supply and clean-up systems. Cleaner technologies (despite difficulties in measuring them, see above) are having important impacts in reducing pollutants which subsequently need to be removed. The segment mainly depends on public expenditure (for example in Italy and Portugal public expenditure accounts for 70 per cent of demand), but also on manufacturing segment compliance with environmental regulations. This is the most mature sector, with large global firms, and barriers to entry are related to costs.

Waste management and recycling: This includes activities providing products, systems and services to reduce the quantity of solid waste produced and to collect, treat and dispose of solid waste. It is the second segment in magnitude in almost all OECD countries. Waste recycling technologies and products, and new and cleaner technologies and products are part of this segment. New modes of treating solid waste, especially hazardous waste and recycling (paper, plastic, packaging) are expected to grow at a rate of 5 per cent over the next few years. In the medium term it will benefit from rising disposal charges. In the longer term, the new regulatory approach, which favours pollution prevention and waste minimisation strategies, will change its structure. Cleaner technologies will complement and eventually substitute clean-up and recycling, and will grow in importance.

Air pollution control: This includes activities providing products, system and services to reduce and eliminate polluting gases and particulates. In the medium term, it will benefit from international conventions (Climate Change Convention, Montreal Protocol) aiming to reduce, stabilise or substitute gas emissions which pollute the air or damage the atmosphere. This segment is relatively young and fragmented with few global firms (the largest are American). Trade, internationalisation and transfer of technologies are foreseen to grow rapidly.

Noise reduction: This includes activities providing products, systems and services to curb noise pollution. They range from noise barriers produced by construction enterprises, to

noise and vibration control equipment produced by engineering and industrial control companies. Noise pollution control largely results from public demand for environmental regulation. The automotive industry participates extensively in R&D and production of these goods and services. Noise reduction is the least mature part of the environment industry, and is very fragmented.

Emergency response/clean-up activities have been developed for land remediation and treating ecological disaster. Land remediation activities are relatively undeveloped in Europe except in Germany, but are well-developed in America and Australia. Industrial structure (particularly mining and mineral refining) and environmental regulations are strong driving forces, and the reason for large differences in market size. Applications of bioremediation may replace many present technologies. In the medium/long term, this sector is expected to show moderate growth.

Environment assessment and monitoring: This includes activities providing products, systems and services for assessment and monitoring of environmental quality. Specialised hardware and software enterprises are the main producers, but in many cases sensor and monitoring systems from other businesses are modified for environmental purposes. It is a fragmented segment.

Environmental services: This includes services such as R&D and laboratory activities; technical services; education and training; environmental accounting; risk analysis; and consultant services. Nature conservation and forestry services and services for protection of biodiversity and natural eco-systems can also be included in this segment. This segment is dominated by small, dynamic companies, and is growing rapidly.

Energy and urban amenities: These are defined as activities providing products, systems and services related to energy efficiency, renewable energy and substitution of private with public transport. The segment received major impetus in the 1970s with the first oil shock, and is still expected to develop, but is difficult to measure satisfactorily due to the wide range of uses for many activities (e.g. cleaner energy generation, public transport). Demand often depends on industry and household efficiency needs, rather than on environmental regulations. R&D and product price are important competitive factors. Poorly developed markets for urban amenities are important obstacles to development. In the case of renewable energy (solar, biomass, wind energy), development costs, capital costs and energy pricing are obstacles to growth. In the long term, however, renewable energy should be able to replace many current non-renewable energy sources.

The relative distribution of some of these activities is shown in Tables 2-4. Water and effluent treatment and control is the most important activity in most countries and regions, and waste management and services are expected to grow most rapidly.

Table 2. OECD environment industry output, 1990

(percentages)

	Canada	United States	Europe	Japan	OECD
Water and waste-water management	48	32	45	28	38
Waste management	24	34	20	28	28
Air pollution control	15	16	22	32	20
Other ¹	13	18	13	12	14
Total	100	100	100	100	100

1. Includes noise control, laboratory equipment, land remediation, resource conservation, etc.
Source: Estimates by Industry Science Technology Canada, in Doyletech (1992).

Table 3. Forecast of market trends for the global environment industry

(US\$ billion)

	1990	2000	Annual growth (%)
Equipment	152	220	5.0
Water and effluent treatment	60	83	4.0
Waste management	40	63	6.4
Air pollution control	30	42	4.4
Other	22	32	5.1
Services	48	80	7.4
Total	200	300	5.5

Source: OECD (1992).

Table 4. Western Europe environment market growth by segment¹

(US\$ billion)

	1990	1991	1995	Annual growth (%)
Waste management	20.9	22.5	28.0	4.5
Water and waste-water	12.8	13.8	21.3	9.1
Air pollution control	9.6	10.3	12.8	4.3
Land remediation	1.0	1.1	2.3	16.1
Total	44.3	47.7	64.4	8.5

1. Definitions differ from those for Tables 2 and 3.
Source: ECOTEC, reported in OTA (1994).

Environment industry structure

The environment industry is characterised by a small number of large enterprises dominating a few market segments and a large number of small and medium-sized enterprises. The supply side is highly diverse (from divisions of chemical firms to consultants). It has a different structure of activities and size distribution in different countries. Large firms are more common in the German industry compared with Italy and Switzerland, where small firms appear to be much more important overall (Table 5). The Canadian industry has many small firms, as in Italy and Switzerland, with less than 1 per cent of environment firms in manufacturing having more than 200 employees, and only 9 per cent of environment firms in services having more than 100 employees.

Table 5. Distribution of environment industry firms by number of employees

(percentage of all firms)

Number of employees	Germany	Italy	Switzerland
	1984	1987	1990
1 - 19	22.4	73.5	80.7
20 - 49	18.4	13.5	10.4
50 - 99	14.6	4.4	5.6
100+	44.6	8.6	3.3
	100.0	100.0	100.0

Source: Wackernbauer *et. al.*, 1990 and CENSIS, 1989, reported in *Le Business écologique*, Conus et Rossi (1992).

The degree of firm specialisation, defined as the ratio of environmental revenues to total revenues, is low to medium. The production of environmental goods and services is often less than 50 per cent of total production. This is especially true for large engineering and chemical firms.

The degree of diversification, defined as the range of environmental products, is highest in more mature segments, and for larger companies which produce a wide range of products and services. The trend is towards providing products which are more complete: from design and equipment production, to providing services related to installation and application of the equipment. Moreover, since regulations are moving towards waste minimisation, complete solutions will replace simple "end-of-pipe" ones and firms increasingly need greater competence in different environmental and technological fields.

The Environment Industry: Growth, Trade and Employment

Markets

The global environmental market is estimated to be around US\$250 billion. Estimates range from US\$200-255 billion in 1990, and US\$210-295 billion in 1992; low estimates exclude clean technologies, higher estimates include some clean technologies -- see Table 1. This makes the industry somewhat larger than the computer equipment or pharmaceuticals industries, but smaller than the information technology industry. The market is also estimated to be growing rapidly, with

sustained development foreseen to continue to the year 2000, with estimates ranging from 4.1 per cent annual growth (OECD) to over 8 per cent (Environmental Technologies Development Corporation), and with widely differing outlooks in different regions.

The OECD market dominates, with about 80 per cent of the total. Among the OECD countries, the United States is the leader, followed by Japan and Germany. Promising future markets include Asia, Latin America, Eastern Europe and the NIS.. These markets will experience rapid expansion, as a consequence of economic growth and increasing public and political environmental awareness (Table 6).

Table 6. The principal environmental markets

(percentage of world market)

	1992	2010
North America	48	42
Western Europe	29	25
Japan	14	13
East and South-East Asia	4	14
South America	1	3
Eastern Europe/NIS	2	4
Total world	100	100

Source: ECOTEC (1994)

Table 7. Pollution abatement and control investment expenditures

(as a percentage of gross fixed capital formation)

	Public sector		Business sector		Total	
	1985	1990	1985	1990	1985	1990
United States	1.1	1.4	2.0	2.0	3.1	3.4
Japan	2.9	2.6	0.5	0.3	3.4	3.0
Germany	1.9	2.1	1.6	1.4	3.5	3.5
France	0.8	0.7	0.4	0.4	1.2	1.1
Italy	1.0	0.9				
Austria	2.7			1.0		
Denmark	1.0	1.8				
Netherlands	2.2	1.0	1.0	1.3	3.2	2.3
Portugal	1.0	1.0	0.5	0.7	1.5	1.6
Spain	0.6	0.8				
Sweden			0.8	1.2		

Data are for nearest year.

Source: OECD (1993a).

Public expenditures and public procurement have been a major part of the total expenditure for pollution abatement and control equipment in all OECD countries (Table 7). In all countries except the United States and the Netherlands, public investment expenditures have outweighed business sector expenditures. The business sector has, however, been increasing expenditures for environmental goods and services, not only to respect environmental regulation, but also to gain the economic benefits from process modifications which reduce consumption of raw materials and energy, and reduce waste and pollution.

A large proportion of business environmental investment expenditures is in manufacturing and energy generating and utilities. Within manufacturing, the major purchasers of environmental equipment are the traditional processing industries such as chemicals, iron and steel, metals, and pulp and paper (Table 8). These industries have made high levels of investment to meet regulations and reduce pollution, and are often in the forefront of the shift towards clean technologies. Across all industry, clean-up and pollution reduction still appear to be the major part of environment expenditures, although this may be due to under-evaluation of clean technologies due to accounting difficulties

Table 8. Environmental investment expenditures by sector, France, 1991

(as percentage of total investment in each sector)

Sector	%	%
Energy	1.8	
of which oil-refining		5.8
Iron and steel and steel working	10.9	
of which steel		12.7
Chemicals	6.5	
of which basic chemicals		9.1
Pulp and paper	8.2	
Metal- working and casting	2.2	
of which casting		7.8
Non-ferrous metals	3.7	
Mineral, glass, construction material	3.1	
Food	2.8	
Wood and furniture	2.8	
Other industry	1.3	
Mechanical engineering	1.2	
Electrical engineering	1.1	
Transport equipment	0.9	

Source: Les quatre pages, 1993.

North America

The United States is the biggest environmental market, estimated at around US\$85 billion in 1992 with a 5 per cent rate of growth. (Most of the following market and market growth estimates are drawn from ECOTEC, excluding “clean” technologies.)

The domestic market is concentrated on solid waste management (recycling and recovery) and water and waste-water treatment, although most sectors have shown regular growth in recent years (see Table 9). The environmental consulting and engineering sector has enjoyed strong development by supplying waste minimisation programmes and developing corporate environmental strategies.

Table 9. Environment industry growth: United States

(percentage growth)

Industry segment in descending order of size	1990-91	1991-92
Solid waste management	5	3
Water utilities	5	3
Resource recovery/recycling	-8	2
Hazardous waste management	3	7
Engineering, construction	10	6
Water infrastructure	3	4
Water management equipment	6	4
Air pollution control	-1	2
Asbestos abatement	-25	3
Environmental energy	10	11
Instrument manufacturing	4	6
Analytical services	1	3
Total	2	4

Source: Environmental Business Journal, in OTA (1994).

The US industry exports about 10 per cent of total output, with strong positions in the production of environmental monitoring systems, services and innovative technologies, but it faces increasing competition.

The Canadian equipment market is foreseen to double by the year 2000, and around two-thirds of the market is supplied by domestic production (ETDC, in Higgins 1994, see Table 10). Other estimates suggest that growth will be at a 10 per cent annual rate to reach some US\$16 billion by 2000. Canadian companies enjoy a good position in international markets, with around one-quarter of environmental goods and services exported in 1990; expertise is particularly in water and waste-water treatment, waste management (especially hazardous wastes), hydrogeology and recycling. In the future, consulting, engineering and environmental technologies, biotechnologies, site remediation and energy conservation are likely to be growth areas.

Table 10. Domestic production and trade in environmental equipment: Canada, 1990

(US\$ million)

	Water and waste-water	Solid waste	Air pollution	Other	Total
Total domestic demand	2 236	1 045	646	582	4 509
Domestic production: to domestic market	1 448	857	248	317	2 870
(per cent of demand)	65	82	38	54	63
Exports:	351	145	133	242	861
(percentage of production)	20	15	35	42	23
Imports	778	188	389	265	1 640

Source: ETDC in Higgins (1994).

The Mexican environmental market is small, around US\$750 million in 1993, but is expected to grow at around 10 per cent annually (US Department of Commerce). Waste-water treatment is the biggest sector, almost 70 per cent of the total (Table 11). As in other Latin American countries, a major obstacle to development has been poor enforcement of legislation in the past. But pressures exerted by the NAFTA agreement and increasing public awareness are extending environmental regulation and enforcement. About one-quarter of demand is met by foreign supply, of which 85 per cent is from the United States. Japanese firms are strong in air pollution control equipment.

Table 11. Environmental markets: Mexico

(US\$ million)

	1990	1991	1992	1993
Water pollution	105	126	400	500
Solid/hazardous waste	83	95	110	127
Air pollution	78	90	104	119
Total	266	311	614	746

Source: US Department of Commerce, in OTA (1994).*Western Europe*

The German market was estimated to be around US\$17.5 billion in 1992, about 30 per cent of the European total. Recent survey-based estimates for the united Germany suggested that public and private expenditures on environment protection goods and services were higher and amounted to US\$27.7 billion in 1991 (RWI/IWH, 1994). Western Germany is highly competitive in almost all

environment areas, while eastern Germany is considerably behind. Table 12 shows estimated expenditures necessary to improve eastern German environmental quality.

Table 12. Estimated environmental expenditures needed in eastern Germany

(expenditures 1992-2000 in US\$ billion)

Water and waste-water	91.0
Waste disposal	22.0
Air pollution	14.4
Contaminated site remediation	6.8
Noise abatement	1.3
Total	135.4

Source: OECD (1993b).

In France, the environment market was estimated to be worth around US\$10 billion in 1992, about 15 per cent of the European total, with strong growth projected. Compared with leading countries such as Germany and the United States, French export performance is weaker in most export markets; nevertheless around 30 per cent of total production is exported (*Les quatre pages*, 1994). France enjoys a strong position in water and waste-water treatment, with large leading enterprises operating internationally.

The UK market was estimated to be worth over US\$8 billion in 1992, about 14 per cent of the European total. The domestic market has developed rapidly, due to stricter environmental regulation and enforcement and to privatisation. The UK environment industry has a trade surplus of US\$289 million (1991) and is particularly strong in water and waste-water, environment monitoring and engineering and environmental services. Foreign firms have penetrated the domestic market, particularly in such areas as waste management technologies and water management. The UK environment industry is expected to perform well in the East and South-East Asian countries, due to their strong growth and the strong links between UK firms and these regions.

The Netherlands market is one of the most advanced, dominated by a few large enterprises. Dutch firms are very dynamic in the area of environmental systems and improvement, e.g. biological treatment systems, water treatment and soil remediation. The Association of Suppliers of Environmental Equipment (VLM, 1992) estimated that 26 per cent of sales are export related. Similarly in the Scandinavian countries, regulatory and institutional systems are generally relatively mature, and the environment industries hold a good position on the global market.

The Italian environment market is somewhat smaller than that of the three leading European markets. It has been characterised by later enforcement of environment regulations and by strong dependence on public expenditures. Italy depends on foreign firms to a considerable extent for innovation and technological development of environmental technologies. Firms from Germany, the United States and France are the most active in Italian markets (Table 13).

Table 13. Foreign environmental licenses acquired by the top 30 Italian firms

(percentage)

Germany	32
United States	26
France	11
Switzerland	7
Japan	6
United Kingdom	4
Other ¹	15

1. Sweden, Denmark, the Netherlands and Finland.

Source: Istituto per la Ricerca Sociale, 1993.

Consequently the presence of Italian environment firms in international markets is limited. Less than 10 per cent of total production is exported. However Italian firms have developed operations in Eastern Europe and the NIS, and programmes for economic assistance have facilitated operations in developing country markets. Expertise in plant engineering and organising, planning and management of complex systems has increased the foreign presence of Italian firms.

Southern Europe (Spain, Portugal and Greece) has smaller markets. In Portugal, for example, the environment industry accounts for 61 firms with approximately 2 000 employees. Global turnover of a sub-set of these firms was around US\$32.5 million mainly placed in the home market (1993). They are mostly small or medium-sized enterprises, with a small range of products, low specialisation, and labour-intensive production.

In general in this region the environmental institutional infrastructure is weaker than in other European countries, and in environment regulation these countries are usually followers of EU regulations rather than innovators. Consequently the environment industry in these countries is not highly developed, but in some areas (cleaner production, waste treatment, analysis and quality control) it is becoming more efficient and effective in applications of developed technologies.

Eastern Europe

Eastern European and NIS environmental markets were estimated at US\$5 billion in 1992 and are expected to increase to US\$23 billion by 2010. The main obstacle to development is lack of financial resources in industry to implement environmental regulations. Privatisation and reconstruction processes are short-term priorities and are slow in coming. Some actions have recently been taken to integrate environmental measures into industrial restructuring -- waste minimisation and environmental management are examples.

The prospects for this region are encouraging. The main developments are expected in water and waste-water treatment, in land remediation (for example estimated clean-up costs in Poland are US\$260 billion over 20-30 years), and energy conservation and efficiency. At present the region is highly dependent on foreign investment and bilateral assistance for financing environment investments, and the environment industry is still poorly developed in most areas.

Japan

The Japanese environment market is estimated at around US\$30 billion and is the second largest (ECOTEC 1994). Recent broad MITI estimates are much higher, around US\$150 billion, due mainly to wider definitions and the inclusion of waste disposal and recycling and energy supply sectors (MITI 1994*b*). Detailed estimates of selected growth areas of the environment industry (covering only anti-pollution equipment, waste management and recycling, waste-water and effluent equipment, new energy sources and energy efficiency; they do not include clean technologies in productive process and environmental R&D activities) project that it will grow from US\$15.2 billion in 1993 to US\$23.3 in 2000 (6 per cent growth rate) and to US\$35.4 billion in 2010 (4 per cent) (MITI 1994*b* estimates). Broader estimates of the industry size show the same projected growth path (MITI 1994*b*).

The Japanese environmental industry is increasingly focusing on the design and production of cleaner products (e.g. in cleaner automobiles and transport equipment), energy conservation, and biotechnologies. Internationally, it is present particularly in other Asian countries.

Australia

The Australian market represents 1 per cent of the global market, estimated to value about US\$2 billion in 1990 with projected growth around 4.4 per cent (OECD, 1992). Although still establishing itself, the Australian environmental industry has competitive sectors such as: rehabilitation and remediation of mining and industrial sites, waste-water treatment, monitoring equipment, and consultant services. Developing Asian economies provide major opportunities.

East and South-East Asia

The East and South-East Asian market is still relatively small. It was estimated to value around US\$5 billion in 1992 and to grow to US\$12 billion by 2000, with estimated annual growth of 12 per cent (ECOTEC, 1994). Rapid economic development and growing demand for improved environmental performance are driving forces. South Korea and Chinese Taipei have the largest markets and strong environmental efforts, both to improve environmental performance and to develop environment industries. Air pollution control, water and waste-water treatment equipment and services are the largest markets in the area.

In China, the environmental market is limited compared with the economic size of the country. It was estimated to have a market of around US\$2 billion in 1992 and was projected to reach US\$5 billion in 2000 (ECOTEC, 1994). However, Chinese environmental regulation and interest in environmental quality remain weak, and growth may remain retarded.

Latin America

Latin America is a promising market, along with the developing Asian economies. It has been estimated at US\$2 billion, with projected growth of around 10 per cent annually (ECOTEC, 1994). It is relatively undeveloped, but economic reform and privatisation have encouraged more explicit development and application of environmental standards. Coupled with increasing environmental awareness, this has boosted the environment industry.

Brazil, Chile and Argentina have the largest markets. Demand is mainly focused on water and waste-water treatment, air pollution control equipment, and other major infrastructure projects. Brazil supplies about 80 per cent of its own demand, Chile relies very largely on imported products. The US industry is the biggest exporter and foreign operator in the region.

International competitiveness

Competitive advantages in the industry derive principally from:

- technological innovation (it has been estimated that 50 per cent of the environmental goods which will be in use in 15 years' time do not currently exist);
- quality and service performance (the ability to adapt products to client needs, capability to produce effective and easily managed products);
- marketing and export strategies (due to increasing globalisation of markets, and new market opportunities);
- flexibility in production (possibility of rapid and low-cost changes in products with changing regulatory requirements).

Less important are conventional scale economies (they are more important in the equipment sector, and large firms and wider competence rather than scale economies are increasingly necessary in many areas), and cost (the industry often supplies tailored solutions where performance and innovation are more important than price).

Competitiveness of firms in different countries varies widely in different segments of the industry. National environmental problems and regulation have enabled firms to build up competitive advantages in different areas. Table 14 shows, in simplified form, areas of high growth in different countries and potential competitive advantages for firms from these countries.

International trade

The industry is already moderately internationalised with international trade in goods and services growing rapidly and with a similar share of production being exported as for the pharmaceutical industry (another highly regulated industry), but much less than automobiles and computers (where products are more standardised and less driven by regulations). There are widely varying estimates of the value and importance of exports. For example, US exports of environmental protection equipment were estimated to value US\$1.68 billion in 1991 (EPA, 1993), but estimates of total exports of environmental goods and services are in the range of 5-10 per cent of production, which is of the order of US\$5-10 billion.

Table 14. Growth prospects¹ and potential advantages²

Country or regional area	High growth	Moderate growth	Low growth	Potential advantage
Northern Europe	Monitoring	Land remediation	Waste management	Monitoring
Germany	High-tech products Recycling	Air pollution	Water treatment Waste management	Waste-water Waste treatment Land remediation Measurement and analysis
France	Waste management	Monitoring services Noise pollution	Air pollution	Waste-water Recycling
United Kingdom	Waste-water Land remediation Waste management	Monitoring	Air control Waste management	Waste-water Waste management
Italy	Waste management	Air pollution	Waste-water Land remediation	Waste management
Southern Europe	Water and waste-water	Air pollution	Waste management	Water quality
United States	Waste management Land remediation	Air pollution	Water and waste-water	Monitoring Remediation: nuclear, mining, agriculture, chemicals. Biotechnologies Air pollution
Canada	Waste-water	Air pollution	Waste management	Toxic emission: industrial and resources
Japan	Air pollution	Waste management	Water and waste-water	Air pollution: urban and industry
Australia	Mine remediation Consultancy services Water and waste-water	Industrial remediation Clean production Air monitoring	Air control Solid waste management	Mine remediation Consultancy services

1. Range of the segment according to the national opportunities.

2. Range of the segment according to opportunities in the international markets

Source: OECD compilation from ECOTEC, EMIAA (Australia), and other sources.

It is expected that the industry will become increasingly internationalised and trade-oriented as it develops, particularly in more mature areas such as waste and water management, and air pollution control. The adoption of world-wide environmental standards will expand international markets, privatisation and de-regulation of utilities such as water and electricity will expand opportunities for foreign firm participation, and consolidation of the industry and increasing firm size as it matures will increase internationalisation.

Currently, the US, German and Japanese industries have the largest shares of most international markets, and have considerable surpluses in environmental trade (Table 15). Some smaller countries such as Finland and Norway have very internationally-oriented industries, exporting around 50 per cent of their production, but they do not have a large share of the global market. Recently, Australia, Canada and the United Kingdom increased their efforts to expand environmental exports.

For the future, environment markets in East and South-East Asia, Latin America, Central and Eastern Europe and the NIS are expected to show rapid growth and opportunities for international trade. This is due partly to strong economic development and rapid industrialisation and partly to increasing environmental awareness. It has been estimated that the Asian countries will increase their demand for water and waste-water disposal in the next few years by about 30-40 per cent, the demand for environmental monitoring will increase by 30 per cent, and much of the equipment will be imported. The major markets in Asia currently show trade deficits which are likely to increase, despite efforts to build up domestic environment industry capacity.

Table 15. Environmental industry trade balances for selected countries: 1992

(US\$ million)	
United States	1 113
Canada	-284
Japan	478
Germany	720
France	14
United Kingdom	14
Mexico	-286
China	-19
Korea	-7
Chinese Taipei	-612 ¹

1. US DoC estimates.

Source: ECOTEC, 1994.

The extent of external dependence of developing countries on imports is illustrated for Latin America. Larger countries supply a considerable share of their domestic requirements, while the smaller countries depend on imports for almost the totality of domestic demand. This is the case for example for Chile, Colombia and Venezuela (Table 16).

Table 16. Latin American environment markets and imports: 1992

	Market (US\$ million)	Percentage imported
Argentina	168	25
Brazil	1 015	19
Mexico	614	24
Venezuela	44	97
Chile	560	89
Colombia	45	78

Source: US AID in OTA (1994).

Overall, recent trends suggest that international trade will develop rapidly. Rapid trade and investment growth in demand, particularly in developing countries, Eastern Europe and the NIS will under-pin trade, as will increasing specialisation and internationalisation of the industry. Furthermore, international environmental agreements (Montreal Protocol, Climate Change, Agenda 21, etc.) and harmonisation of national environmental standards will have considerable trade-expansion impacts by setting common technical targets for environment quality and by increasing investment to reach new standards.

Further significant changes in the industry can be expected from global expansion of major firms, as they set up foreign operations to enter markets, and seek foreign partners to develop new technologies in areas such as biotechnology and bioremediation, and renewable energy. Globalisation is also driven by privatisation and liberalisation of utilities in many countries (notably water and energy supply), which allow much greater scope for operations by foreign firms in domestic markets.

Employment

Estimates of employment in the environment industry vary widely, depending on definitions. In most OECD countries, the environment industry narrowly defined employs less than 1 per cent of the total labour force (Table 17). On the basis of wider definitions, including some services, but excluding clean technologies, employment is close to 1 per cent, as is the case for the United States and Japan. Secretariat estimates (conservatively assuming average labour intensity, excluding clean technologies) are close to 1 per cent of total employment.

Potential growth for environmental employment is high. Available estimates suggest that growth is expected to be strong over the next few years, ranging from around 3 per cent in Canada and Japan to 10 per cent in the United States (Table 18). Moreover, a recent survey in Australia showed that one-half of enterprises which consider themselves as environmental had expanded employment by more than 20 per cent from 1988 to 1993, and expected faster growth in future.

The industry is labour-intensive, and principally hires people in the following occupations: professionals and engineers, scientists and technicians, plant and machine operators and skilled trades. Occupational specialisation varies in different areas, with professional staff concentrated in energy, waste management, clean production and waste-water treatment, and machine operators and labourers in recycling (ACF/ACTU, 1994). In Canada almost 40 per cent of employees in environmental manufacturing and over 70 per cent in environmental consulting are engineers, scientists or technical employees, whereas over one-half of employees in waste handling were process operators (Employment & Immigration, Canada, 1992). There are relatively large shares of university and technical graduates. In Germany qualifications are high in general and highest in service-related activities such as engineering. Because of the high use of professional, technical and skilled staff in the industry, shortfalls in supply of these occupations have been forecast at various times -- for example in Western European waste management in the early 1990s (ILO, 1992).

Table 17. Environment industry employment, 1992

	Employment (thousands) ¹	Share of total employment (per cent)	OECD estimated shares ² (per cent)
United States	1 070.0	0.91	0.69
Canada	65.0	0.53	0.72
Japan	580.0	0.90	0.90
France	110.0	0.49	0.98
Germany	171.5	0.48	0.59
Italy	12.7	0.06	
Netherlands	24.4	0.37	
Finland	15.0	0.69	
Norway	4.2	0.21	
Switzerland	15.6	0.45	
Australia	11.0	0.14	1.36

1. Employment values relate to different years (1990, 1992, 1993), and are based on widely differing national definitions, usually covering only part of the industry.
2. Secretariat employment estimates are derived as the ratio between total production (ECOTEC) and GDP, assuming that the industry has average labour intensity.

Source: Australian Council of Trade Unions & Commonwealth Department of Employment, Australia; Employment Canada; Ministry of Industry, Finland; Ministry of Industry, France; Ministry of Economics, Germany; Ministry of Industry, Italy; MITI, Japan; CBS and Industry Association, the Netherlands; Ministry of Industry, Norway; OFQC, Switzerland; Department of Commerce, United States. Total employment is for 1992 from OECD (1994c).

Table 18. Estimates of environment industry employment growth

	Period	First year	Last year	Annual growth (per cent)
United States	1990-95	1 070 000	1 780 000	10.7
Canada	1992-95	65 000	71 000	3.0
Japan	1993-2000	581 000	744 000	3.6
Italy	1993-94	12 760	12 746	-0.1
Norway	1992-93	3 800	4 100	7.0
Australia	1993-95	11 000	12 000	4.1

Source: Environmental Business Journal reported in OTA (1994), MITI (1994b), Employment Canada (1992), Australian Council of Trade Unions & Commonwealth Department of Employment, Australia (1994), Ministry of Industry, Italy (1994), Trade Council, Norway.

It has been suggested that the environment industry may play a major role in creating jobs and the above analysis suggests positive net job creation. Overall employment change related to environment protection is, however, the sum of two different effects. There will be net job creation in the environment goods and services industry provided that it is growing rapidly enough. At the same time there will be job creation and job destruction associated with the impact of environmental regulations on other industries. A number of studies have tried to estimate the general economic impacts of regulation, but the aggregate direct and indirect benefits and costs, gains and losses is difficult to model. Partial results suggest small positive net effects. For example an ILO study (1992) has suggested a general positive, though small, impact on the economy in terms of development of employment and production. The overall impacts for individual countries which have specialised and competitive environment industries may be more clearly positive as employment

generation in the environment industry outweighs job losses linked with environment regulation elsewhere.

Environment Industry Development

Factors affecting the environment industry

The main factors affecting demand for environmental goods and services are regulation and the shift towards incentives and economic instruments; public expenditures; technological developments; and social pressure and changes in life style. National and international environmental regulation has been the engine driving the environment industry. Countries with tighter regulations have larger and more competitive environmental markets.

Nevertheless, regulations can be impediments to growth. For example, the requirement to apply and use particular established technologies or techniques can inhibit the spread of innovative new approaches to environmental problems. Similarly, the timing of regulations, and rapid introduction of stringent standards, can inhibit exploration and development of better solutions and improved environmental performance. The shift from regulations and standards as the main instrument of environmental policy towards complementary economic instruments (taxes and charges, and other incentives to reduce overall pollution emissions) can positively benefit the environment industry, particularly when the shift towards economic instruments is coupled with clear definition of expected outcomes and performance linked with underlying regulation and standards.

Public expenditures are a major part of total expenditures for pollution abatement and control equipment (Table 7). This makes priorities and methods of public procurement important for shaping many of the activities of the industry, particularly in water supply, drainage and effluent treatment in many countries. Procurement will also have an important bearing on technological development and competitiveness if it is based on performance and outcome-based criteria, encouraging new solutions to problems.

The business sector has been increasing expenditures for environment goods and services, to respect environmental regulation and to capture economic benefits from reducing consumption of raw materials and energy and minimising waste and pollution. Economic benefits and economic instruments are becoming the most important driving forces to achieve environmental goals. More enterprises are perceiving the environment as a scarce and strategic resource, and investing in environmental management.

The industry is highly dependent on technological innovation and development. Demand is shifting to product substitution and process modification to reduce emissions generated during production. This is partly due to greater emphasis on pollution prevention policies and partly to strategic environmental planning by firms, which drive new technological development and hence create new markets for environment goods and services.

Social pressure and public awareness constitute the first step in the chain to regulation and cleaner technologies. The demand for improved environmental quality has started to affect choices in private consumption. These changes in life style can strongly influence development of the industry.

A considerable change in the structure of the environmental industry is taking place with a shift from “end-of-pipe” equipment and clean-up services to integrated and “clean” environmental technologies. In the long term, this substitution may radically affect the structure of much of the environment industry by increasing the importance of research, design, consulting and other services compared with clean-up and remediation goods and services. This structural change will, in part, be driven by increasing policy focus on the diffusion of clean environmental technologies integrated into processes and production as due to social pressures as well as other factors outlined above.

Barriers to development

The environment industry may face development problems in the following areas: regulation, finance, markets, and acquisition of technical knowledge. Environmental regulation is one of the main driving forces for the development of demand, but it may also create obstacles to development (see above). Lack of regulation in some areas, uncertainty, and inconsistent application of regulations and standards all increase uncertainty for supply-side enterprises, and inhibit the development of demand. Moreover, the environment industry has not been influential in directly shaping or influencing regulation. Only recently in a few countries (the Netherlands, some Scandinavian countries) has industry in general been involved in the process of developing regulation or compliance, for example through voluntary agreements.

Small environment firms face barriers to financing common to all small firms starting or developing new businesses. In particular, investors may be reluctant to invest in environmental firms and projects characterised by high levels of uncertainty and depending on a regulatory framework beyond their control. Consequently, there may be a scarcity of risk capital or an inability to access equity capital. The structure of the industry (many small, new firms developing new technologies or environmental approaches) can make this a particular problem.

Market barriers facing the industry include general ones such as slow economic growth, and low levels of investment. There are also demand side market failures specific to the environment industry, such as lack of information about new environmental solutions, undeveloped markets for new products or limited numbers of customers, and on the supply side due to uncertainty, risk and lack of information of market opportunities. Moreover, lack of information exchange and co-operation between environmental suppliers and their customers may slow expansion of the industry.

The decision to invest in environmental R&D is influenced by three factors common to all R&D decisions: the predictability of demand for new products and processes, uncertainties in R&D itself, and whether the firm can capture enough benefits to justify R&D expenditures. The environment industry also has some features which have a particular bearing on R&D decisions. Development of new environment goods and services can be discouraged by regulatory uncertainty in areas such as the level of standards, timing of regulatory measures, and the extent and efficiency of enforcement. The mix of technological areas which can be involved in environmental R&D and innovation also provides uncertainties. New combinations of technologies (materials, biotechnology, IT) may offer new solutions to environmental problems. But lack of expertise and information to span different technologies and combine them into workable solutions may inhibit development. There are particular problems associated with the small size and high specialisation of many firms in the industry. Network formation may be one solution to develop and supply products, systems and services requiring wide technical expertise and resources.

Policies for the Environment Industry

Policies have two kinds of impacts on the supply industry:

- indirect impacts, operating on the demand side through environmental regulations and standards, economic instruments and incentives, and government-industry agreements, all designed to improve current and future environmental quality and deal with the legacy of past environmental degradation;
- direct impacts by promotion of the industry through support for environmental R&D, financial support (e.g. for start-ups and SMEs), export incentives, etc., either as general incentives for all industry, or specific incentives for the environment industry.

General policies

Environmental regulation, standards and incentives

Regulations have been the traditional driving forces for the environment industry, by defining priorities and directions for environmental investment by businesses and governments. The areas which have received greatest regulatory attention have been the most visible causes of environmental degradation, most notably in established processing industries (chemicals, pulp and paper, ferrous and non-ferrous metals); energy generation; urban and household waste (solid waste and sewage treatment); and air pollution (noxious and green-house gases).

Subsequently there has been a shift towards encouraging clean production and clean products which minimise the need for subsequent clean-up of effluent, exhaust and waste, and encouraging re-cycling. Accompanying this shift has been a major emphasis on complementary economic instruments focused on outcomes, rather than on detailed regulations. Despite this shift, the major area of environmental expenditures in most countries is still clean-up of water and effluents, air and solid waste. Recycling and minimisation of pollutants is still somewhat less important, and monitoring and control are less important again in terms of expenditures.

Recent examples of measures promoting recycling and waste minimisation include: in Austria a decree on packaging, expected to encourage an 80 per cent recycling rate; regulations have been introduced in Belgium to recycle packaging material and reprocess toxic waste; an Action Plan in Denmark for Waste and Recycling; action in Finland to increase re-cycling waste paper into paper manufacture to reach EC requirements; regulations in France that by 2002 there will be no waste disposal without prior treatment, and a decree whereby firms must recover their waste packaging or subscribe to a waste recovery service; tax incentives in Japan for recycling; waste disposal taxes in Turkey; and in the United Kingdom a recycling and waste minimisation target of one quarter of household waste by the year 2000, with higher targets for some materials.

A number of countries have introduced voluntary government-industry accords. For example in Austria, voluntary agreements have been introduced to increase recycling in the paper, cement, plastics and motor vehicle industries, in the Netherlands, these cover basic metals, chemicals and printing, and in Japan they focus on waste reduction and energy conservation, with some 87 industrial groups (such as automobiles and electric power) requested to formulate voluntary plans in October 1992, with a status report issued end-1993. Finally the switch to the use of economic instruments can be exemplified by initiatives in Norway to promote recovery and safe disposal of

waste, and to reduce emission through levies on CO₂ sources, and in Sweden through taxes on sulphur emissions, charges on nitrogen oxides, differential taxes on diesel oils, CO₂ taxes, and environmental taxes on domestic air traffic. In both countries, economic instruments have encouraged innovation rather than the application of standard solutions to existing problems.

General industry policy

The pattern of support for the environment industry illustrates two general directions in industrial policy: diminishing sector-specific support, and the increasing importance of technology and technology-related measures. Specific promotion directed at established environmental goods and services may hamper structural change and market dynamics and slow down technical progress. Furthermore, the industry covers a very wide range of equipment and services supplied by both established firms and industries and by new firms, and it may be difficult to target more than a few parts of the industry.

Many general industry policy instruments have major impacts on the environment industry. The most important of these are in the areas of:

- *R&D and innovation.* General incentives to R&D and innovation such as tax deductions, tax credits, tax allowances and general programmes to provide direct R&D grants, loans, etc., to industrial firms may be used to develop clean technologies and abatement equipment. The industry will also benefit from initiatives designed to increase collaboration in technology development, reduce costs and spread risks.
- *Physical investment.* Although incentives for physical investment have been reduced due to tax reform and tax rate reduction, remaining general investment incentives lower the cost of investments in new technologies (e.g. waste minimisation, energy-saving, etc.), and hence expand demand for new technologies in environmental goods and related services.
- *Small firms and entrepreneurship.* Industry structure (many specialised start-ups and small firms) and difficulties in financing, mean that the environment industry will benefit from general measures which improve the circumstances for start-ups and small firms (removing market failures in provision of finance, simplifying regulations, etc.).
- *Globalisation.* Incentives to expand international business operations (through exports, international investment, international collaboration and contracting, etc.) are being introduced or re-organised in many countries. Although it is not yet highly globalised, the structure of the industry, the growing small firm sector, equipment and product standardisation (application of world standards) and utility privatisation in many countries all suggest that international opportunities are increasing and incentives to promote international operations of firms will be of growing importance for the industry.

Specific policy measures

There are few specific policy measures to support the industry. The most common are for promotion of new and clean technologies.

R&D and technology support

In most OECD countries the share of government appropriations for R&D going to environment programmes has increased, although the share has remained rather low -- less than 5 per cent of the total (Table 19). By 1992, government appropriations for environment programmes in OECD countries totalled almost US\$2 billion (in purchasing power parities). These data understate the importance of environmental expenditures in total government R&D support. A considerable share of support for environmental R&D is undoubtedly carried out under other objectives such as industrial development, health and welfare and other socio-economic objectives.

Scattered data for OECD countries suggest that government and higher education are major founders and performers of environmental R&D, particularly basic research. In areas such as environmental R&D there are large spillovers, high social returns and potentially large social benefits in public support for R&D. Government support is often justified on the grounds that there is under-investment in environmental R&D by firms due to:

- externalities associated with environmental research, where individual firms are unable to capture enough benefits from R&D to justify their expenditures, but total social returns are high;
- uncertainties in the conduct of research due to the importance of environmental regulations in determining areas where future business opportunities may arise and the possibility that these regulations may change;
- uncertainties about existing markets and demand for new products; and
- the large-scale of some environmental research (e.g. in energy conservation and alternative energy sources).

Table 19. Government budget appropriations for environmental R&D

	US\$ million in PPPS		Share of total government R&D appropriations	
	1981	1992	1981	1992
Australia	29.6	60.3 ¹	2.7	3.5
Austria	1.5	21.5	0.4	2.3
Belgium	15.1	18.2	2.8	1.7
Canada	21.0	70.5	1.2	2.1
Denmark	4.3	28.2	1.8	4.5
Finland	2.1	16.7	0.9	2.0
France	39.6	150.4	0.5	1.1
Germany	136.6	529.2	1.8	3.6
Greece	2.3	4.7	3.1	2.1
Iceland	-	0.4	-	1.7
Ireland	0.3	1.6	0.4	0.8
Italy	52.0	177.8	1.8	2.2
Japan	-	59.8	-	0.5
Netherlands	-	91.1	-	4.2
New Zealand	-	6.5	-	2.6
Norway	10.3	29.7	3.6	3.3
Portugal	14.0	-	3.2	
Spain	4.9	51.4	0.7	1.9
Sweden	17.7	66.1	1.8	3.6
Switzerland	6.7	21.1	2.7	4.4
United Kingdom	81.4	112.6	1.2	1.3
United States	271.0	487.0	0.8	0.7

1. 1991.

Source: OECD, STIU database (DSTI/EAS Division), 1994.

The importance of business-funded technology development performed in the business sector should not be underestimated; a large share of research in the engineering, automobile, chemical and process industries is devoted wholly or partly to environmental objectives.

Recent examples of government programmes to support environment technology development include:

- In Canada under the Green Plan, the Environmental Technology Commercialisation Program supports up to 50 per cent of costs up to C\$ 5 million of strategic alliances or consortia to develop, demonstrate and commercialise new environmental technologies. New environmental technology exploitation centres provide technology transfer services to help SMEs commercialise technologies.
- In Denmark the Action Plan on Cleaner Technologies runs over 1993-97 with funding of DKr 360 million; the Strategic Environmental Research Programme has 1992-96 funding of DKr 300 million.
- France has concentrated EUREKA commercially-oriented R&D programmes on four project areas, one of which is waste treatment.

- Development of environmental technologies is largely supported in Germany. Programmes are promoting either focused environmental R&D (e.g. environmental and climate research, biotechnology and new materials research and research for renewable energy) and/or implementation of environmental technologies in the industrial sector (e.g. financial support to promote investment to control pollution, grants for innovative measures to improve the environment which go beyond statutory requirements). A special programme has been launched to promote development and testing of innovative products and processes that have a significant impact on environmental protection
- In Italy, a few measures support and promote research and implementation of cleaner technologies (law 46-82 on technological innovation; law 317-91 on environment investments in small and medium-sized enterprises; law 441-87 on energy generation from waste). Some regional administrations have established credit lines for environment protection.
- Japan is funding collaborative R&D (firms with national laboratories and universities) on environment-related industrial technologies, managed by the Research Institute of Innovative Technology for the Earth. Seven international environment-related projects were being carried out in 1993 in Japanese and foreign laboratories. Japan also has tax incentives to develop environment-friendly technologies.
- In the Netherlands, stimulation of technological innovation is a major part of industry policy with a special focus on the environment. Specific incentives are available for environmental technology research and development, re-use and recycling and energy technology R&D, as well as general R&D personnel tax advantages and technology development credits. Moreover, co-operation among government, industry, technological institutes and universities has been successful in developing environmental technologies.
- In Norway, environmental technologies have been supported by research programmes on environmental technology for export (Nkr 27 million government funding in 1994, with 85 per cent from industry), sustainable process industries (Nkr 8 million with 50:50 financing), and a cleaner technology programme to develop, demonstrate and transfer cleaner technologies (government budget Nkr 30 million, 50:50 financing).
- Sweden has programmes to support development of cleaner technologies and products, particularly in the energy sector (energy-saving and alternative sources).
- The United Kingdom is promoting collaborative research, for example on engine emissions, and is supporting some R&D linked with the wider diffusion of best practice environmental technology.
- The United States has a wide range of programmes that support development of environmental technologies: the Interagency Environmental Technology Initiative, co-ordinated by the Environment Protection Agency, partly devotes its funds to the private sector to promote technology development. The Department of Energy has programmes related to energy efficiency and renewable energy. The Department of Defense has a funding programme to support R&D in environmental compliance and environmental R&D in general. The Department of Commerce, NASA and the Bureau of Mines all fund R&D for environmental technologies. The general approach was to support not only R&D for new solutions favourable to the environment but also commercial applications.

Overall, support is given to help firms move into new areas and to overcome the problems of small size by encouraging networking, demonstration and diffusion. However, further efforts may be needed in areas where markets may not be developed and which cross established technological and industrial boundaries.

Procurement policy

Government procurement policy has important impacts due to the relative importance of the public sector in purchasing environmental systems and services (see Table 7). The importance of procurement in shaping national industries depends on:

- the organisation of the procurement process and whether it takes into account and fosters longer-term technology development, and encourages innovative solutions based on outcomes rather than on established standards, designs and technologies;
- the implementation of procurement, for example whether contracts can be broken-up to encourage small firm participation, etc.;
- the largely national stance of much government procurement and the extent to which procurement is open to foreign suppliers and foreign competition.

Globalisation

Considerable attention is being paid to export promotion for the industry. General schemes of export credits, foreign aid and project finance for developing countries and other export assistance, are used extensively to finance environmental exports. Many countries also provide special export services focused on the environment industry. These range from export motivation and awareness campaigns, business counselling and advisory services, training and education, market information, publicity and trade missions, contract and project assistance, etc. They mainly provide information on markets and export opportunities, and facilitation services.

International environmental agreements are seen to foster trade and present trade opportunities. For example, the Montreal Protocol for the control of ozone depletion increases the market for alternative ozone-friendly products and technologies, and the Basel Convention controlling cross-border movement of hazardous and household wastes creates markets for waste management and re-cycling equipment and services. On the other hand, there has been continuing concern regarding the trade effects of domestic environmental measures, which can act as *de facto* barriers to trade, and international environmental agreements which may prohibit trade between parties and non-parties to agreements.

There are a few examples of programmes to increase foreign investment in the industry. For example, Australia has focused on a few areas, including waste and environmental management, as key industries to attract inward direct investment.

Other targeted policies

A few countries also target the environment industry for assistance through special measures for small firms, through campaigns to improve the competitive position of the industry, and through special investment promotion and accelerated depreciation to boost demand for environment investments.

ANNEX

SELECTED DEFINITIONS AND CLASSIFICATIONS OF THE ENVIRONMENT INDUSTRY

Selected definitions and classifications of the environment industry include:

OECD (1992) "...a diversified industry spanning a variety of industrial products and services which have not been statistically classified and for which data are limited... Environmental equipment and related services can be subdivided into four main types of products according to the end-use: water and effluents treatment, waste management, air quality control and other (primarily land reclamation and noise reduction). Environmental technologies which are incorporated in industrial processes...are not included in this classification. General environmental services...often relate to the installation of clean technologies [and] are listed as a separate category”.

The US Administration (1994) defines Environmental Technology as “a technology that advances sustainable development by reducing risk, enhancing cost effectiveness, improving process efficiency, and creating products and processes that are environmentally beneficial or benign. The word ‘technology’ is intended to include hardware, software, systems and services.”

It has divided environmental technologies into four categories: avoidance, monitoring and assessment, control, and remediation and restoration:

- Avoidance technologies include equipment, processes, and process sensors and controls designed to prevent or minimise the generation of pollutants, hazardous substances, or other damaging materials, as well as technologies used in product substitution or in recycling and recovery of useful raw material, products, and energy waste streams.
- Monitoring and assessment technologies include the design, development and operation of monitoring instrumentation with associated quality assurance and risk evaluation aspects.
- Control technologies include the treatment of pollutants or other natural or anthropogenic materials to eliminate or reduce environmental and human health hazards, or the reduction of pollutant/waste material volume or mobility to make subsequent management more effective.
- Remediation technologies include those that either remove the risks associated with harmful wastes or make them more manageable (for example bioprocessing). Restoration technologies improve ecosystems that have declined (for example reforestation).

In Japan the Ministry of International Trade and Industry (1994*b*) broadly defined “eco-business” as “industrial sectors with a potential to help reduce environmental burdens”. It

comprises pollution prevention equipment, waste disposal and recycling, environmental restoration, environment-friendly energy supply, environment-friendly products, and environment-friendly production processes.

The Australian Industry Commission (1993) defined the environmental waste management equipment, systems and services industry as a “diverse collection of industrial producers and service providers encompassing any entity providing technology- or service-related solutions to solid, liquid, or gaseous waste management problems. Thus it embraces parts of product-based industry sectors engaged in engineering, construction, design, scientific instrumentation and consultancy services.”

The Netherlands Association of Suppliers of Environmental Equipment (1992) uses the following definition: “companies producing, supplying and/or installing (parts of) equipment/machines for the abatement of environmental damage (excluding noise hindrance) as well as companies advising on environmental issues”. The Netherlands Central Bureau of Statistics defines environmental services as “the prevention, restriction or reparation of damage to the environment by companies that are neither cause nor victim of the (potential) damage”.

To evaluate “green” jobs, the ILO (1992) classified the environment industry into nine sub-sectors: pollution abatement with respect to air, water and soils; agricultural land rehabilitation; transport and communication soft energies and energies conservation; water and sewerage works; recycling and waste management; conservation and forestry (including eco-tourism); environmental research and development and training; environment administration and public works.

The ACF-ACTU (1994) study of “green” jobs in Australia, made a further classification of the environment industry. It divides the industry into five areas: energy efficiency and renewable energy industry; waste management and clean production industries; recycling industry; eco-tourism; water and waste-water.

BIBLIOGRAPHY

- Contributions in response to an OECD Secretariat request for information came from: Canada, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal, Sweden, Switzerland, Turkey, the United Kingdom, the United States, and the European Commission.
- ACF/ACTU (1994), *Green Jobs in Industry - Research Report*, Australian Conservation Foundation, Australian Council of Trade Unions and the Commonwealth Department of Employment, Education and Training, Melbourne.
- AUSTRALIAN INDUSTRY COMMISSION (1993), "Environmental Waste Management Equipment, Systems and Services", Draft report.
- CHAMBRE DE COMMERCE ET D'INDUSTRIE DE PARIS (1993), *L'industrie française de l'environnement: caractéristiques et marchés*, Paris.
- CHEMISTRY AND INDUSTRY (1994), News Report, "Environmental Technology: Dirt busters", 6 June, pp. 389-400.
- CONUS, J. and A. ROSSI (1992), *Le business écologique : Rapports sur les structures économiques*, Series of studies edited by OFQC, Zurich.
- DOYLETECH (1992), *Building a Stronger Environmental Technology Exploitation Capability in Canada*, Environment Canada and Industry, Science and Technology Canada, Ontario.
- EMPLOYMENT AND IMMIGRATION CANADA (1992), "Human Resources in the Environment Industry", report prepared by Ernst & Young.
- EUROPEAN COMMISSION (1994), "Eco-industries in the EC", in *Panorama of EU Industry 94*, Brussels.
- ECOTEC (1994), *The U.K. Environmental Industry: Succeeding in the Changing Global Market*, Department of Trade and Industry, and Department of the Environment, HMSO, London.
- EMIAA (1993), *Environmental Industry Association of Australia in Environmental Waste Management and Equipment Systems and Services*, Australian Industry Commission.
- EPA (1993), *International Trade in Environmental Protection Equipment: An Assessment of Existing Data*, US Environmental Protection Agency, Washington, DC.
- HIGGINS, J. (1994), "Global Environmental Industry", in *Ecodecision*, January, pp. 20-22.
- ILO (BHALLA, A. S., ed.) (1992), *Environment, Employment and Development*, Geneva.
- ISTITUTO PER LA RICERCA SOCIALE (IRS) (1993), *The Pollution Abatement Industry in Italy*, Contributi di Ricerca, No. 29, Milan.

- MITI (1994a), *Environment Industry Vision* (Sangyo kankyo vision ni tsuite), Tokyo.
- MITI (1994b), “Environment Industry Policy in Japan”, mimeo, Tokyo, September.
- OECD (1992), *The OECD Environment Industry: Situation, Prospects and Government Policy*, Paris.
- OECD (1993a), *Pollution Abatement and Control Expenditure in OECD Countries*, Paris.
- OECD (1993b), *Environment Performance Reviews: Germany*, Paris.
- OECD (1993c), *Environment and Employment: Facts and Issues*, Paris.
- OECD (1994a), *Export Promotion and Environmental Technologies*, Paris.
- OECD (1994b), *Biotechnology for a Clean Environment: Prevention, Detection and Remediation*, Paris.
- OECD (1994c), *Employment Outlook*, Paris.
- OTA (1994), *Industry, Technology, and the Environment: Competitive Challenges and Business Opportunities*, Office of Technology Assessment, Washington DC.
- Les quatre pages* (1993), “Les investissements de l’industrie protégeant l’environnement”, Ministère de l’industrie et du commerce extérieur. Section générale des Stratégies industrielles, Paris
- Les quatre pages* (1994), “L’industrie investit les marchés de l’environnement”, Ministère de l’Industrie et du Commerce Extérieur, Section générale des Stratégies industrielles, Paris.
- RWI/IWH (1994), “Die Umwelttechnische Industrie in der Bundesrepublik Deutschland”, Report for the Federal Ministry of Economics.
- STATISTICAL OFFICE OF THE EUROPEAN UNION (1993), “Statistics of the Environment - Environmental Protection Industries and Services”, F3 Environment, working paper, Luxembourg.
- US DEPARTMENT OF COMMERCE (1993), *Environmental Equipment*, Industrial Outlook, Washington, DC.
- US DEPARTMENT OF COMMERCE (1994), *Environmental Technologies and Services*, Industrial Outlook, Washington, DC.
- VLM (1992), *Environment Technology, Directory of Dutch Firms*, FME, Zoetermeer, Netherlands.