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Technological Leapfrogging

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IV. TRANSFER OF ENVIRONMENTALLY CLEAN TECHNOLOGY FROM NORTH TO SOUTH

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JOSÉ GOLDEMBERG*

I. INTRODUCTION

Environmental costs in industrialized countries are currently at a level of 1-2% of their Gross Domestic Product ("GDP"). Although Western European countries rarely expend more than 1%, Figure 1 illustrates that the United States expends at least 2% of its GDP, or approximately $100 billion, on the environment each year.

The environmental consequences of industrial development in developing countries are beginning to reach sizeable proportions. Not only do they threaten the local populations, but they are beginning to have a sizeable affect on global climate change. In due time, the cost to reduce or eliminate these problems will be significant, and will consume resources that are presently committed to growth and development.

At the local level, cities such as Beijing or Mexico City are notorious for their high levels of smog and pollution. Generally, the problem is related to transportation and to the use of fossil fuels for heating and industrial purposes. Perhaps the worst case is that of the Cubatão area near São Paulo in Brazil, which was once known as the "valley of death."[1]

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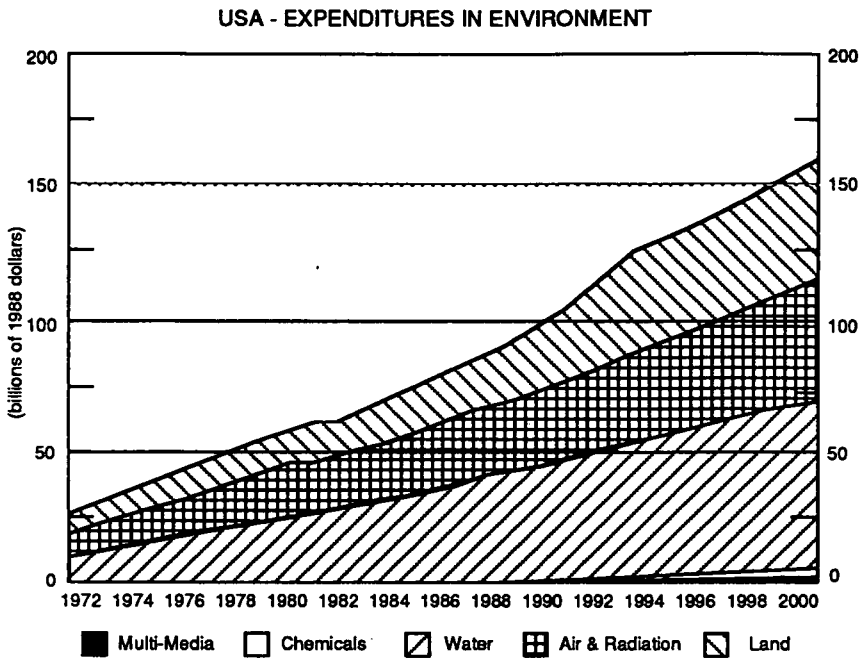
1. The region of Cubatão in the early 1950s was an ideal location for industry. Not only

FIGURE 1



was it just 60 kilometers from the largest consuming center of the country, São Paulo, but Cubatão was also in the immediate vicinity of the Port of Santos, the region's main gate for imports and exports. Cubatão also had excellent roads, connecting it to other cities, railroads, and an abundance of water, electrical energy, and labor.

During that period, environmental concerns were not practically considered, or at least they were deliberately absent in the decision about where to locate the large industrial activities. In a few years, a large complex of siderurgical, fertilizer, petrochemical, paper and pulp industries were in full operation, occupying an area of 148 square kilometers and employing 15,000 people.

The environmental consequences were devastating. Because Cubatão is located in a narrow valley between the sea and high mountains, the air, rivers, and underground water were all severely polluted. In addition, vegetation on the slopes of the surrounding mountains was destroyed by the deforestation and toxic emissions. The destruction of vegetation resulted in landslides, threatening many of the polluting industries.

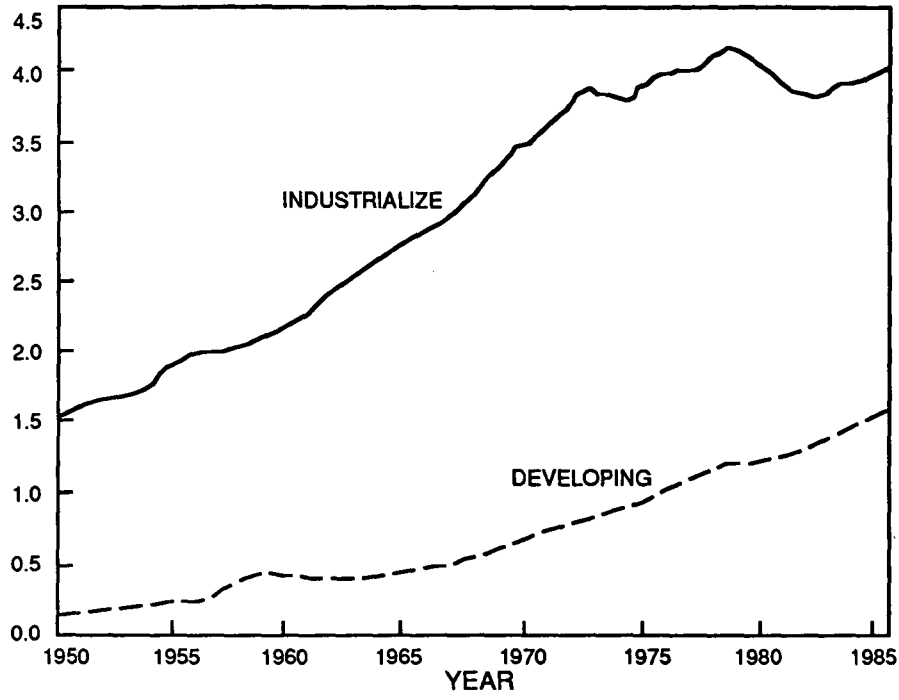
In 1984, leaks in a gasoline pipe line caused a great fire, which killed over 100 people. In response to this accident, São Paulo authorities imposed heavy fines for violating environmental regulations.

In December, 1990, after an investment of $450 million, approximately 90% of the 320 sources of pollution were included in the program to "clean" Cubatão. Particulates in the air were reduced by 71%, fluorides were reduced by 92%, ammonia by 96%, hydrocarbon by 78%, and sulphur dioxide by 37%.

The program also attempted to clean up the water supply. By December, 1990, 97% of

On a global level, CO_2 emissions are increasing, in large part because of a 5% annual increase in CO_2 emissions in developing countries. In the countries of the Organization for Economic Cooperation and Development ("OECD"), however, CO_2 emissions have basically leveled off.

FIGURE 2



If negotiations for a Climate Convention succeed in the 1992 United Nations Earth Summit Conference on Environment and Development ("UNCED"), then CO_2 emissions will decline, just as they have in Western Europe. There is no sign, however, that any developing countries will reduce their CO_2 emissions. These countries are trying to avoid any commitments that would limit their efforts to de-

the organic compounds and 80% of the fluorides were eliminated from the water. The previously "dead" Cubatão River soon became repopulated with several species of fish.

Finally, of the 46 million tons of solid residues created, 60% are now recycled and 82% of the total are either treated or suitably disposed of. Of these solid residues, only 0.8% are dangerous. Further, 60 sq. kilometers of degraded slopes in the hills around Cubatão were recovered, eliminating further slides. Overall, from an environmental viewpoint the situation in Cubatão has improved dramatically.

velop. This fear is based on the old cliché that economic growth is inextricably linked to energy consumption. Although in the past development and energy consumption were linked in limited periods in the industrialized countries, the historical evidence does not substantiate such a cliché.

FIGURE 3

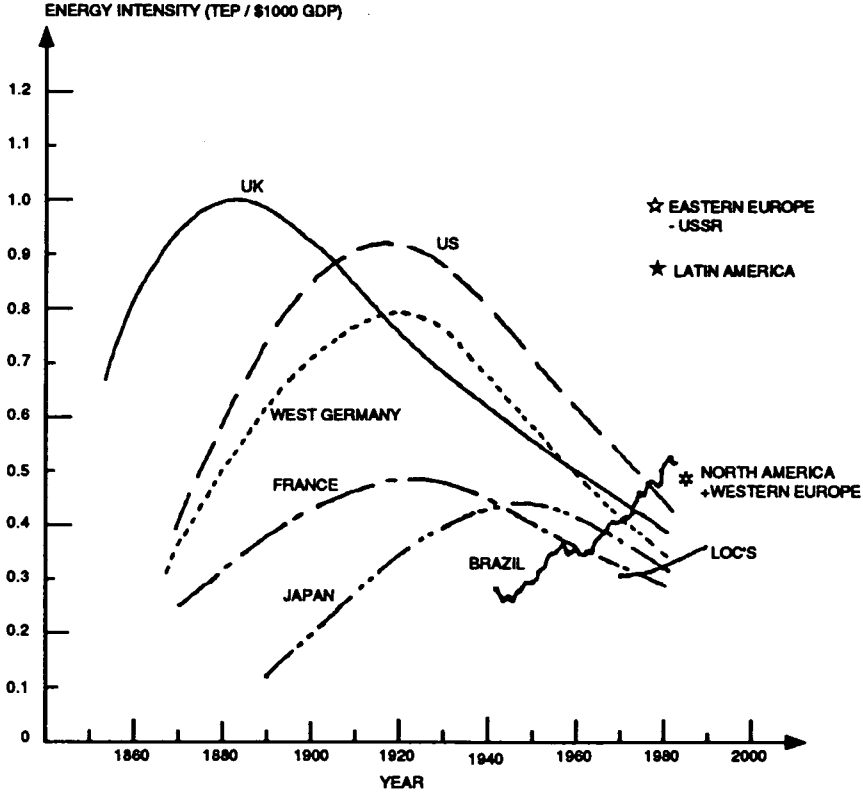


Figure 3 demonstrates the evolution of the "energy intensity" for a number of industrialized countries over the years. "Energy intensity" is defined as the total energy required to produce $1 thousand of GDP. Energy is calculated as oil, coal, gas, hydro, nuclear, solar, etc., converted into equivalent tons of petroleum.

As Figure 3 demonstrates, during the initial stages of development, all countries grow in energy intensity until it reaches a peak, and then declines as the infrastructure is built. This decrease continues as the country enters a post-industrial stage, when population

growth slows, and services are emphasized over the production of basic goods. Further, during this period modern methods of production and energy efficient technologies are optimized, thereby reducing the overall energy requirements of the country.

Figure 3 also indicates that peaks in energy intensity are less intense for latecomers to industrial development than they are for pioneers of industrial development, such as the United Kingdom or the United States. This is because the later developing countries have more modern and efficient technologies at the outset, which allow them to "leapfrog" steps taken by pioneers of industrial development. This paper argues that the strategy of "leapfrogging" is the only way to reconcile the aspirations of developing countries for modernization with the high environmental costs that such modernization creates at both the local and global levels.

II. TECHNOLOGICAL LEAPFROGGING

As Touche & Ross Management Consultants write:

> The broad objective of economic development is to enable the citizens of developing countries to fulfill their aspirations for higher living standards by raising the level of productivity, GDP, and incomes.
>
> This objective can be achieved by the acquisition and diffusion of more productive technologies throughout the economy. Technologies encompass both hard technology, in the form of plant, machinery and equipment, and soft technology, in the form of training, know-how, and more efficient means of organizing the existing factors of production. Technology is often interpreted in a narrower sense than this, to mean only the hardware of production; however, hard technologies can only be successfully absorbed and developed if complementary soft technologies are in place, and one of the main constraints on successful technological development in developing countries has been the tendency of hard technologies to run ahead of the training, institutional capacity, and infrastructural support necessary to sustain them.[2]

A useful concept in this respect is "technological leapfrogging," whereby developing countries employ new technologies and policies. There are two alternative methods of using these technologies: (1) either they are deployed first in developing countries, or (2) state-of-

2. TOUCHE & ROSS MANAGEMENT CONSULTANTS, GLOBAL CLIMATE CHANGE - THE ROLE OF TECHNOLOGY TRANSFER (1991).

the-art technologies of the industrialized world are introduced early in the process of development. These technologies are then used as an integral part in building the infrastructure and industrial base.

Below are examples of "technological leapfrogging" in developing nations. In order to illustrate the wide range of options available, and some of the problems faced, these examples refer to pollutants other than CO_2.

A. Example I: Trace Metals and Aluminum Cans

A company in a small Gulf state electroplated designs onto aluminum cans. However, the process left trace metals in the waste water. The company did not know how to properly dispose of the waste water. But, another company, Alcoa, had faced the same problem in the past, and designed and built a system to handle the trace metals. Alcoa saw no competitive interest in the area, and sent all blue-prints, plans, and cost estimates to the other company so it could duplicate its system.

This example illustrates two points: First, that companies in developing countries can tap into information that companies from developed countries willingly provide. Second, it illustrates that commercial interests do not always conflict.

B. Example II: Methanol Manufacture

About twenty-five years ago, in the United Kingdom, Imperial Chemical Industries ("ICI") developed a low-pressure process for the manufacture of methanol. This process relies on a specially formulated catalyst which is effective at a lower temperature and pressure than the catalyst used in the old high-pressure process. The resulting energy savings are approximately 15%. Additionally, the plant does not have to withstand such high temperatures and pressures.

Once ICI successfully established commercial production at its Billingham plant in England, it licensed the process to other companies world-wide, in both developed and developing countries. Today, there are a number of different companies competing to license this technology. This example demonstrates that companies of industrialized countries are frequently willing to license modern and efficient technologies. In so doing, they satisfy local requirements and maximize local engineering content.

C. Example III: Patent Protection in Southern Asia

A multinational chemical company which manufactures and sells pesticides in southern Asia limits its production to older, less sophisticated products whose patents have either expired or are near expiring. The company is unwilling to incur the substantial costs of registering newer, more effective products. This is because it believes that the lack of patent protection will permit local companies to manufacture and sell the same product without the high costs of research, development, and registration. Thus, they would be able to price their products much lower. Thus, if developing countries are to benefit from using high technology products, intellectual property must be protected, and manufacturers must be allowed to earn a return that adequately covers the costs of research and development.

D. Example IV: Vehicles in Southeast Asia

The OECD undertook a comparative analysis of vehicle technologies in six southeast Asian countries, which was published as an Annex to its 1990 "Background Paper by the Secretariat on Technology Transfer and Climate Change." The OECD found that although most of the major cities in the region have mass transportation systems the use of the private automobile has risen dramatically. Therefore, the importance of CO_2 reducing technologies emissions from motor vehicle emissions has increased.

The study found that Hong Kong, Singapore and Taiwan, the most advanced countries in the regions, have incorporated current CO_2 efficient technologies in their vehicle fleets. Thailand and Malaysia, having a lower overall technical capacity. The Philippines, the poorest country in the group, was the least advanced technologically.

A number of factors contributed to this result: (1) the higher rate of investment in new vehicles in the more advanced countries implied that they built the most efficient vehicle fleets; (2) the more advanced countries had the best maintained roads, which maximized fuel efficiency; (3) unleaded and high-octane petrol were readily available in minimizing the carbon-intensity of the fuel; (4) countries such as Hong Kong, have lower taxes on lead-free petrol which encourages its use over leaded petrol; (5) competitive markets for both exports and imports stimulated the use of the best technologies; (6) the more advanced countries had a high level of technical training, which enables vehicles to be efficiently maintained and operated; (7) the more advanced countries had the capacity to monitor and enforce set stan-

dards for emissions and fuel quality. This example illustrates that a range of conditions need to be in place in order to minimize CO_2 emissions from vehicles. Further, regulations and price signals have an important role to play in the process. As stated before, developing countries do have access to advanced technology. There does not have to be a trade-off between economic development and the environment. As demonstrated by this example, the most economically advanced countries were also the most advanced in terms of environmental technologies.

E. Example V: The Energy Matrix in Brazil

Brazil's energy system relies on renewable resources such as hydropower and biomass. Biomass includes fuelwood, charcoal, ethanol, and bagasse from sugarcane. Currently, 62.7% of all energy used in Brazil is renewable, and 37.3% is non-renewable in the form of oil, gas and coal. In the last ten years, the energy consumption has grown 4.8% each year. With such growth, total consumption is predicted to grow 2.5 times, from 183.6 million tons equivalent of petroleum ("TEP") in 1990 to 473.6 million TEP in the year 2010.

The 1990-2010 energy matrix of the Brazilian Government incorporates energy conservation and increases the use of natural gas, continues the use of biomass, and adopts modern technologies. Modern technologies include gasification for electricity generation, which uses highly efficient gas turbines. Under the new matrix, the present consumption of 183.6×10^6 TEP would grow to 386.6×10^6 TEP in the year 2010. This is a 30% reduction compared to historical growth, and will result in savings of $85 billion in investments. Further, it will reduce CO_2 emissions by approximately 30%.

TABLE 1
BRAZIL
ANNUAL GROWTH RATE 1990/2010

	Historical Trend	New Energy Matrix
GDP	4.3%	4.3%
Energy Consumption	4.8%	3.8%
Energy Consumed (Year 2010/1990)	473.9 TEP/183.6 TEP = 2.5	386.6 TEP/183.6 TEP = 2.1
Renewable Energy/ Total Energy (Year 2010/1990)	54%/116.7%	55.6%/118.3%

This example demonstrates that a developing country can steer development in directions that are environmentally sound.

F. Example VI: Air Conditioners in the State of São Paulo, Brazil

In the state of São Paulo, nearly 100,000 air-conditioners are sold every year. These units use outdated technology such as piston-driven compressors, and require approximately one kilowatt of power. As a result, the local utility companies must generate 25% additional power each year to supply the energy these air-conditioners require. This cost Brazil nearly $50 million per year just to operate air conditioning units manufactured by local companies.

Simultaneously, the same companies that manufacture these air-conditioners are producing units for export to the United States. These units use modern technologies, and require only .5 kilowatts per unit. The reduction in power required is attributed to the compressors which are imported from Japan. However, under strong pressure from the government, these companies will now manufacture locally the new efficient compressors locally, using technology from the United States. This will allow Brazil savings of half the power and an important financial investment each year. Although the investment needed to modernize the factories will be around $50 million, this should be recovered within the first year of production.

Since electricity is generated by hydrostations in Brazil, the reduction in CO_2 emissions are not significant. However, the reduction in CO_2 emissions would be great in countries where electricity is generated by fossil-fuel burning thermoelectric plants.

III. Barriers to Technology Transfer

Developing countries are characterized by scarcity of capital for investment, immense repressed demand and a lack of clear domestic policies. The main reason for the lack of domestic policies is the contradictions among different sectors of the population. Most developing countries have dual-economies in which a "modern" urban sector serves an affluent middle class elite representing some 20-30% of the population while the larger, traditional sector exists in the rural parts of the country, or in slums. The prosperous cities are islands in a sea of poverty. Political power is generally in the hands of the urban "elite," but because of the division between the two groups there is always fertile ground for demagoguery in the political process.

The repressed demand, created mainly by population growth,

makes the search for solutions both urgent and disorderly. Immediate solutions, even if less adequate, are given priority over better long term solutions. One reason why authoritarian governments are tolerated in developing countries is because they are more capable of solving problems than officials operating in a more complex democratic decision process. Under such circumstances, an enlightened government can achieve enormous success if it mobilizes local resources, invests in education, and develops a capacity to choose selectively from various foreign technologies. For example, Japan found itself in this position after the Meijii restoration in the last decades of the nineteenth century, and in thirty years converted itself into a world power.

Aside from this solution, multinational corporations are one of the few remaining instruments with which to bring modern technologies to developing countries. In some cases, however, these corporations transfer obsolete factories to developing countries as a marketing strategy. Although on the surface these factories represent progress in the recipient country, in reality the corporations are dumping pollution and energy-inefficient machinery into the developing countries which ultimately generates environmental damage and higher costs.

If developing countries take the initiative, local research and development are very important when selecting modern technologies. However, if they rely on multinational corporations, research and development are less important. By relying on the latter some developing countries have become quite modern, yet their universities and research institutions are almost non-existent or dilapidated.

An interesting list of barriers to the transfer of environmentally-sound technologies to developing countries was complied by the United Nations Center on Transnational Corporations. In that list, the perceptions of both transnational corporations and developing countries were identified, some of which are listed here:

A. "Barriers" cited by transnational corporations:

1. It is not profitable enough to sell environmentally-sound technologies in developing countries, because:

a. markets are too small for environmentally-sound technology in developing countries;

b. environmental laws in developing countries do not require environmentally-sound technologies;

c. there is insufficient market information on environmentally-sound technologies in the developing countries;

d. costs of energy and natural resources are too low to justify expenditures for conservation;

e. developing countries' customers are unwilling to pay for added costs associated with cleaner production.

2. It is too difficult to import capital intensive environmental technologies, because it is too costly to maintain environmentally-sound technologies in developing countries. This is because:

a. developing countries lack sufficient adaptation mechanisms such as adequately trained personnel for computer-based technologies;

b. developing countries lack adequate infrastructure such as steady electricity systems, for complex computer-based technologies.

c. import restrictions restrain environmentally-sound technologies.

3. It is competitively unfair to expect transnational corporations to use environmentally-sound technologies, because:

a. national firms are not similarly expected to use environmentally-sound technologies;

b. there is a lack in international environmental-protection policies to prevent "pollution havens;"

c. developing countries do not have adequate quality controls and assurance standards, which makes it difficult to make local environmental assessments and meet international standards.

4. It is unreasonable to give away patent protections for environmentally-sound technologies, because the research and development costs will not be recovered, and the motivation for future research and development will be diminished.

5. Developed countries' governments support an international policy of encouraging development and aid, yet they fail to provide financial incentives to match their policy statements, and are ambiguous in their own national environmental standards. Further, they avoid opportunities to create stable international environmental agreements.

B. "Barriers" cited by developing countries:

1. Patent holders prevent the use of environmentally-sound technologies in developing countries by refusing to license such technologies, and by setting prices too high for the local market.

2. Developed countries discourage developing countries from using environmentally-sound technologies, because:

a. costs of such technologies are greater than existing techniques used;

b. there are insufficient financial resources to cover the incremental costs;

c. there is a lack of new resources and information regarding the technologies;

d. spare parts and equipment service are not available at a reasonable costs or on a timely basis.

3. Developed countries are not prepared to directly finance the new technologies for developing countries, because they are not serious about environmental protection or sustainable development abroad, they are unfavorably biased against indigenous technologies, and they do not understand the environmental needs of developing countries.

4. Producers of the new technologies do not sufficiently disclose information, which weakens the developing country's product choices and negotiating advantages, and reduces the likelihood of good decisions regarding appropriate technology transfer.

5. Current international standards are set based upon knowledge and technology from developed countries, which may be incompatible with specific local geographic and cultural conditions.

6. Technologies marketed by transnational corporations are designed to benefit themselves, and not to benefit the host countries, since:

a. the technologies come from outside the country without adaptation to local needs;

b. purchasers are dependent on international firms for product maintenance;

c. there is no assurance that the technology transfers will not follow the same patterns.

d. the technologies from developed countries ignore simpler local technologies.

7. Developing countries do not have ecological incentives, due to the lack of information on local ecological problems, and the existence of more pressing priorities. Further, it is more beneficial for them to wait for further financial incentives or subsidies. United Nations, Environment and Development Branch, UNCTC - United Nations Centre on Transnational Corporation, Options to Increase Transfer of Environmentally Sound Technologies to Developing on Favorable Terms (1991).

Although transnational corporations and developing countries share at least some of the same views, the overriding consideration in the matter is the new environmental concern of developed countries. The governments of developed countries have realized that something

has to be done to reduce the dangers of climate change caused by development. As Touche and Ross Management write:

> It is not wholly within the gift of developed countries to solve the problem of limiting the growth in greenhouse gas (GHG) emissions from developing countries. There must be the local *will* to create the right environment within the local economy, and to seek out solutions. Then, assistance from developed countries can play a part.[3]

This notion of combined efforts seems to have emerged out of the need to reach an agreement on the problem before the UNCED conference in Brazil in 1992.

In the context of controlling GHG emissions, another series of barriers to technology transfer exists. The first is the barrier of "access." Developing countries generally have better access to the required technologies, although this is more of a *perceived* barrier than a real one. Second, there is the barrier of cost. There are some low-cost or even net-benefit options to limit GHG emissions. Frequently, however, the choice of environmentally-sound technologies imposes additional costs not associated with alternative technologies such as license fees and royalties. Third is the lack of information. With the large number of available technologies, needs and actors involved to limit GHG emissions, it is difficult to make a completely informed choice. However, lack of sufficient information is only a potential barrier, and it is not insurmountable. This is an area where the local capacity for making the right choices is fundamental.

Further barriers include the lack of infrastructure, indigenous support and political will to face environmental problems. Improving the local educational system is a critical prerequisite to building infrastructure and generating indigenous support. The lack of political will can only be overcome by local demand for technology transfers. The existence of local demand is the best driver of new technology. However, this demand is influenced by a country's pricing signals and environmental regulations.

IV. CONCLUSION

The transfer of technology from industrialized to developing countries for the purpose of minimizing environmental costs depends on fulfilling three main conditions:

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3. TOUCHE & ROSS MANAGEMENT CONSULTANTS, *supra* note 2.

First, adequate technology must be offered by industrialized countries, without commercial conflicts, in mutually profitable business deals.

Second, developing countries must guarantee fair remuneration for patent rights, and provide local infrastructure, which is needed to facilitate the transfer and absorption of the technology.

Finally, governments must commit themselves to reduce environmental deterioration. They must implement these policies even if it requires them to expend resources in specific areas and shift resources from profitable to less profitable ventures.

Some of these conditions require legislation while others require financial resources. Since resources are scarce, investments that would lead to a cleaner environment compete with other much needed economic and social investments such as health care, sanitation and public transportation. Therefore, it is unlikely that developing countries will be able to shoulder the burden alone. Therefore, it is fundamentally necessary to receive assistance from bilateral and multilateral institutions such as the World Bank.

Recently it has been argued that introducing modern technologies that minimize energy consumption and environmental impacts (and indirectly reduce CO_2 emissions) makes economic sense, if the initial economic hurdles can be overcome. In response, the World Bank, UNDP and UNEP created a new "window" to support developing countries that address global environmental concerns. Approximately $1.5 billion were allocated by the donors to the Global Environmental Facility ("GEF") for a period of three years under a pilot program. The results of the program will be evaluated in 1994.

Donors to GEF underscored the need to distinguish GEF from other development programs submitted to the World Bank, UNDP, and UNEP. These organizations agree on three types of investment which could generate both domestic and global environmental benefits.

The first type of investment is economically viable on the basis of a domestic cost-benefit analysis. This type of project is not eligible for GEF financing, unless the operation in question would not proceed without GEF involvement.

The second type of investment is one that is not justifiable when the full costs are borne by the implementing country. However, if a portion of the cost can be offset by concessional assistance from GEF, then the project's overall rate of return could be raised just enough to

attract the implementing country. Further, substantial global environmental benefits would be realized. This type of project should be eligible for GEF funding if it is within the cost-effectiveness guidelines established.

The last type of investment is justifiable alone but the country cannot bring about additional global benefits without additional costs. However, the proposed program must still be within the established cost-effectiveness guidelines.

The GEF initiative is a step in the right direction, but only so long as new or additional conditions are not attached to be eligible to receive funding. New conditions are common with World Bank projects, and it is not clear if GEF will be "contaminated" by such procedures. In any case, except for modest bilateral environmental assistance, GEF is the only mechanism in place to assist in this area. Optimistically, GEF will begin a new channel for support of projects in developing countries, and the 1992 UNCED Conference in Rio will make it permanent.