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**TECHNOLOGY TRANSFER FOR SUSTAINABLE DEVELOPMENT:
Transfer of environmental technologies - what does it mean?**

a discussion paper presented to the

**UNIDO International Conference on
Ecologically Sustainable Industrial Development
Copenhagen, 14-18 October 1991**

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1.0 INTRODUCTION

The term 'technology transfer' has become as fashionable, and has acquired the same magic ring as the term 'sustainable development.' Put together the two form a combination of euphonious but unspecified United Nations jargon: 'technology transfer for sustainable development.' Nevertheless, behind the rhetoric and the misty words, are both a real problem and a serious suggestion for a solution. On the whole, there is no doubt that the countries of Eastern Europe and the developing countries consume more resources and destroy more of the environment per material consumption entity than do the countries of the Organisation for Economic Co-operation and Development (OECD). It is also clear that one of the reasons for this is primitive technology coupled with deficient use. If the modern technology available in the OECD countries would be used by the developing countries - within the scope of rational systems for production, distribution and maintenance - the material standard could be raised without increasing the level of resource consumption. Therefore, if the needs of this generation are to be met without compromising the possibilities of future generations, it is an urgent task to transfer knowledge on this efficient technology, and on the systems within which it can be used.

At the same time it is obvious that only a minor part of the people of the earth can live at the present OECD level with the present OECD technology over a sustained period of time. Calculations have been made which indicate that the tolerance of the global ecosystem does not go beyond 400 to 800 million people. Consequently, technology which can raise the material standards of living for the people of the earth to the present level of the OECD countries does not exist. Such a technology has yet to be developed.

This important reservation has to be kept in mind but does not change what has already been said, i.e. that modern techniques combined with appropriate system solutions (=technology) would lead to an improved situation for the developing countries and the countries of Eastern Europe. It would also lead to an improved relation between resources utilization and pollution on one hand and material living standards on the other. This statement, which is the main thesis of this paper, does not automatically imply that the peoples of Eastern Europe or the developing countries would necessarily choose to take advantage of the increased possibilities for environmental improvement. It is perfectly possible that the priority would be placed on development of material standards. (This is the second reservation.)

Keeping the two reservations mentioned in mind, the starting point of this paper is that environment friendly and resource saving technology available in the OECD countries should be made available to the developing countries and countries in Eastern Europe. What obstacles are there? How do environmental techniques and resource saving technology differ from all other techniques and technologies?

To what extent is confidential technology required to solve environmental problems in developing and Eastern European countries?

These issues will be discussed below but first some words on the concepts of technology transfer and sustainable development.

2.0 TECHNOLOGY TRANSFER

The development and dissemination of new technologies have been and are a natural and integral part of the development of the human technological society. Learning through imitation is an inherited part of the individual development of humans and primates. If one individual succeeds better than another, due to better techniques for example fishing or lighting a fire, the second one will copy those techniques. This has been a natural behaviour throughout the history of mankind. The first and foremost criterion for successful transfer of such practically useful knowledge is that the receiver is interested in and committed to the process. Historically speaking, the giver has probably mostly lacked interest in or even been negative to the transfer.

The situation today differs from this historical picture, especially in some respects. First of all, the technologies in question are so complex that they cannot be grasped by individuals. The receiver organization must include a large number of people, and it must be adapted to an existing society. This society must also supply them with the necessary articles and demand their products. Secondly, technology transfer to developing countries is more often the result of a wish of others to propagate the technology than a desire in the population of the country to get it, that is, there has mostly existed a committed giver but no committed receiver.

The history of Sweden is rich in examples of successful importation and assimilation of techniques and technology. One of the more well-known examples is the "importation" of a large group of people from Belgium: the Walloons, who brought knowledge on mining and forging with them. Another example is the gigantic infrastructure project, the construction of Göta Canal. The project was a complete failure but as a spin-off effect, a basis for the engineering industry in Sweden was created.

When the LAMCO project was introduced, which included iron ore extraction and the construction of a railroad and harbour in Liberia (the Swedish company Gränges was one of the partners), many parallels were brought up to the two examples mentioned above. Those in favour of the project held that Liberia would get not only royalties from the iron ore but also an injection of knowledge comparable to what Sweden got from the Walloons and in connection with the construction of Göta Canal. Today, when all the ore has been extracted, virtually all the structures created by LAMCO in Liberia have collapsed like a house of cards. The civil war offers only one explanation for this. The harbour, the railroad, the construction shops and other parts of LAMCO were never connected to the Liberian society. It constituted an internally functioning entity, linked to the outside world but not to the country at large. When the links to the outside world - the ore deliveries - were cut off, the structure rapidly collapsed.

As stated above, transfer, adaptation and development of techniques and technologies is an integral part of the human technological society. When the issue is debated in relation to the problems of the developing countries, the point of reference is often the assumption that this process is smooth and efficient in and between the industrialized countries themselves. However, the debate in advanced industrialized countries who feel their GNP growth lagging behind their rivals, shows that even countries like Norway, Switzerland, Sweden and Austria

have problems acquiring what is best in the field fast enough. The computer technology, which has gone victorious over the world in the past few decades, offers an illustrative example. For example, the production technology for memory devices is controlled by a few companies in a few countries. Millions of companies around the world possess the knowledge on the application of the technology but the costs for acquiring this knowledge varies considerably. Obviously, a company or an organization has to choose the right computer (hardware), and buy or develop the right programmes (software). Furthermore, the computerized routines have to be adapted to the business of the company to ensure that the increase in efficiency aimed at by computerization will not also bring an increased rigidity, which will make the organization less adaptable in a changing environment. And to complicate the picture, existing personnel has to be trained, specialists have to be recruited, and new employees must answer tougher demands than before. It is impossible to assess the total size of the mistakes made in the introduction of computer technology but calculations made after the fact indicate that 10 to 80% of the money spent did not produce the desired effect, or indeed any positive effect at all for the companies. One fourth to one third of the money invested by the industrialized countries on the new technology may have been lost in this way. The general conclusion is that it is difficult and problematic to introduce new technologies, and furthermore, unexpected costs and a significant amount of waste are an inseparable part of the process.

The introduction of computer technology in the industrialized countries also illustrates another issue: who possesses technology, and to whom has it been transferred?

Obviously a great number of companies and organizations have achieved user knowledge and many people have become either (well-paid) specialists or routine users. But there is a significant gap between the mostly middle-aged or young people who are computer literate and the elderly who are not. The basic question to be asked is: who controls technology, and to whom is it transferred? This is in fact the key question in the whole discussion about technology transfer. A great deal of today's technical development is being made within companies, and this technical knowledge is usually protected, either by patents or otherwise. Obviously, companies are motivated to develop technology because they profit from it. That is to say that they want the new techniques to have an application which is as wide as possible, and which will bring them as much money as possible. National frontiers are not an obstacle for most companies; they are perfectly willing to spread their products and their production plants over the world, provided the economic conditions are advantageous. But flexibility in selling and producing in different countries is changed to rigidity when it comes to giving competitors of today and tomorrow access to protected technology - unless the immediate profit is big enough to compensate for estimated future disadvantages.

Consequently, it is probably possible for Brazil or Indonesia to get United States or Japanese companies to sell and produce products protected by patents within the country, provided the companies are allowed to own the plants and cash in the profits. In that case, will it be correct to say that technology has been transferred? The question would probably be answered in the positive by a defender of market economy, and in the negative by a mercantilistic or socialist view. In large regions, the political trend today is a strong development in favour of market economy and free trade. Many deadlocks in the view on technology transfer may be resolved through this political process. Still, the question remains: who is to have knowledge of and control over technology? Companies? The state? Everyone or no one?

The examples in the preceding discussion have illustrated a number of crucial questions for the application and transfer of technology. As a rule, every new technique or technology consists of a hardware component, a physical object. Then it has a software component, knowledge on how the object is to be used; in this case it may be computer programmes. But there is also a third element: the knowledge of how the new techniques can be adapted to companies, organizations and society in general. The physical object and the knowledge of how to use it, i.e. what is called technology, can be transferred. However, adapting to and transforming companies, organizations and the surrounding society has to be made anew in every new case. This technology assimilation cannot be transferred, even though previous experiences may and will be useful to avoid mistakes. The lasting success of technology transfer is not guaranteed only through the first two components, it has to rely on the third element as well. In the case of LAMCO, hardware and software were installed but technology assimilation was missing. If we look back on the Swedish historical example of the Walloons and their mining and forging skills, we find a case where knowledge was assimilated as was the group who possessed it. Generations of Walloons had a position of monopoly through their trade-guild. The high status acquired by the skillful Walloons in the Swedish society can still be traced in the pride with which many Swedes mention their Walloon ancestry.

Many discussions and analyses of technology transfer give special attention to the availability of confidential information and technical knowledge for developing countries and Eastern European countries. There are two main types of confidential information.

- 1) Technology of military value, made inaccessible by the legal obstructions raised by some state (usually the United States) and respected by allied countries.
- 2) Technology of commercial value in the possession of individual companies.

Later parts of this paper will discuss to what extent and in what environmental areas such confidential techniques are needed to solve the environmental problems of developing countries and Eastern European countries.

Another subdivision of techniques and technologies illustrated by the case of computer technology discussed above, is that of producer vs. user technology. Advanced computer memory devices are produced by a limited number of companies in a few countries but they are used by millions. Telephones and telecommunication systems are produced by a dozen or so companies but they can be found in virtually all the countries of the world and are used by billions of people. Commercial aeroplanes are produced by a few companies but airline companies and international airports can be found in most countries. Apart from the military sector, user technologies can be said to be generally available. The bottleneck here is almost always the scarcity of committed and informed customers. The importance of interaction between the informed and committed customer on the one hand, and the supplier on the other, for the development of techniques and technology, is worth noting in this context. (Swedish examples of relevance for this phenomenon are Swedish Telecom/Ericsson and Vattenfall/ASEA.)

Another important element is the fact that many power and telecommunication companies in the OECD countries have a policy that places large emphasis on established technology. Technical solutions are never considered of interest if not offered by at least three

independent suppliers. So these companies, experienced and knowledgeable technology users, reject innovative technologies and leave others to pay for the experience.

Military technologies have been mentioned a couple of times in the preceding discussion on confidential and available technologies. Evidently, all military powers try to stop the enemy from obtaining knowledge on weapons and defense systems. In spite of this, the military sector is probably the field where technology is spread most efficiently!

A comparative study of technology dissemination in the military and civilian spheres would be of great interest. Awaiting this study, it can only be observed that the importance of a committed receiver can hardly be overstated.

3.0 SUSTAINABLE DEVELOPMENT

So far, technology transfer has been discussed in general terms, without discriminating between techniques and technologies which are in any sense environment friendly and those that are not. What special criteria are valid for environmental technologies? Obviously there is a psychological and ethical difference between denying somebody access to technology which protects the environment and those aimed merely at luxury consumption. However, this type of conflict is not exclusive for environmental issues. Similar arguments can be applied to life-saving techniques within the food and pharmacology sectors.

A great number of analyses and political speeches show, and take as their starting point, the fact that at least some environmental issues are truly global, whereas others concern large regions. In the absence of national solutions for stratospheric ozone or the global climate, we have to find common solutions which cover and are embraced by (almost) everyone. In order to handle acid rain and marine eutrophy all neighbours must show their good will. There is another, more brutal way of expressing the same thing: for global and some regional environmental issues the developing countries are potential extortioners in a balance of terror. "Help us, or we'll sabotage everyone."

As the general economic development has made products and labour force in developing countries less interesting for the industrialized countries, certain environmental issues have emerged as constituting some of the few areas of actual mutual dependence. One of the crucial tasks of international diplomacy in the next few decades will probably be the realistic estimation and handling of this situation.

"Sustainable development" has been the key environmental issue since the late 1980's. The term was launched by the United Nations Commission for Environment and Development (UNCED) and had great success, as it answered the obvious dilemma between the need to protect the global environment against a continued destructive exploitation, and the simultaneous need for increased material prosperity for the growing masses of poor in the developing countries. The combined euphony and vagueness of the term probably explains its rapid political acceptance. It has largely the quality of a religious tenet or an incantation

but its two components did not automatically become more compatible by being joined in one formula.

The opening section of this paper claimed that a technology which would allow the people of the earth to achieve and remain on the average material standard of living of the OECD countries is not yet in existence. Today's average OECD technology would not allow more than 500 million people within the limits of environmental tolerance. That would seem impossibly far from a global population of five billion, growing rapidly and irreversibly towards ten. However, the situation is not quite as bad as that. If calculations would be made on the basis of the best technology applied today rather than the average technology of the OECD countries, the result would show that well over one billion people could maintain a high material standard of living within the limits of nature. (That is more or less the number of people living at this standard today.) Moreover, there exists in blueprint, in laboratories and in research stations technology which is either ultra-modern, or old and rediscovered, and which could expand the limits placed by resource supply. Thus another billion would be enabled to maintain the 1990 OECD material standards of living.

However, this discussion on the potential of technologies is based on the two parts of the expression "sustainable development" in one sense only. Another sense, another dimension (not in the mathematical sense) of the term becomes clear when comparing two reports: the Rome Club's "Limits to Growth" from the early 70's, and the Brundtland Commission's "Our Common Future" from the late 80's. The former has a static, the latter a dynamic approach. Historical examples once again provide an illustration.

The technology of the Bronze Age was dependent on the supply of copper in rich superficial ore deposits. With the present knowledge on the copper ore deposits of the earth one can pose the question: how many people could live, and for how long, with Bronze Age technology? The answer is: a couple of million people for a couple of thousand years.

Obviously, Bronze Age technology was not sustainable - but development was. Bronze technology enabled a development of metallurgical knowledge and mobilisation of resources which meant taking the step to early Iron Age technology. With that step, the dependence on copper was gone and the limitations of raw material supply practically eliminated. "Sustainable development" allows technology to evade dead ends.

It is easy to find other examples of technology which was impossible to retain in the long run. When the cultures dependent on a specific technology found no way out of the dead end, they perished. The Babylonian irrigation technology which created fertile land out of the area between the Euphrates and the Tigris, but which eventually turned the soil into desert, is a well-known example.

The history of mankind has seen many cultures rise and fall with the rise and fall of technology. New tribes, groups and peoples have replaced the ones that perished together with the collapsed technology. As history is often written by the victors, this development would often seem the reward of foresight and wisdom. In reality, coincidence, luck and adaptability may have been the decisive elements.

However, the situation today differs widely from this history. We are moving rapidly towards a global technological system where raw materials can be transported anywhere on the earth. This global technology does not collapse on a local level. No independent people are waiting to take over the leading role from the cultures that go down with technological failure. From the point of view of resources and environment, humanity is one and indivisible. We have the future in common.

4.0 TECHNOLOGY NEEDED TO SOLVE ENVIRONMENTAL PROBLEMS

The basic question is whether confidential technology which is hard to get access to for developing countries and the countries of Eastern Europe is clearly superior or even necessary to solve environmental problems, implement desired environmental protection measures, or further a lasting sustainable development. This set of problems is illustrated by three different approaches:

- 1) Environmental situation and problems in the developing countries
- 2) The UNCED Preparatory Committee's agenda
- 3) Societal sectors

4.1 Environmental situation and problems in the developing countries

4.1.1 *Tropical deforestation*

A number of causes lie behind the rapid destruction of the tropical rain forests. Among the most important are the need for arable land, the need for firewood and the exportation of tropical timber. The countermeasures can be summarized as follows: efficient use of existing arable land, a change of tax and financial laws to give small farmers access to large landed property already in existence, cultivation of biofuel together with more efficient utilization (e.g. through the use of better stoves), the use of technology, cultivation of coveted tropical woods.

In several of these cases technology has to be developed; in no case is it likely that steps to limit the felling of the rain forest are hindered by a lack of confidential technology. Future bio-technology based on the organisms of the rain forests, however, may be confidential and difficult to access.

4.1.2 *Desertification*

The most common anthropogenic causes for desertification are overgrazing, intense exploitation of marginal lands, irrigation which lowers the groundwater for cash-crop production, and tree felling. The majority of these causes are linked to poverty and increases in the population. Consequently, the main components of possible solutions are

socio-economic rather than technological. National animal species (rather than cows, sheep or goats), forest farming, and plant species which are resistant to salt and droughts can form parts of future solutions based on bio-technology. Limited access to confidential technology is hardly a problem today. In the future, access to bio-technological knowledge may be important to check the desert spread and win back desert land.

4.1.3 *Destruction of coastal zones*

One of the large-scale environmental problems which have received least attention in tropical and subtropical areas (in developing countries) is the physical destruction of the coastal zone. A rapid increase in population combined with new forms for economic exploitation have caused the extinction of mangrove swamps, sea grass beds and coral reefs. Coastal roads and local construction cut the shore zone off from the hinterland, while destructive fishing methods such as bottom trawling, dredging for navigation purposes and mineral extraction contribute to further destruction.

As production in tropical and subtropical seas is highly dependent on the coastal zone and its physical structures (as opposed to the situation in temperate seas), the destruction of coastal zones described above constitutes a direct and very real threat against fishing and the supply of sea products, the primary source of protein for about one billion people in the developing countries. Possible steps are mainly socio-economic and legal: planning of coastal zones and water resources, and control over exploitation. Access to confidential technology is not considered a limiting element for the protection of the coastal zone.

4.1.4 *Urbanization*

The explosive growth of large cities, especially in the developing countries, is an enormous problem in the process of creating a sustainable development. Given today's technologies, mega-cities with tens of millions of people are incompatible with the concept of "sustainable development." From the perspective of the people moving into the city, the decision is often a rational one. In their native villages the misery they face is certain, in the city it is only highly probable. The environmental problems of course, are made more severe by the fact that the infrastructure, in the form of water, sewage and waste treatment, stands no chance of keeping up with the growing population.

The solutions to urbanization problems are socio-economic. In existing cities, measures are limited mainly for economic reasons. The access to confidential technology is not an element of significance in the treatment of environmental problems caused by urbanization.

4.1.5 *Industrial issues*

Most developing countries have what is called industrial free-zones or "export processing zones." The concept is a loan from free ports and means that companies established in those zones are excluded from importation and exportation regulations, taxes, and, most often, from labour and environmental laws. Originally, the main attraction for international capital

investers was cheap manpower and local raw material. In the mid and late 80's, the absence of regulations for both working and exterior environment became a dominant attraction for companies leaving their own countries. As a result of this process, many industrial zones in the developing countries have become today's counterpart to the Osaka, Pittsburgh and Ruhr of yesterday.

Central steps to be taken are of legal character, combined with marked economic elements. In some circumstances, especially in the case of chemical production industry, the access to confidential production technology could be decisive to enable technical solutions to the problems. Many free zones generate considerable quantities of hazardous waste. In some cases there may be a demand for advanced methods of destruction but these are also available, albeit expensive.

4.1.6 Indiscriminate use of pesticides

Analyses made by the World Health Organization (WHO) and the United Nations Environment Programme (UNEP) of DDT contents in breast milk have shown that in many developing countries these contents are several magnitudes higher than in the industrial countries. This is explained partly by the warmer climate inspiring a higher general use of pesticides but primarily it has to be put down to a more indiscriminate use. Persons applying pesticides wear no protective clothing, toxic substances are used directly in kitchens and sleeping rooms, insecticides are powdered onto fish and meat to avoid fly-maggots etc., and all this leads to a higher direct exposure of people. The primary antidote is information, teaching and training. To this can be added a better supply of modern low-dose pesticides with a lower toxic content, as a rule, the more expensive ones. To a certain extent, access to confidential production technology for modern biocides can provide a solution, and in the long run bio-technology may play an important part for pest control. In that case confidential technology may become an article of short supply, and thus form an obstacle to progress.

4.1.7 Microbially contaminated drinking water

Probably the most serious and extensive environmentally related health problems in the world are those caused by microbially contaminated drinking water. The solution lies in separating drinking water from sewage and waste dumps but this is an enormous problem in the multi-million slums formed by the developing countries' mega-cities. However, the problem is almost exclusively an economic one (sometimes combined with religious beliefs). It can be solved easily enough by well-known, generally available technology.

4.1.8 The use of mercury in small-scale gold extraction

A special environmental problem which has spread relatively widely in many developing countries in the 1970's and 80's, is professional exposure and contamination with mercury of watercourses and fish. The origin of this problem is the use of mercury in small-scale gold extraction according to the following principle. A layer of mercury is substituted for the pan and the gold is amalgamated; when the mercury is considered saturated with gold

it is boiled down, and pure gold remains. As this allows even very small grains of gold to be taken care of, the yield is multiplied. The method is often used on a small scale under extremely primitive circumstances in inaccessible places like the Amazonas and New Guinea. Furthermore, the morals and law-abidingness of such temporary goldrush societies are often low. Solutions to the problem are primarily legal and economical; no confidential technical solution exists.

4.2 The UNCED Preparatory Committee's agenda

4.2.1 *Protecting the atmosphere through fighting climatic changes, the thinning of the ozone layer, and transboundary air pollution*

Within the general climate complex there is of course scope for advanced technology. But by and large, and from the perspective of the developing countries, climate measures will be a question of fairly simple interventions in existing production systems (e.g. in the fields of operation and maintenance), and of steps towards an increased energy effectiveness. Such technology is probably generally obtainable on the market, and should be available within the limits of normal investments and aid. Closer study of technology for new and renewable energy sources may be needed. Such studies are in fact being carried out at present, e.g. within the United Nations system.

When it comes to transboundary air pollution, primarily sulphur and nitrogen, practicable and efficient technology is probably available on the market today at reasonable prices. In order to discontinue the use of freones, substitutes are needed (to function as cooling agents, among other things). At present, these are controlled by the big chemical companies. However, mechanisms for the transfer of new environmentally friendly technology should be offered by the Vienna Convention and the Montreal Protocol already now.

4.2.2 *Quality and supply of freshwater*

Again, the issue of technology transfer seems of marginal relevance to the problems of freshwater quality and supply. It can be assumed that necessary water technology is available and perfectly possible to finance given the limits of existing systems of aid. Moreover, to a large extent the technology needed should be relatively simple. Problems are more likely to arise when it comes to the operation and maintenance of equipment and processes for water treatment.

4.2.3 *Sea and coast*

Problems relating to sea and coast are most likely to be caused by landbased pollution, fishing methods and dumping. For all these areas, technology should be available, and affordable within the framework of existing aid plans.

4.2.4 *Soil degradation, deforestation, desertification, droughts*

The cause of most of the problems covered by this heading is of a socio-economic character, and there are probably few technological solutions. Necessary technology - farming methods in agriculture and forestry, irrigation systems, etc. - should be available on the market and could be covered by present aid forms.

4.2.5 *Biological diversity - biotechnology*

Advanced biotechnology offers a classic example of new technology which for economical and legal reasons is difficult to access by developing countries. It is also a significant potential development resource. Provided that the issue of biological diversity is linked with that of technology transfer in the field of biotechnology, the availability of the latter may increase.

4.2.6 *Waste - chemicals*

Here, technology is relevant for production processes as well as for methods of destruction and treatment. There are potential techniques for production processes which will not generate toxic waste. In the future, technology may be transferred or "soft" conditions in this field. The level of knowledge is not very advanced even in industrialized countries but a rapid development may be expected.

4.2.7 *Poverty, health and environment*

Problems with the transfer of technology hardly constitute obstacles for the treatment of poverty, health and environmental problems. To a large extent, it is a matter of well-known infrastructures, where technology is easily accessible and well within the limits of normal aid plans. For the health sector, there is obviously a technology dimension to the issue of advanced hospital equipment as well as the access to special medicines. Nevertheless, health issues must primarily be treated with simpler methods and within the local basic hospital care covered by existing aid plans.

4.3 *Societal sectors and types of industry*

4.3.1 *Agriculture*

Environmental aspects of agriculture in developing countries range widely and depend strongly on climate, crops, technology and so on. A general observation is that hydrocultures usually are associated with fewer environmental problems than cultivation on dry soil used for crops such as wheat, corn or durra. The fertility of rice fields tends to increase over time, when important nutrients such as phosphates are bound to aqueous

sediments. Dry soils, however, lose both nutrients and humus substances. In arid environments with artificial irrigation and insufficient drainage, the salt content of dry soils tends to increase. Moreover, the cadmium content often increases with artificial manuring. An environmental problem shared by most cultivated crops but most marked at the cultivation of export crops or "cash crops," is caused by the use of biocides and biocide residues. Increased contents of nitrides in the ground water have been found in most cases where artificial fertilizers are generously applied. It is stated above that water cultures such as rice have the best chances of being permanently sustained. From a health and work environment point of view, however, one has to consider the risks of contracting waterborne tropical diseases such as malaria and schistosomiasis.

A general question is whether dry soil cultivation without breeding of cattle to match can be of lasting duration. The present agricultural technology of the western world is not.

The technical measures that can be taken to minimize soil erosion, nutrient leakage and the occurrence of biocide residues, as well as the accumulation of salt and cadmium in the soils, are well within the limits of existing aid plans and do not constitute confidential technology. In the future, biotechnology can become extremely significant for the development of a highly productive and environmentally compatible agriculture.

4.3.2 The transport sector

As a rule, road and railway networks in developing countries are poorly developed compared to those of industrialized countries - the transport sector often constitutes a bottleneck. Consequently, the direct effects on the environment are few in rural areas. (As opposed to indirect effects, which arise when transportation routes open areas for settling and exploitation.) The specific resource consumption, measured as fuel consumption per kilometre and ton of transported goods, is often extremely high due to the poor condition of roads among other things. The big cities often have chaotic traffic situations which significantly affect the air quality. Practically the whole modern transport sector is dependent on fossil fuel, and can consequently not be permanently sustained. The most important exceptions to this are electric railroads (where the electricity is not generated by fossil fuel) and the ethanol-driven cars of Brazil.

Techniques and technology available in the industrialized countries which could help minimize the specific resource consumption in the transport sector - and, incidentally, increase the total consumption by encouraging traffic work - is generally accessible.

Generally speaking, the transport sector is one of the really tough nuts to crack in order to achieve a permanently sustainable development.

4.3.3 Water and sewage systems

Water and sewage systems are consistently poorly developed in the big cities of the developing countries, a fact which is one of the main causes of polluted drinking water and accompanying infectious diseases. On the whole, there are good reasons to claim that

waterborne sewage is a defective system. A commodity in short supply - water - is used as conveyor, thereby turning potentially useful nutrients into pollutants. It would involve considerable costs to develop and maintain modern water and sewage systems but no confidential technology is needed.

4.3.4 The energy sector

The developing countries have a very heterogeneous energy sector, which varies according to local conditions and, historically, the supply of investment capital. Some characteristics compared with OECD countries are the importance of wood and charcoal as household fuel (with felling of woods as a consequence), a heavy reliance on low grade coal (with pollution problems as a consequence), and large losses in transfer and distribution in electric systems. User technology for exhaust gas purification and ash treatment from charcoal furnaces is available, as is the technology for efficient transfer and distribution of electricity. The production technology for important key components is confidential.

4.3.5 Food industry

The food industry, often small-scale, is one of the largest industrial sectors in most developing countries. Slaughterhouses, dairies, mills and bakeries, fishing industry, breweries and distilleries all generate large quantities of organic waste which causes oxygen deficiency in water environments.

Traditional purification techniques are costly, and seldom installed without imperative legislation. Modern anaerobic techniques with biogas production are often profitable since other energy forms can be economized on. Both traditional and new techniques are accessible but the latter are not yet established in all sub- sectors.

4.3.6 Tanneries

Leather is produced from hides through tanning. This type of industry - often small-scale but sometimes enormous - is widespread in the developing countries while the most environmentally conscious OECD countries have practically abolished them. Tanneries cause serious problems with water pollution, and some local problems with bad odours. Hides normally arrive salted at the tanneries. In the pre-processing step, they are soaked and fat and blood is scraped off. In the final tanning process, chromium and tannic acid are let out with the processing water. There is no good solution to all the environmental problems (caused by this method) but modern processing and purification techniques could significantly limit water pollution. This technology is generally accessible.

4.3.7 *Cement industry*

The environmental problems caused by cement production are several. Limestone quarries often create wounds in the landscape of precious areas. Sometimes corals are used as raw material. A fine-grained, strongly alkaline dust is often spread in large quantities in the production process itself. This dust can be irritating for humans and damage neighbouring vegetation. As a result of the high temperature combustion, large quantities of nitrogen oxides are often emitted, a fact which seldom receives much attention. There is an often neglected potential of destroying waste - and using its energy content - in cement furnaces in an environmentally acceptable way. There are available and profitable techniques for keeping the dust locked up and turning it into a product - cement - instead of a pollutant. Likewise, there is available technique for a certain reduction of nitrogen oxide emissions but this is more costly. The technique for using cement furnaces to destroy waste, finally, is not confidential but can nevertheless be difficult of access.

4.3.8 *Surface treatment*

The term surface treatment is used here to refer to chromium-plating, galvanizing, copper coating, etc. - a metal treatment step often related to engineering industry. The environmental effects are emissions of heavy metals and cyanides with the sewage water. There are processing and purification techniques available which will solve these problems. Some parts of advanced techniques for process control and regulation may be confidential. Within the field of electronics proper, most technology for surface treatment and cleaning is confidential.

4.3.9 *Mining*

Not all developing countries have a mining industry, and the problems connected with such industry are highly dependent on what is being mined, as well as local conditions such as the amount of rain and the groundwater level. Ore dressing plants linked to the mining industry often consume a great deal of water. Mining is often done in open-cast mines in developing countries. Some of the obvious effects on the environment are: changed landscapes, surface water pollution, lowering of the groundwater level and continued leaking of metals from waste rocks and sludge basins long after mining has stopped. Present environmental technology can minimize these problems but not eliminate them within reasonable economic boundaries. The technology is not confidential.

4.3.10 *Iron and steel industry*

Emissions from iron and steel industry consist of dust, heavy metals such as iron and nickel, and oil from rolling mills. Modern processing techniques have lowered the energy consumption and made the use of raw materials more economical.

Purification techniques to reduce traditional emissions are generally available. Modern processing techniques are partly confidential but licences may be obtained.

4.3.11 *Coke production*

Coke is generally produced in connection with the steel industry. There can be extremely large emissions of dust, sulphur and a spectrum of hydrocarbons including benzopyrene. Purification methods are available but costly.

4.3.12 *Cellulose industry*

The pulp and paper industries in developing countries are often small-scale and lack recycling systems for chemicals. Besides pulpwood, the raw materials used are waste products from farming such as bagasse and rice straw. There is extensive water pollution, with sulphite lye, fibres and oxygen consuming organic substances as main ingredients. Some areas have serious odour problems.

Systems and technology for the recycling of chemicals are available but as a rule they are not profitable in small plants. Fibre recycling systems are also available and generally profitable. Techniques for water purification are available but costly, and they are seldom introduced without imperative legislation. When chlorine is used for bleaching, the outlets contain organo-chlorine compounds. Alternative and modified bleaching technology which could significantly reduce these outlets has been developed; in part it is confidential.

4.3.13 *Petrochemical industry*

Generally speaking, only those developing countries which produce oil themselves have petrochemical industry. Modern processing technology can reduce outlets and waste significantly, and air and water purification techniques are available which could further minimize emissions. Purification techniques are generally available, whereas advanced processing technology usually is confidential. However, through their position as oil producers the countries in question have been able to obtain licences.

4.3.14 *Other chemical industries*

A heterogeneous group with a large number of different types of industry remains: production plants for sulphuric acid, potassium hydroxides, detergents, pesticides, explosives, cosmetics and fertilizers. As environmental problems and technologies for this group obviously differ a great deal, only a very general statement can be made. Usually, purification techniques for air and water are user accessible whereas advanced processing technologies often are confidential for commercial reasons. Furthermore, parts of the pesticides and explosive industry border on military areas and may be covered by military secrecy.

5.0 A CASE STUDY OF CONFIDENTIAL TECHNOLOGIES; TRANSFER OF NON-CFC TECHNOLOGIES

5.1 Introduction

Chlorofluorohydrocarbons (CFC's) and halones have been found to be major factors contributing to the destruction of the stratospheric ozone layer and important contributors to the green-house effect.

The Convention for the Protection of the Ozone Layer was adopted in Vienna in 1986 and went into force in 1988. A protocol to enforce control measures was approved in Montreal in 1988. A meeting in Helsinki 1989 discussed a strengthening of the Montreal protocol.

The countries that have ratified the Protocol at present account for 80% of the consumption of the regulated compounds and 85% of the production. The 20% of the world consumption not yet covered by the Protocol is in Newly Industrialized Countries and other developing countries.

It has been emphasized by a large number of developing countries that technology transfer is a prerequisite for their ability to live up to the provisions of the Montreal Protocol and this question is clearly a key issue for the success of the phasing out of CFC's.

5.2 Basic considerations

From a technology transfer point of view there are three clear groups of CFC uses.

- i) where alternative technologies are freely available (e.g. spray propellant, dry cleaning and flexible foam plastic production).
- ii) where replacement chemicals will be patent protected properties of private companies (e.g. refrigerators, heat pumps and air-conditioners)
- iii) where military specifications and export restrictions on high-tech apply.

5.3 Aid opportunities and options: evaluation of ideas

In the first economic review of the Economic Assessment Panel of the Montreal Protocol some important conclusions are drawn. Firstly it is stated that approximately 50 % of present CFC cost can be replaced without additional use. Secondly it is argued that transfer of non-CFC technologies for a variety of reasons should be less difficult than general technology transfer and certainly not more difficult than transfer of CFC technologies.

The report also lists a number of possible forms that the international assistance might take:

1. Action by multilateral lenders that are supportive of the goals of the Montreal Protocol. For example, CFC-substituting potential could be included among the criteria for project evaluation, or rapid transfer of projects could be made a requirement for funding. Loans for CFC-using projects could be restricted, while lending to promote alternative technologies is expanded. The president of the World Bank has recently stated that the Bank "should be there to help" countries whose industries face costs to re-equip because of international efforts to protect the ozone layer (World Bank, 1989).
2. Special access to CFC-substitute products to the markets of Protocol signatories. These incentives would be the positive counterpart to trade restrictions on products containing or made with CFCs.
3. Facilitation of the licensing or transfer of patents for substitute technologies. This could take the form of direct subsidies (whereby assisting countries would purchase patents or other rights in the new products or processes and make those rights in the new products or processes and make those rights available to developing countries) or the offering of tax and/or regulatory relief to firms that transfer their CFC substitute technologies on a private basis.
4. Training of personnel. Countries have made the investment in R & D and shifting to non-CFC technologies could provide demonstrations, symposia, fellowships, or internships to technical personnel of developing and newly industrializing countries. These technical experts would then carry knowledge on the substitute technologies to their home countries and firms.
5. Linkage of CFC controls with external debt relief. Compliance with the Montreal Protocol (and its successors) could be a necessary or sufficient condition for favourable resolution of international debt issues.
6. Support of non-CFC infrastructure in conjunction with other assistance projects. Vaccination and other public health programmes, for example, could be designed to use non-CFC medical refrigeration devices as part of their efforts, or to employ new technology that could avoid refrigeration altogether in delivery of medicines and vaccines.
7. Providing technical assistance to developing countries in carrying out technical/economic assessments of various CFC replacement technologies in the context of their particular industrial structures and development plans and priorities. This assistance could include providing an information clearing house and helping to fund consultancy studies on how the developing countries can make the best choice of replacement technologies.

8. Direct subsidies for CFC-free projects (e.g., grants to build factories to manufacture CFC substitutes or CFC-free refrigeration equipment).

A number of suggestions have also been made in different fora:

9. Change patent legislation in order to make environmentally sound technologies freely available to developing countries. This will be discussed below.
10. Encourage companies possessing non-CFC technologies to set up fully owned filial companies in developing countries, thereby transferring technology between countries but keeping them within companies.

When studying these and other possible forms of assistance as to their contribution to the goal of replacing CFC-technologies with non-CFC ones some criteria have to be established against which the evaluation can be made. For this first attempt the following goals of assistance have been used as evaluation criteria:

- a) encourage developing countries to employ non-CFC technologies;
- b) facilitate the transfer of non-CFC technologies that are not patent protected;
- c) make patent protected non-CFC technologies available to developing countries;
- d) encourage private sector R & D in the field of non-CFC technologies.

In the following table the ten proposed forms of "assistance" are evaluated with these goals as criteria. "Yes" means that the form of assistance contributes to achieving the goal; "(Yes)" that it does so but only to a minor extent; "No" means that it does not and "No" that it works against the goal in question.

Evaluation table is shown below.

Evaluation table

Proposal	CRITERIA			
	Encourage developing countries to employ CFC-tech.	Facilitate transfer of not patent protected non-CFC technologies	Make patent protected technologies available	Encourage private R&D on non-CFC technologies
1	yes	no	no	no
2	yes	no	<u>no</u>	no
3	no	no	yes	yes
4	no	yes	no	no
5	yes	no	no	no
6	(yes)	(yes)	no	no
7	(yes)	yes	no	no
8	yes	yes	no	no
9	no	no	yes	<u>no</u>
10	no	no	yes	yes

Obviously none of these alternatives would simultaneously meet all the four goals used as evaluation criteria. Thus a combination of different forms of assistance will be required. It is also clear that only two of the proposals would contribute to goals 3) and 4).

Discussions within several international bodies, such as the draft UNIDO Environment Programme, on the possibility of a fund that should buy licenses from private companies on commercial terms and make them available to countries on soft or symbolic terms, should be seen against this background.

Some linkage could be made to the windfall profits that are going to come to CFC-producers when production is limited according to the Montreal Protocol and a situation of short supplies is created. Clearly prices are going to increase sharply while production costs are unaffected. Thus CFC-production which companies should be encouraged to decrease will become highly profitable.

- Direct subsidies for CFC-free projects (e.g. grants to build factories for the manufacture of CFC substitutes or CFC-free foam plastic production.)

For the CFC uses where military specifications require them and where restrictions on high-technology transfer apply, no specific action has been proposed other than to inform Governments, where appropriate, to ensure that they are aware of the situation. A first step in this area could be that specifications are written as to cleanliness or performance of electronic equipment rather than to the techniques employed to clean.

6.0 SUGGESTIONS FOR MEASURES FOR TRANSFER OF ENVIRONMENTAL TECHNIQUES AND TECHNOLOGY

The above survey indicates that the terms technique and technology should be seen in a wide context: issues of training, operation, maintenance, administration and management form part of the concept of technology transfer. In order to build up a functioning and efficient environmental and natural resource administration with related legislation, maintenance and control, and access to laboratories, a special support system for developing countries and Eastern European countries should be created.

The survey also stresses the crucial significance of a committed and informed receiver as a general basis for successful technology transfer. The significance of technology assimilation is also stressed. In the environmental area, "centres of excellence" for environmental technology could be utilized, strengthened or created as appropriate. WAITRO - being the organization for collaboration among industrial and technical research organizations - would like to continue to play an important role in this field. Such centres of excellence could have great importance for the development of a basis of knowledge in the technology receiver, and assist at the assimilation of new techniques. These centres might also include the laboratories mentioned in the section above.

Some areas in which technology transfer measures need to be concentrated and where they may become important for problem solving include: substitutes for ozone harming substances, alternative energy sources, biotechnologies, chemical processing techniques and treatment of hazardous waste. Techniques for process control and regulation are significant for environmental issues but they are also of interest outside this sphere.

However, the picture which emerges shows that the access to and transfer of refined and advanced techniques on "soft" conditions to developing countries is not always a prerequisite for their possibilities of improving the environmental situation and create a sustainable development.

Another thing clearly shown is that technology for sustainable development is missing in central social sectors. Consequently, completely new technology must be developed or society be organized in a different way.

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