**NATIONAL CENTRE FOR CLEANER PRODUCTION AND ENVIRONMENTAL TECHNOLOGIES**

# DIAGNOSTIC STUDY ON CLEANER TECHNOLOGY CAPACITIES AND NEEDS IN COLOMBIA AND COMMERCIALIZATION OPPORTUNITIES IN LATIN AMERICA AND THE CARIBBEAN

## FINAL REPORT

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# INTRODUCTION

## Background to the project

The United Nations, through the Division for Sustainable Development, Department of Economic and Social Affairs (DSD/DESA), has been promoting the design of strategies for the innovation, commercialization and dissemination of clean technologies. In the course of this initiative, the Latin America and Caribbean region was selected for the first exercise, with a meeting of experts on the development of national clean technology strategies.

The project was to be implemented in a series of phases, including the design of a methodology for developing national clean technology strategies (output 1), a case study (output 2), an inventory of opportunities, a set of strategic action guidelines for technology policies, and a manual of recommendations and proposals for designing and implementing cleaner technology policies.

The UN selected Colombia as the pilot country. The National Centre for Cleaner Production and Environmental technologies (CNPMLTA) was chosen as the coordinating entity for the entire study. The study has two components: a diagnostic study of clean technology capacities and needs in Colombia, and a study of the opportunities for Cleaner Production in Latin America. The Centre contracted the "Quinaxi Instituto para el Desarrollo Sostenible" to carry out the diagnostic study in Colombia. This document contains the results of that research. The CNPMLTA also hired a Swiss consultant, Jurg Gruetter, to conduct the study of Cleaner Production opportunities. There was as well an advisory group, consisting of the Ministry of the Environment (MMA), the Departamento Administativo del Medio Ambiente (Environmental Management Department) of Santa Fe de Bogotá (DAMA), the Asociación Nacional de Industriales (ANDI) and CNPMLTA.

## Conceptual framework

To clarify the concepts used in this report, definitions of Cleaner Production, eco-efficiency, clean technologies and environmental (or environmentally sound) technologies are provided below, together with a description of the approach followed by CNPMLTA.

The UNEP (United Nations Environment Programme) has defined **Cleaner Production** (CP)[1] in the following terms:

CP is the continuous application of an integrated preventive environmental strategy applied to processes, products and services to reduce the risks to humans and the environment. For processes, CP includes conserving raw materials and energy, eliminating toxic raw materials and reducing the quantity and toxicity of all emissions and wastes. For products, CP involves reducing the negative impacts along the life cycle of the product, from raw materials extraction to its ultimate disposal. For services, the strategy focuses on incorporating environmental concerns into designing and delivering services[2].

[1] This concept was introduced by UNEP in 1989 during consideration of ways in which industry could work towards sustainable development.
[2] Extract from the National Cleaner Production Policy.

Cleaner Production includes making more efficient use of natural resources, and minimizing wastes and pollution, as well as risks to human health; it attacks these problems at the source, rather than at the end of the production process. Cleaner Production is a dynamic and systematic process that is applied permanently at each stage of the product life cycle, in the search for continuous improvement. Cleaner Production requires a change of attitude and acceptance of responsibility for environmental management and evaluating technological options.

The following management tools, among others, can help businesses identify Cleaner Production opportunities: pollution reduction audits (wastes, emissions, discharges), environmental impact studies, life-cycle analysis, environmental management systems, quality certification audits[3].

In this context, **clean technology** is only one integral element of the Cleaner Production concept, which also includes such factors as management attitudes and practices conducive to the continuous improvement of environmental management.

According to UNIDO (United Nations Organization for Industrial Development) Cleaner Production requires a change in the old "end-of-pipe" way of thinking, moving the focus from remediation to prevention. Prevention techniques and technologies go well beyond reducing pollution and disposing properly of wastes; they imply changes in management attitudes, in factory operations, in industrial processes, equipment and product design.

Cleaner Production calls for an integrated preventive environmental strategy that must be applied systematically and continuously. It therefore means conserving raw materials and energy, eliminating toxic raw materials and reducing both the quantity and toxicity of all emissions and wastes before they leave the productive process. For products, Cleaner Production involves reducing their environmental impact throughout the product life cycle, from raw materials extraction to final disposal of the product.

The National Centre for Cleaner Production and Environmental Technologies (CNPMLTA) has adopted these concepts in the belief that a **Cleaner Production Strategy** can be applied in various areas of business:

- Product changes: optimizing products with lower consumption of raw materials and/or inputs (energy, water etc.), replacing toxic by non-toxic raw materials, product life-cycle considerations, among others.

- Process changes: "good housekeeping", process optimization, changes in materials and inputs, improved productivity with a view to minimizing wastes and saving water and energy, among others.

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[3] UNIDO defines these instruments as follows: i) A waste reduction audit is a systematic examination of the materials flow in a process or plant to identify opportunities to reduce emissions and wastes, thereby saving money. This type of audit is applied to an existing plant that is seeking to minimize waste generation. ii) A product life-cycle analysis estimates the environmental impacts of a product from raw materials extraction through final disposal and identifies cost-effective options for minimizing wastes at each stage of the product life-cycle. Product life-cycle analysis is applied to a product either existing or new, to determine overall ecological impact. iii) An environmental impact analysis predicts the most significant environmental impacts of a project (for instance a new plant or a major modification of an existing plant). It also identifies opportunities for avoiding adverse impacts. The least-cost mitigation opportunities are often source reduction measures rather than pollution control technologies. iv) An environmental compliance audit assesses how an enterprise complies with current and anticipated future environmental standards.

- Internal recycling of inputs, materials and wastes.

- Technologies: switching from "dirty" to cleaner technologies, with the understanding that technology includes both hardware and software.

The Centre has set priorities for its actions. The first priority is to avoid and reduce pollution at source, through a preventive approach consistent with the concept of Cleaner Production. Since some degree of wastes will continue to be generated, despite efforts to minimize them, the second and complementary priority calls for reusing, recycling or upgrading wastes as preferred alternatives to final disposal, but these steps are clearly not part of the Cleaner Production concept. Another possible approach is to treat and dispose of wastes and emissions through "end of pipe" solutions; this falls under another set of environmental technologies that are not included in the Centre's activities.

The concept of **eco-efficiency** was developed by the World Business Council for Sustainable Development (WBCSD) as an approach complementary to Cleaner Production[4].

"Eco-efficiency is reached by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level in line with the earth's estimated carrying capacity." Eco-efficiency thus combines economic improvements with the more efficient use of resources and the prevention of emissions.

The WBCSD has identified 7 components of eco-efficiency:

- reduce the material intensity of goods and services,

- reduce the energy intensity of goods and services,

- reduce the dispersion of toxic materials,

- enhance the recyclability of materials,

- maximize the sustainable use of renewable resources,

- reduce the durability (degradability) of products,

- increase the service intensity of goods and services.

The concept of eco-efficiency goes well beyond simply reducing pollution and resource use. It stresses the creation of value, and links environmental excellence to economic excellence (a firm's economic performance). The eco-efficiency programme seeks to disseminate best practices (successful cases) and to measure and report on companies' environmental performance.

**Environmentally Sound Technologies**[5] are technologies (hardware and software) which contribute, in the particular national situation, to achieving or restoring the balance between objectives regarding social development, economic growth and the sustainable use of natural resources (including protection of the environment).

[4] UNEP and WBCSD, 1998.
[5] UN, 1996.

Environmentally sound technologies do not refer to any one technology or group of technologies in particular. This means that: a) a technology that is regarded as sound today may not be so regarded tomorrow; and b) a technology must be viewed in its relationship to socio-economic, cultural and environmental conditions, thereby creating an interaction the results of which must be constantly evaluated. These technologies may be classed on a scale ranging from preventive to remedial. Preventive environmental technologies are those that avoid the generation of wastes and emissions from the outset, through changes or substitutions at the source of pollution, while remedial environmental technologies are applied to reduce the environmental impact of wastes or emissions after they have been generated.

As an aid to distinguishing clearly between Cleaner Production and environmental technologies, there follows a typology of environmental technologies, prepared by UNEP, one category of which is Cleaner Production.

UNEP Typology of Environmentally Sustainable Technologies[6]

| | |
|---|---|
| Water Pollution Control and Water Supply | Technologies for water and wastewater treatment, water supply and water resources management |
| Air Pollution Control | Technologies for the control and treatment of air pollution emissions (COx, NOx, $CO_2$, - excluding greenhouse gases) |
| Noise and Vibration Protection and Abatement | |
| Solid Waste Management | Technologies for collection, transport, storage, treatment, recycling and disposal of solid waste |
| Hazardous Waste Management | Technologies for collection, transport, storage, treatment and disposal of hazardous waste |
| Energy | Technologies for alternative and renewable energy supplies and for energy conservation |
| Cleaner Production | Integrated preventive environmental strategies for processes and products to reduce risks to humans and the environment |
| Land and Agriculture | Technologies related to the sustainable development and conservation of land, agriculture and natural resources, including land remediation, soil conservation, mineral extraction, biodiversity, agro-chemicals, sustainable agriculture and re-forestation |
| Construction, Building and Engineering | Technologies related to engineering, infrastructure development and building construction (including machinery, equipment or methods/techniques of construction) which are environmentally sound |
| Global Climate Change | Technologies for reduction of greenhouse gas emissions, mitigation of global warming and alternatives to ozone-depleting substances (ODS) |

[6] Extract from UNDESA, 1998.

The ultimate goal of all these approaches, of course, is sustainable development, which must be built on three pillars: economic growth, environmental balance, and social progress. In this respect, a company will be sustainable to the extent that it can strike a proper balance between profitable operations, environmental protection, and social progress.

If we think in terms of a pyramid[7], where the vertex is the goal of sustainable development and the base consists a set of complementary management tools to that end, we can summarize the concepts, strategies, instruments needed for sustainability as follows:

- Objective: Sustainable development
- Macro-programmes and concepts: Agenda 21, Factor X, Environmental Space
- Business strategies: Clean Production and Eco-efficiency
- Administration systems: Environmental Management Systems, ISO 14000, Total Quality Control
- Administrative tools: Environmental audits, eco-labelling, Cleaner Production Evaluation, Environmental Performance Evaluation, Benchmarking

The following chapter presents the methodology used in conducting the diagnosis of clean technology development in Colombia.

## 1. METHODOLOGY

According to the terms of reference of the United Nations project, a methodology was to be prepared especially for conducting this diagnosis. Such a methodology was developed by the American consultant, Richard Bendis. When it was analyzed by the working group (CNPMLTA, advisory committee, Colombian consultants and the Swiss adviser), however, it was found to be inapplicable (for lack of information) and inadequate (it related generally to scientific and technological development, and was not sufficiently specific to the development of clean technologies). Moreover, in terms of science and technology policy and planning, Colciencias (Colombian Institute for the Development of Science and Technology) has available a number of works and reports, which will be discussed in section 3.4.

In light of the foregoing, the Quinaxi Institute prepared and used the following methodology for conducting this study. The Swiss consultant also prepared a methodology for measuring Cleaner Production opportunities in Latin America. These proposals were approved by the advisory committee.

The methodology is consistent with the requirements of the diagnostic study requested by the United Nations, the main purpose of which was to collect information on clean technology capacities and needs in Colombia, and on the various institutions working with Cleaner Production programmes, in order to assess and compile a state-of-the-art report on this area in Colombia.

[7] UNEP and WBCSD, 1998.

## 1.1. Analysis of Cleaner Production opportunities and capacities

### *1.1.1. Identification of opportunities*

Opportunities were identified through an analysis of:

- National environmental problems as defined by the National Cleaner Production Policy. To this end, the MMA prepared a Matrix of Environmental Problems associated with Colombia's productive sectors, which was included as the basis for the policy (Annex 12.1),
- The national demand for environmental technologies as identified by R&D Centres,
- Domestic and international legislative requirements (emission fees, Cleaner Production cooperation agreements, international conventions on climate change, etc.),
- Quality demands in national and international markets (ISO 14000 and other standards),
- The world market demand for clean technologies[8].

### *1.1.2. Determining capacities for R&D, the supply of clean technologies, and environmental management services*

Capacities for Cleaner Production R&D, supplying clean technologies and environmental management services were determined essentially on the basis of information provided by Colciencias and CNPMLTA. This information was organized in the following manner:

- Public technology research and development centres,
- Private technology research and development centres,
- Public universities,
- Private universities,
- Manufacturing companies,
- Engineering consulting firms,
- Industry associations and NGOs,
- Regional Autonomous Corporations (CARs).

## 1.2. Compiling and analyzing information

### *1.2.1. Selecting the sample*

A list of companies and institutions was selected for interview as representative for purposes of the study. These entities were classed according to their functions (government agencies, associations,

[8] CNPMLTA hired as Swiss consultant to prepare the report on the potential demand for Cleaner Production in Latin America and Caribbean, and the Quinaxi Institute therefore did not address the issue of international market demand for clean technologies.

universities, technology research and development Centres, businesses, NGOs), their nature as public or private bodies, and the production sector to which they belonged (energy, mining, agriculture, industry, transportation, environment and consumer goods). Annex 12.2 shows the institutional matrix. Not all entities identified in that matrix were actually interviewed. The business sector listing includes the names of only a few companies recognized for their commitment to Cleaner Production.

#### *1.2.2. Designing an information-gathering instrument*

The form used for gathering information was designed, first, with a view to the different kinds of entities to be interviewed. Subsequently, it was standardized to facilitate processing. At the same time, the corresponding database was designed. The first interviews, in Bogota, were used to test the instrument, which performed well. Given the complexity and possible confidentiality of the information being solicited, it was considered best to proceed by means of interviews. The instrument was, therefore, not designed to be filled out directly by the entity or enterprise in question (Annex 12.3).

#### *1.2.3. The interview process*[9]

Interviews were conducted according to plan in several cities of Colombia that had been previously identified as having the greatest concentration of Cleaner Production activities. Annex 12.4 presents the list of entities interviewed, organized by type of institution, sector and city.

In Bogota, interviews were held with government bodies (primarily ministries), businesses, associations, NGOs, universities and local environmental authorities. In Cali those interviewed included associations, research centres, universities and industrial firms. In Medellin, various kinds of entities were interviewed (businesses, NGOs, engineering consulting firms, a Regional Autonomous Corporation, scientific research and technological development centres, and universities). In the city of Cartagena, several companies in this industrial corridor were interviewed with the support of the Mamonal Foundation. In Bucaramanga the firms interviewed were concentrated in mining and energy (especially hydrocarbons), since these are the sectors where R&D and production capacities are most highly developed.

### 1.3. Review of international treaties and technical cooperation agreements on Cleaner Production

International multilateral treaties were reviewed, specifically the Vienna Convention for Protection of the Ozone Layer and its Montreal Protocol, and the United Nations Framework Convention on Climate Change and its Kyoto Protocol. The analysis focused on the parts of these instruments that deal with Cleaner Production and technologies.

With the support of the Colombian Agency for International Development and the Ministry of the Environment a list of bilateral agreements in the environmental area, and in particularly those relating to Cleaner Production, was also obtained.

[9] Annex 12.4 includes a list of entities interviewed, by city and type of institution. A copy of the surveys conducted will be provided in electronic format.

## 1.4. Identifying companies with ISO 9000 and 14000 quality certification

The official list of companies in Colombia certified as ISO 14000 compliant by ICONTEC (the Colombian Technical Standards Institute) was consulted. Because the list of companies certified nationally and internationally was so short (6), a list of those certified ISO 9000 compliant was also consulted as representing companies best placed to initiate certification of Environmental Management Systems, and information was requested on those in the process of certification.

## 1.5. Prospective analysis methodology

For purposes of deriving a forecast of Cleaner Production development trends in Colombia, an "Expert Workshop" was held, in which some initial basic assumptions were adopted as a framework for conducting the analysis. These assumptions were:

- The subject of the analysis is a process that has been underway formally since 1994, when the National Cleaner Production Programme was included as part of the National Environment Policy in the National Development Plan. The analysis therefore relates to a dynamic, ongoing process that has already produced results.

- The process of making internal progress in the search for Cleaner Production criteria, methods and technologies is closely related to international progress in this area, and to market demands.

- The prospects for successfully commercializing Cleaner Production processes and products in the world market will depend on creating a solid domestic basis for Cleaner Production, which in turn means that these concepts and products must be appropriated and adopted internally before attempting to export them to international markets, where they will have to compete with countries that have long experience in this field.

- The matrix of the Cleaner Production Opportunities component in Latin America and the Caribbean (developed by the Swiss consultant for CNPMLTA under the UN study) was applied to determine Colombia's position in the regional context.

In carrying out the analysis, the "expert workshop" methodology was used, whereby a group of persons regarded as experts, drawn from various entities and backgrounds, was asked to produce a quantitative assessment of the various factors that influence progress towards Cleaner Production in Colombia.

Three points in time were selected for the analysis - the present year 2000, and time horizons extending to 2005 and 2010 - thereby allowing trends in various factors to be assessed over the periods of time indicated. It was felt that any projection beyond the year 2010 would suffer from too great a degree of uncertainty.

We next defined a set of factors of various kinds that would reflect the possibilities of developing Cleaner Production. These factors were arranged in a ranking matrix for the three years targeted, and the experts assigned them ratings of high (3), medium (2), low (1) and nil (0) during the workshop. The factors used where identified on the basis of a spectrum running from the general to the specific, for a total of 26 factors divided into two groups, starting with the general framework and its development possibilities, such as policy and standards, and moving to highly specific aspects such as research and development facilities, industrial scale and competitiveness. The attached

matrix shows in detail the 24 factors involved in the analysis, and the rankings assigned them by the experts.

This method produced useful results for analyzing trends, and it is considered appropriate for purposes of the study and for the level of detail of information available in Colombia.

### 1.6. Inventory of companies working on environmental technologies

In response to a supplementary request from CNPMLTA, a telephone-based inventory was drawn up of companies working on environmental technologies in Bogota, Cali and Medellin. Companies were selected from the telephone directories and from a list of environmental suppliers prepared by the Ministry of the Environment. This information will be provided in electronic format.

The inventory covered a total of slightly over 1000 companies located in the cities of Bogota, Cali and Medellin, which were classified by category, subcategory, type of product or service, specifying whether the company is a producer or importer and providing company data, including name, address, telephone and fax.

This work should be very useful for the Centre's future activities and will allow it to interact with companies and individuals involved in producing and marketing environmental technologies and services.

## 2. GOVERNMENT SUPPORT PROGRAMMES FOR CLEANER PRODUCTION[10]

Following are the results of research into the Cleaner Production activities undertaken by the government over the past five years, i.e. since the concept of Cleaner Production was specifically included for the first time in a National Development Plan. It is important to note that this report refers to an ongoing policy.

In addition to presenting the National Cleaner Production Policy, the report refers to three government entities (two at the national level and one local) offering support programmes that have a major impact on Cleaner Production. These entities are the Ministry of Agriculture, the Colombian Institute for Science and Technology Development (Colciencias), and the Departamento Administrativo del Medio Ambiente (DAMA) of Santa Fe de Bogotá.

### 2.1. Ministry of the Environment -- National Cleaner Production Policy

The National Cleaner Production Policy was approved by the National Environment Council in 1997. This policy was formulated with a long-term view, in response to emerging environmental issues in the country's productive sectors. It was targeted primarily at preventing pollution at source, rather than dealing with it after it had been generated. According to this policy, environmentally cleaner production will produce a final product that is more respectful of the environment, as a result of a process that incorporates best environmental practice at each stage of the product life cycle.

[10] According to the terms of reference for the UN project, this chapter corresponds to the inventory of government technology programmes and R&D programmes financed with public funds.

The overall objective of the policy is to prevent or minimize impacts and risks to human beings and the environment, so as to ensure environmental protection, economic growth, social welfare and economic competitiveness, by introducing the environmental dimension into productive sectors as a long-term challenge.

The specific objectives are to:

- Optimize the consumption of natural resources and raw materials,
- Increase energy efficiency and use cleaner forms of energy,
- Prevent or minimize the generation of pollutants,
- Prevent, mitigate, correct and compensate for environmental impacts on people and ecosystems,
- Adopt cleaner technologies and practices that will ensure continuous improvement in environmental stewardship,
- Minimize and make use of wastes.

The strategies for developing the policy include:

- Coordination with other government policies,
- Establishment of an Environmental Quality System,
- Institutional strengthening,
- Promotion of Cleaner Production,
- Promotion of self-management and self-regulation,
- Design and implementation of economic instruments,
- Continuous policy monitoring.

Several activities to promote Cleaner Production in the productive sectors were included:

- Dissemination of the Cleaner Production concept,
- Facilitating access to clean technologies,
- Conducting demonstration and pilot projects,
- Human resource training programmes on Cleaner Production,
- Designing and using databases on clean technologies,
- Fostering basic and applied research into Cleaner Production,
- Generating mechanisms for international cooperation.

The policy contains several chapters, of which only three will be discussed here: the causes of environmental deterioration, policy instruments for promoting Cleaner Production, and policy guidelines for Cleaner Production.

The policy document offers a diagnosis of environmental problems (type of pollution generated) associated with Colombia's various productive sectors. The type of pollution refers to water pollution, atmospheric pollution, waste management, and erosion and landscape degradation. The productive sectors considered are: hydrocarbons, electricity, mining, agriculture, manufacturing, transportation and the household sector. The identification of these problems is expected to provide opportunities for developing environmentally sound technologies in the country (see Annex 12.1).

The following **policy instruments** are called for as a means of promoting Cleaner Production:

- Economic instruments of an environmental nature, aimed at changing the behaviour of businesses with respect to pollution fines or emission charges, water consumption, forest exploitation.

- Fiscal and financial instruments: tax incentives and IFI-CAF-MMA lines of credit for financing environmental upgrade projects.

- Cooperation agreements: an initial framework agreement on cooperation for Cleaner Production was signed, followed by a series of sectoral and regional agreements.

- Voluntary environmental stewardship codes: these are generally private initiatives aimed at continuous improvement of environmental management, based on self-regulation and self-management[11].

The *tax incentives* for Cleaner Production, according to the Taxation Statute, are as follows:

- Article 424-4. Goods exempt from income tax: "Domestic or imported equipment and elements intended for use in the construction, installation, assembly and operation of control and monitoring systems necessary to comply with prevailing environmental provisions, regulations and standards, as certified by the Ministry of the Environment (MMA)".

- Article 428 (f). Imports exempt from VAT: "The import of machinery or equipment, provided such machinery or equipment is not produced in the country, intended for recycling and processing garbage or wastes (such machinery includes that for washing, separating, recycling and extrusion), and intended for purifying or treating wastewater, atmospheric emissions or solid wastes, for the recovery of rivers or basic sanitation for improving the environment, provided such use is part of a programme approved by the MMA. In the case of contracts already signed, this exemption must be reflected in a lower contract value. As well, equipment for environmental control and monitoring, including that to be used in fulfilling commitments under the Montreal Protocol".

To be eligible for the VAT exemption, the supplier or manufacturer of the equipment must be accredited with the MMA and must have the appropriate certificate.

- Article 158-2. Deduction of income tax and other taxes for investment in environmental controls and improvement. "Corporations investing directly in environmental control and improvement have the right to deduct from their annual income the amount of such investments made during each fiscal year. The amount to be deducted may in no case exceed 20 percent of the taxpayer's net income, before subtracting the value of the investment (Law 6/92 article 123)."

This deduction is made directly and requires no special procedure.

[11] Examples are CECODES, Asocolflores and the Colombia Responsible Care programme.

*Cooperation agreements* are governed in the first instance by the Framework Agreement on Cleaner Production which was signed by the MMA, the Ministry of Mines and Energy, state-owned productive enterprises and most of the country's business associations. Its objective is to support sectoral and inter-sectoral efforts to improve public management and the control and reduction of pollutants, by adopting sustainable methods of production and operation; and to improve the coordination of public management between the MMA and the private sector (businesses, NGOs, associations etc.).

There are several types of cooperation agreements for Cleaner Production: i) sectoral agreements to deal with environmental impacts caused by industrial activity in a specific field (for sample coal); ii) association agreements to deal with environmental problems of a group of related industries and products (for example Asocaña); and geographically based agreements related to the problems of industrial activities in a given area (for example Mamonal).

The sector agreements in place cover small-scale gold mining, hydrocarbons, coal, electrical, sugar, African palm, the manufacturing industry, agricultural chemicals, bricks and clay products. The regional agreements relate to the industrial corridors of Mamonal - Cartagena, Barranquilla, Sogamoso, Oriente Antioqueño. One approach used in Antioquia combines both regional and sectoral agreements in the areas of flower growing, swine raising, sisal growing and poultry raising.

The *policy guidelines* establish a general objective and several specific objectives, strategies and other actions for promoting Cleaner Production. The overall objective of the policy is to prevent or minimize impacts and risks to human beings and the environment, so as to ensure environmental protection, economic growth, social welfare and economic competitiveness, by introducing the environmental dimension into productive sectors as a long-term challenge.

The MMA has played a limited role in these agreements, to the extent that their execution (and financial responsibility) falls essentially to the signatories, in particular the companies concerned. The Ministry's responsibility is thus restricted to assessing and monitoring commitments, and it does not have a proactive role in carrying them forward.

Some of the signatories to these agreements (such as the Corporación Empresarial de Oriente, the Mamonal Foundation, Asocaña and Cornare) have played key roles in achieving their goals, and in training and sensitizing businesspeople to the negative environmental impacts of production processes.

The role of Cornare, the environmental authority for Oriente Antioqueño, has been key in developing cooperation agreements, in creating an environmental awareness among producers and in enforcing environmental standards. When it comes to creating environmental awareness, for sample, the Corporation has provided training to business people in environmental stewardship. It regards itself not merely as an authority seeking to enforce standards, but rather as a partner and adviser in creating awareness about the importance of Cleaner Production and sustainable development. The Corporation's proactive efforts to promote Cleaner Production can be seen in the fact that it is a party to 6 cooperation agreements.

The MMA conducted an evaluation of efforts to promote Cleaner Production in Colombia, and has published the resulting report under the title "Towards Cleaner Production -- Progress and Prospects 1995-1998".

### *2.1.1. Coordination of government policies and agendas*

One of the most important things that the government can do to promote Cleaner Production relates to adopting common policies and coordinated agendas among the various ministries, and ensuring that they include environmental variables and issues, in particular those relating to Cleaner Production, in their policies, programmes and projects. The importance of this strategy is clear, given the role of the State as a principal player in national development.

Since 1995 the Ministry of the Environment has been making steady progress in articulating its Cleaner Production Policy with the efforts and policies of other government bodies. It has signed interdepartmental agreements with ministries and entities at the national level such as the ministries of Economic Development, Agriculture, Defence, Mines and Energy, and Education. As a further development of the Framework Agreement for Coordination for Cleaner Production, signed in June 1995 between the Ministry of the Environment, the country's principal business associations and the public mining and energy sector, the COMIS (Inter-Institutional Committee for Cleaner Production) was established to coordinate work with the productive sector; the MMA and the Ministry of Mines and Energy have members on the committee, and there are six representatives of business associations.

At the sector and regional level, progress has been made towards signing Cleaner Production agreements in several sectors, and in specific geographic areas. These agreements have been supported and signed by the MMA and by most of the Regional Autonomous Corporations.

As noted earlier, the MMA has issued a publication entitled "Towards Cleaner Production. Progress and Prospects 1995-1998", which reviews the history of achievements to date, underscoring the interest of the MMA in consolidating and highlighting its leadership role. The report provides background information on Cleaner Production in Colombia, describes progress in implementing the policy by sector, and offers an analysis of future prospects.

The most recent step in the strategy for inter-institutional environmental coordination was the signature on 24 August 1999 of the Joint Working Agenda between the MMA and each of the following ministries: Economic Development, Mines and Energy, Agriculture and Rural Development, Health and Transport. While these agendas embrace a wide range of environmental issues, in each case (with the exception of the Health Ministry) they contain specific proposals for action towards Cleaner Production.

The Working Agendas are structured around the following areas:

- Formulating and implementing environmental policies and technical regulations,
- Establishing joint programmes, plans and projects,
- Institutional strengthening.

Following in an outline of the proposed agendas as they relate to clean processes and technologies; in some cases they contain specific references, while in others they open the possibility for development and utilization.

#### *2.1.1.1. Ministry of Economic Development*

The following actions have been planned for formulating and implementing environmental policies and technical regulations:

- Design and implementation of economic and financial instruments in support of proposed activities in each area,
- Wastewater emission fees,
- Efficient use of water (Law 373/97). Programmes to promote water savings and efficiency, with their respective implementation guidelines.

Joint programmes, plans and projects have been established in several areas:

- Urban management:
  - ♦ Pilot project for sustainable urban transport in a medium-sized city,
  - ♦ Implementation of a project for mass use of gas as a vehicle fuel.
- Tourism: promotion of sustainable tourism in various forms: urban tourism, sun-and-beach tourism, agro-tourism among others. As an initial phase, a pilot project will be undertaken in San Andrés and Providencia.
- Industry: incentives to industrial development structures at the regional and sectoral level. Cleaner Production agreements, competitiveness agreements, CARCES, and Regional Investment Promotion Centres. In the initial phase, several projects have been undertaken:
  - ♦ Project to identify opportunities for cleaner technologies in priority industrial sectors,
  - ♦ Energy efficiency programmes, rational use of water and pilot projects for integrated management of hazardous wastes in the industrial corridors of Mamonal-Cartagena, Barranquilla, Oriente Antioqueño, Santa Fe de Bogotá D.C., Sogamoso and Cali-Yumbo,
  - ♦ Environmental technical assistance for businesses, particularly SMEs, and rehabilitation projects in the coffee-growing region,
  - ♦ Consolidating regional units to provide environmental technical assistance to businesses, through "environmental windows" and ACERCAR, among others, and extending their coverage to the trade and services sectors.

#### *2.1.1.2. Ministry of Mines and Energy*

As part of the strategy for formulating and implementing environmental policies and technical regulations, greater emphasis will be placed on Cleaner Production agreements at the subsector level (three agreements have already been signed, and others are awaiting signature), with an initial focus on the agreements already signed (coal, electricity and hydrocarbons). In addition, work will be undertaken to design and implement economic and financial instruments in support of proposed activities.

Joint programmes, plans and projects to be undertaken include the following:

- "Clean Development Mechanism" projects and others, under the Convention on Climate Change (Kyoto Protocol),
- Pilot projects for Cleaner Production in the electricity, hydrocarbons and coal sectors.

The following projects will be undertaken in the initial phase:

- Pilot project for efficient energy use in industrial corridors,
- National cleaner fuels strategy,
- Promoting the use of natural gas as an automotive fuel.

#### *2.1.1.3. Ministry of Agriculture and Rural Development*

Joint programmes, plans and projects include the following:

- Consolidation of Cleaner Production Agreements in the sector,
- New regional agreements for the raw sugar, sisal, yucca, rice milling and poultry subsectors,
- Promoting action plans under the agreements on pesticides, palm oil, sugar, flower growing, swine raising, sisal and poultry raising,
- Implementation of the National Plan for Sustainable Agriculture and Ecological Agriculture[12],
- Programmes to promote efficient water use in agricultural sectors,
- Design and implementation of economic incentives.

#### *2.1.1.4. Ministry of Transport*

Joint projects will be established and implemented to apply the clean development mechanism under the Convention on Climate Change. The initial phase will see the preparation of draft legislation for vehicle conversion, by the National Centre for Cleaner Production and Environmental Technologies.

With respect to institutional strengthening, economic and financial incentives will be designed and implemented for projects in the sector.

[12] See Section 3.3 for a brief explanation of this programme.

## 2.2. DAMA -- Programmes to promote Cleaner Production

The DAMA (Departamento Administrativo del Medio Ambiente of Santa Fe de Bogotá D.C.) is active on a number of fronts in promoting environmentally sound technologies. These include: i) monitoring industrial effluents; ii) the ACERCAR programme; and iii) the project to minimize industrial pollution by promoting Cleaner Production technologies.

As a result of the industrial effluent monitoring programme, 76 water treatment plants have recently been constructed, and water pollution levels have been significantly reduced.

ACERCAR is the Environmental Technical Assistance Unit for small and medium-sized enterprises in Bogota. The ACERCAR window was created in 1996, and provides free information, training and technical assistance to industries in obtaining the transfer of technology to mitigate the environmental impact of their activities.

In the first phase, 566 companies received advisory assistance, primarily in the food, leather, metallurgy, chemicals and graphic arts sectors, and 140 plant visits were conducted, mostly in the same sectors. The result was the implementation of environmental impact mitigation measures in 117 businesses. During the second phase, there were 1,669 consultations, again primarily in the sectors mentioned above, plus the rubber and plastics sector. Some 410 plant visits were conducted.

In addition, there are other tools such as the Sector Agreements on Environmental Stewardship (ASGA) signed between the Technical Assistance Unit and groups of businesses in various productive sectors, to help industrial participants gain readier access to environmental solutions, achieve better results from technical assistance, access information more promptly, and participate in technology seminars programmed by ACERCAR. Twenty-five ASGAs have been signed, covering 333 companies.

The principal services offered by ACERCAR are:

- General advice on environment and Cleaner Production issues,
- Identifying sources of credit for environmental conversion projects,
- Assistance to businesses in assessing the implementation of environmentally sound technologies from an economic viewpoint,
- Advice relating to environmental legislation,
- Information on clean technologies available to productive sectors,
- Specialized technical assistance for productive sectors,
- National and international technology update seminars,
- Pollution control guidance.

As a follow-up to these advisory services, the company can access resources under the Industry Environmental Conversion Fund, FRATI. The purpose of this fund is to provide co-financing for designing and implementing conversion projects by microenterprises and SMEs seeking to prevent or mitigate their environmental impact.

The fund finances the following activities:

- Environmental studies and diagnoses, aimed at minimizing wastes and emissions and, in general, at preventing and controlling industrial pollution,
- Design of environmental conversion projects for industries, aimed at achieving one or more of the objectives listed above,
- Research and applied technology development projects for modifying processes and incorporating the best available technologies, in order to minimize wastes and emissions, control pollution or undertake tests or pilot projects,
- Demonstration projects in environmental conversion, to highlight the economic, social and environmental benefits of incorporating clean technologies,
- Sponsorship or cofinancing to help microenterprises and SMEs attend national and international trade fairs demonstrating the latest technological developments and how they can be used in industrial processes.

The IFI-DAMA offers a rediscount facility for environmental conversion projects by microenterprises and SMEs. This line of credit carries concessional terms with below-market interest rates, and can be used to finance the following:

- Environmental diagnoses and studies aimed at Cleaner Production (eco-efficiency),
- Design of technology research and development projects for minimizing wastes and emissions, controlling pollution, or undertaking tests or pilot projects,
- Fixed assets and working capital (raw materials) needed by microenterprises and SMEs to carry out the recommendations of the studies referred to above.

As of June 1999, the value of applications for credit under the IFI-DAMA facility amounted to 2,223 million pesos.

The first two phases of the ACERCAR programme were carried out by the CINSET advisory and consulting firm. In 1999 the programme was suspended for several months for restructuring, and was recently awarded to another consulting firm.

The project for minimizing industrial pollution by promoting Cleaner Production technologies has been supported by the Japanese cooperation agency, JICA. The basic project consisted of conducting an environmental diagnosis of four sectors (10 firms per sector), and a subsequent detailed environmental audit of two firms in each sector. The sectors were selected primarily for their environmental impact and for the degree of support and participation by their respective industry associations. The textile, electroplating, oils and fats, soaps and detergents sectors were selected in this way. The project is now completed, and consideration is being given to replicating it at the national level, with the support of the Ministry of the Environment. As well, another project is under negotiation with JICA for the construction of industrial parks for the electroplating, poultry and tanning sectors, where the environmental impact is high.

## 2.3. Ministry of Agriculture -- Ecological Agriculture Programme

The Ministry of Agriculture, through its Environmental Stewardship Unit (UGA), is developing an initiative to promote ecological agriculture (total or substantial reduction in the use of synthetic inputs as fertilizers and pesticides). This programme is aimed at small-scale producers, and its objective is to enhance their competitiveness for export. At least than 14 producers have now been certified, with operations covering about 20,000 hectares, and products worth some 5 million dollars have been exported. The principal products are raw sugar, refined sugar, African palm, coffee, palmito, sugar cane, bananas, aloe, mangoes and herbs and spices. Export markets are the European Union, the United States and Canada.

Although ecological agriculture is not considered an initiative under the Cleaner Production programme, but rather a form of Cleaner Production in its own right, it may be regarded as a technological advance for small and medium-scale producers. The technology package for this system consists of a set of ecological practices for managing crops, soils, diseases and wastes in such a way that they will have no or negligible negative environmental impact compared with traditional production systems. Ecological agriculture practices, however, are not applicable to large-scale production that requires a high degree of mechanization and involves crop rotation (with high demands for synthetic inputs to maximize yields per hectare).

## 2.4. Colciencias -- Cleaner Production research activities[13]

The National Science and Technology System, SNCyT, is developing a strategic vision of the country's priorities for scientific research and ecological development, and of the role of education in this area, in particular that of the universities, and on this basis is formulating a strategic agenda for making Colombia a Knowledge Society[14].

SNCyT has established the National Innovation System (SNI) embracing innovative companies, universities, technology centres, engineering and consulting firms, suppliers, quality control laboratories, design centres and financial institutions. The National Apprenticeship Service (Sena[15]) is an active participant in the National Innovation System, where it plays several roles. For example, it is supporting work of the Technology Development Centres (CDTs) by promoting and financing joint projects with businesses, CDTs and Sena training centres[16]. For purposes of this study, the SNI is the most important entity, because of its close links to technology development.

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[13] See Salazar, M., 1998.

[14] See Chaparro, F., Knowledge, Innovation and Building Society - An Agenda for Colombia in the 21st Century, Colciencias y Tercer Mundo, Bogota, October 1998.

[15] For several years Sena has been a council member for national science and technology programmes, particularly in the area of innovation and business development.

[16] Sena is committed by law to channel 20 percent of its funding to projects promoting business competitiveness and technological development. It will also play an important role in the recently created Productivity and Competitiveness Fund, sponsored by the Ministry of Foreign Trade, Bancoldex and Colciencias.

In developing this strategic vision of science and technology, strategic plans have been formulated for national science and technology programmes[17], which will serve as a point of reference for higher education institutions and for technological research and development centres and groups, not only in the area of research and development -- with the focus on world trends and national research priorities -- but also as a guide for improving the quality and relevance of instruction at both the undergraduate and postgraduate level.

The following tables set forth the R&D priorities of national science and technology programmes relating to Cleaner Production, clean technologies and environmental technologies relevant to this study.[18] These tables also identify the research groups working on each line of research (those that have won tenders from Colciencias in support of research centres and groups in 1996 and 1997 are shown in italics)[19]. In the course of analyzing these lines of activity, keywords or specific research priorities have been identified in some cases to help in understanding the tables.

The science and technology programmes covered by this study are:

- Environment and habitat,
- Oceans,
- Biotechnology,
- Agriculture,
- Energy and mining,
- Electronics, telecommunications and computers,
- Industrial technology development and quality control.

### *2.4.1. Environment and Habitat Science and Technology Programme*

This programme has financed very few projects in the area of environmental technology over the period 1991-1998. Those projects are:

- Design, construction and installation of pollution control equipment in the electric steelworks of Siderúrgica del Muña and Siderúrgica de Boyacá.

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[17] The strategic plans of the national science and technology programmes contain projections of R&D activities, in accordance with the terms of reference of the United Nations project. In addition, the research work of the various research groups and centres helps to set the parameters for clean technology development in Colombia (see chapter 6).

[18] The other science and technology programmes not covered by this study are: health sciences, scientific studies in education, social sciences and basic sciences. Basic sciences, with their various disciplines (chemistry, biology, physics, mathematics, earth sciences and basic medicine) are key to developing other areas of science and technology, but since they have no direct and immediate application to the development of clean technologies they are not included here.

[19] The Web page of Colciencias provides an updated list of the most important and productive research centres and groups in the country. Information is provided for individual national science and technology programmes and for calls for tenders.

- Evaluation of dry anaerobic digestion of the solid fraction of municipal wastes, Universidad de los Andes.
- Use of molecular sieves in the decontamination of liquid wastes, Universidad de Antioquia.
- Study of the contents of three pesticides used in the basin of the Cauca River and their relation to environmental degradation and pollution absorption, Universidad del Valle.
- Catalysts for controlling environmental pollution, Universidad de Antioquia.
- Use of natural and synthetic fibres to protect slow sand filters in tropical environments, CINARA Universidad del Valle.
- The CIPAV decontamination system: a technology for reducing water pollution from agricultural runoff.

The first two projects have been completed, and the others are still in execution.

| LINES OF ACTION[20] | KEYWORDS | CENTRES & GROUPS |
|---|---|---|
| Technology and environment | Treatment of contamination and environmental restoration<br><br>Clean and alternative technologies<br><br>Eco-efficiency and the product life cycle: inputs and outputs, savings, re-use and recycling | *Potable Water and Basic Sanitation Research Centre – CINARA, Univalle*<br><br>Research programme on solid wastes –PIRS, UN<br><br>*Centre for Environmental Studies and Research, UIS*<br><br>Colombian Oil Institute, ICP<br><br>Environmental Research Centre -CIA, U. de A.<br><br>*Environmental Engineering Research Centre, U. Andes*<br><br>*Heterogeneous Catalysis Centre, U.N.*<br><br>Univalle<br><br>*Research Centre for Sustainable Agricultural Production Systems –CIPAV*<br><br>UPB |

In addition, the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM), which falls under the Ministry of the Environment, conducted an Inventory of Environmental Research in Colombia a few years ago, covering the period 1990-1996.[21]. The inventory collected information from 3100 projects of basic and applied research, conducted by various kinds of institutions,

[20] The other lines of activity under this programme are: biodiversity and natural resources, environmental quality, and population, land and human settlements - models of development and sustainability.
[21] Unfortunately this initiative was not continued, and the database is not available over the Internet.

universities (primarily), CARs, businesses (very few), NGOs etc. The information is classified by thematic areas, one of which is "technology", and which in turn is subdivided into clean technologies, biotechnology and agricultural technologies. The area of clean technologies has four divisions: technologies for Cleaner Production, energy, pollution remediation technologies (waste recycling and reuse; water and air pollution remediation), and environmental monitoring technologies. The area of biotechnology includes general, animal and plant biotechnology and vegetative propagation technologies. Agricultural technologies are divided into biological controls, fertilizers and organic inputs, sustainable and integrated agriculture, and integrated pest management.

Most of the projects summarized in this database as relevant to our study were collected during interviews at universities and research centres. A few others came to our attention through other sources.

### *2.4.2. Ocean science and technology*[22]

| **ECOSYSTEMS AND USE OF NATURAL RESOURCES**[23] | **RESEARCH PRIORITIES** | **CENTRES & GROUPS** |
|---|---|---|
| Aquiculture systems | Technology packages for diversifying into molluscs, marine fish, algae<br>Wastewater purification and bio-filters<br>Closed cycle and genetic selection<br>Multi-crop development | INPA<br>CENIACUA<br>Univalle<br>INVEMAR<br>Corp. Regionales<br>U. Llanos<br>U. Nariño<br>U. de A.<br>U. Magdalena |

[22] A list of the projects financed by this programme can be found at the Colciencias web site.

[23] The other ecosystems covered by the programme are: coral reefs, estuaries (mangrove swamps, estuaries, deltas and coastal waters); beaches and cliffs; continental shelf and slope and the exclusive economic zone; ocean systems; and fishery resources.

### *2.4.3. Biotechnology*[24]

| LINES OF ACTION[25] | KEYWORDS | CENTRES & GROUPS |
|---|---|---|
| Agricultural and plant biotechnology | Biofertilizers<br>Biopesticides<br>Biological control<br>Biopesticides<br>Pathogenic resistance or tolerance<br>Micropropagation<br>Sanitation and certification<br>Biochemical and molecular characterization of plant materials<br>Plant transformation | CORPOICA<br>CENICAFÉ<br>CENICAÑA<br>CENIBANANO<br>AUGURA<br>U. N.<br>CIB<br>CIAT<br>CIF<br>Politécnico Colombiano Jaime Isaza Cadavid<br>Fundación Centro de Biotecnología Mariano Ospina Pérez<br>U. Javeriana<br>U. de A.<br>U. Católica de Oriente<br>U. Caldas<br>U. Córdoba<br>U. Andes<br>Univalle<br>U. Magdalena<br>IBUN, U. N.<br>U. N. Medellín<br>U. Pedagógica<br>UPTC<br>UPB<br>U. Tecnológica de Pereira |
| Industrial biotechnology | Development of fermentation processes | U. Andes<br>U. N.<br>UPB |

[24] Hodson & Aramendis (1999) presents a complete listing of projects (completed or underway) financed by the Biotechnology Programme for the period 1991-1997.
[25] The areas of human and livestock biotechnology are also part of the programme.

| LINES OF ACTION[25] | KEYWORDS | CENTRES & GROUPS |
|---|---|---|
| Environmental biotechnology | Wastewater treatment systems | UIS<br>U. Andes<br>U. de A.<br>ICP<br>U. Jav.<br>Univalle<br>U. N.<br>U. N. Medellín<br>UPB |

*2.4.4. Agricultural science and technology*

| PROGRAMME COMPONENTS[26] | KEYWORDS | CENTRES & GROUPS |
|---|---|---|
| Agricultural production: perennial and annual crops | Integrated pest management<br>Biological crop management<br>Sustainable agricultural production systems<br>Biotechnology | CORPOICA<br>CENICAFÉ<br>CENICAÑA<br>CENIPALMA<br>CIAT<br>CENIBANANO<br>FEDEPAPA<br>FEDEARROZ<br>CORPOCEBADA<br>CIB<br>Biological Crop Management Research Group, UPTC<br>CIPAV<br>Plant Biotechnology Unit, U. Javeriana<br>U. Nacional<br>UJTL and U. de A. |
| Resource management (soil and water) | Treatment of soils, water and sediments | CIPAV<br>CORPOICA<br>UJTL |

[26] The other components of the programme are: livestock production (cattle and other species), rural business development and management, aquiculture, forestry and agro-industry.

### *2.4.5. Energy and mining research*[27]

| LINES OF ACTION[28] | KEYWORDS[29] | CENTRES & GROUPS |
|---|---|---|
| Coal: making greater and more efficient use of the resource with the best technologies and least environmental impact | Clean technologies<br>Eco-efficient technologies for coking and carbochemistry<br>Thermal generation<br>Transportation<br>Combustion processes and conversion | FONIC<br>Ecocarbón<br>Carbochemistry and Catalysis Research Group, U. de A. |
| Mining: assimilation and adaptation of competitive technologies that are environmentally friendly and readily applied and accepted | Environmental conservation<br>Exploitation: rational use of resources | Ingeominas<br>Research Group on Minerals, Biohydrometallurgy and Environment, UIS |
| Oil and natural gas: production and use of hydrocarbons with effective and environmentally friendly technologies | Petrochemicals<br>Environmental conservation<br>Efficient and rational use<br>Biofuels<br>Exploration, exploitation and transformation | ICP<br>CORASFALTOS<br>Corrosion Research Corporation -CIC<br>Asphalt Research Group, UIS |
| Energy sector: an increasingly efficient, competitive, integrated and reliable sector with minimal environmental impact | Rational and efficient use | Research Group on the Use of Water Resources U. N. Medellín<br>INEA |
| Electricity sector: an efficient and competitive sector with assured supply to all users, and environmentally sound technologies | Rational and efficient use<br>Transportation<br>Transmission (technical losses and blackouts) | CIDET<br>Signal Acquisition and Analysis Group PAAS, UN<br>High-Tension Research Group, Univalle<br>Energy and Thermodynamics Group, UPB |

[27] An updated listing of projects financed under this programme may be consulted at: www.colciencias.gov.co/programmeas/minproyectos.htm.
[28] In this case, all the programme's action lines are included, since they all are of interest to Cleaner Production and eco-efficiency.
[29] Only keywords relating to this study are included, since the programme addresses other interests as well.

| LINES OF ACTION[28] | KEYWORDS[29] | CENTRES & GROUPS |
|---|---|---|
| Alternative energies: adaptation and assimilation of technologies for making better use of alternative energy sources | Wind energy<br>Solar energy<br>Biomass<br>Electric micro-stations | INEA |

### *2.4.6. Electronics, telecommunication and informatics[30]*

| LINES OF ACTION[31] | KEYWORDS[32] | CENTRES & GROUPS |
|---|---|---|
| Application of ETI in sectors of particular development importance for the country | Environment: pollution sensors<br>Agriculture: automatic controls | Advanced Engineering Computation Centre, U. Andes<br>U. Javeriana<br>Univalle<br>U. Norte<br>U. Tecnológica de Pereira<br>EAFIT |

### *2.4.7. Industrial technology development and quality control*

The strategic plan for Industrial Technology Development and Quality Control has some particular features that make it unsuitable for presentation in a table. It is explained further below, after discussion of innovation policy.

Following are extracts from the National Innovation and Technology Development Policy that relate to four programmes: industrial technology development and quality control, telecommunications and computer electronics, agriculture and energy and mining.

The innovation policy relies on four basic concepts as elements of articulation.

- The first of these is support for innovation in the productive sector, through the encouragement of innovation networks that will facilitate linkages between companies, research and technology development centres, universities and other entities engaged in fostering technical interchange. This approach calls for the creation and strengthening of a National Innovation System in Colombia.

[30] The Colciencias Web site provides a listing of projects financed under this programme.
[31] The other lines of activity identified for this programme are: permanent generation of electronic knowledge as matrix technology; telecommunications and information technologies for the national information infrastructure; R&D support for development of the national software industry; industrial automation and innovation in the productive sectors.
[32] Other fields of application for ETI technologies are education and health.

- The second is the central role played by productive chains both in terms of ensuring a suitable level of competitiveness along the production chain and in terms of agro-industry and mining-industry linkages as dynamic elements of the productive sector.

- In the third place, the policy stresses the need to ensure sustainable development, based on preservation of the environment and maintaining social equilibrium. True competitiveness can only be achieved by integrating these two factors actively.

- In the fourth place, there is the need to address innovation promotion in an integrated manner, based on creating favourable conditions through macroeconomic policy and active sectoral policies.

The importance of productive chains is based on the need to secure greater value added in national production, generate more employment and take better advantage of complementarity among the various productive sectors and subsectors. This reflects the growing importance of inter-industry and intra-industry trade[33]. These agro-industrial and mining-industrial chains can be a driving force in responding to the growing worldwide demand for manufactured products.

The Industry Technology Development and Quality Control Programme has defined the following priority lines of action, as part of its strategic plan 1997-2003:

- Dynamic industrial chains,

- Export and technology-driving chains,

- Chains with a social impact and job-creating opportunities,

- Industrialization of natural resources and environmental technologies,

- Technological management and institutional development,

- Strengthening training and education in engineering and technology,

- Internationalization, strategic alliances and cooperation among industrial enterprises,

- Strengthening the infrastructure for research and technological services.

The policy for creating and applying scientific and technological knowledge in the productive sector will be based essentially on reinforcing the principles and values of the universal model of sustainable development. Preserving the environment, maintaining the social balance and developing clean technologies will constitute the pillars of the new technological policy, and incentives provided by the government will be aimed at encouraging projects with clearly defined social and ecological objectives.

It is clear that for the Industrial Technology Development and Quality Control Programme, the issue of sustainable development is an important part of its strategy, and the development of environmental technologies is one of its priorities.

[33] Inter-industry refers to trade between the agricultural sector, the industrial sector and the mining sector, or among different branches of the same sector. Intra-industrial trade refers to exports and imports of products belonging to the same branch or sub-branch of industry.

Some of the projects finance under this programme and considered as clean technology endeavours are (to mention only those not included in other chapters of the study)[34]:

- VARELA: With the support of CNPMLTA, this soap and detergent producer is consolidating its technology centre for developing and optimizing products, with the design and construction of four pilot plants: a laundry products plant, a soap-making plant, another to produce dishwashing liquids, and the last intended to produce liquid detergents. In addition, other technology development projects have been supported to optimize the handling of solid wastes, to reduce their environmental impact, and to design and develop a new, biodegradable product.

- INCOLBESTOS: This project consisted of producing friction materials for breaking systems that will eliminate asbestos as the primary raw material and substitute it with fibreglass, metallic and ceramic compounds. Financing from Colciencias is intended primarily for construction of a pilot plant. The technology was obtained under licence. These products are aimed essentially at the export market.

- MAQUINARIAS SUPER-BRIX: This project was intended to design and manufacture ovens for drying grain (rice and cereals), using as fuel waste products that are difficult to decompose biologically, such as rice husks, in the place of traditional fuels such as diesel, coal or gas. This technology is clean from a number of viewpoints, first because it uses agro-industrial wastes, secondly because particulate emissions are lower than from other fuels, and finally because of greater combustion efficiency. The ovens are exported to several countries in Latin America and the Caribbean.

## 3. NGO AND INDUSTRY ASSOCIATION PROGRAMMES IN SUPPORT OF CLEANER PRODUCTION

Nongovernmental organizations and industry associations have mounted a number of programmes for encouraging Cleaner Production. For example, there are institutions dedicated to promoting environmental stewardship among businesses, by providing monitoring, reporting and consulting services[35]. Other institutions have more "operational" programmes, such as training and advisory services for integrated waste management, and recycling in particular. On the other hand, there are entities undertaking programmes to apply best-practice manuals with affiliated companies.

Following is a description of some of the most noteworthy examples in Colombia.

[34] Examples of successful innovation and technology development projects can be found in the Colciencias book (1998b) or on the Colciencias Web site.

[35] Two major activities have been identified in the area of environmental stewardship support provided by businesses and NGOs: environmental reporting and environmental management accounting. In Colombia, the most notable cases of environmental reporting are CECODES and Responsible Care Colombia. In terms of environmental management accounting, Alpine (a food products company) has undertaken a very interesting experiment in this field.

## 3.1. Colombian Business Council for Sustainable Development -- CECODES

This is the Colombian chapter of the World Business Council for Sustainable Development (WBCSD), created in 1993. The Council was established to foster business leadership as a means of moving toward sustainable development. CECODES has the following objectives:

- To promote the creation of an institutional framework that will facilitate sustainable development.
- To give the productive sector a respected voice in creating and implementing policies, by promoting eco-efficiency among member companies and associations.
- To promote a clearer understanding of sustainable development in Colombia, particularly among the business community.

The Council has worked particularly on the design of eco-efficiency indicators, for which it collects and monitors data from member companies.

The Council consists of 31 companies and two associations, belonging to various sectors of the Colombian economy: mining, oil, agro-industry, manufacturing, construction, trade, banking and insurance. Member companies of the Council have undertaken various activities and investments to promote Cleaner Production[36].

## 3.2. Promotora de Desarrollo -- Codesarrollo

The Codesarrollo Foundation is committed to sustainable development through the promotion of ecological, economic and social programmes of research, education, advisory and consulting services.

This nongovernmental organization is engaged in various activities and programmes in the environmental field. In the first place, it has a programme known as CORRECICLAR, devoted to the marketing of recyclable wastes; it also provides training in proper waste management and offers classification and final disposal services for solid wastes. This programme is aimed at industry, trade and the household sector. In support of its efforts it also has plants for recycling glass and PET and plastic containers. These plants were established through strategic alliances with Peldar and ENKA, which buy their raw material output and use it in their production processes.

Through its environmental stewardship department, Codesarrollo offers various services, including the following:

- Environmental consulting and advisory services: diagnosis, characterization and implementation of integrated waste management programmes; environmental diagnoses; environmental impact studies; environmental audits; implementing environmental management systems under ISO 14000; water saving programmes in industry, among others.
- Environmental education and training: environmental awareness; integrated waste management with an emphasis on recycling; environmental management systems to ISO 14000 standards, among others.

[36] See Cecodes, 1998.

- Project pipeline: preparing applications for international cooperation and for the National Investment Projects Bank (BPIN).

It should be noted that for Codesarrollo integrated waste management implies: i) reduction at source, through process optimization; ii) classification, separation and commercialization; iii) recovery and use of wastes (for example through recycling); and iv) final disposal.

In the course of its activities it has performed the environmental diagnosis, pre-design and design and introduction of the Environmental Services Window for small and medium-scaled enterprises in the Aburra Valley, a programme similar to the ACERCAR sponsored by the DAMA in Bogota. The objective of this programme is to generate practical and efficient solutions to environmental problems facing SMEs in the region. The window is a mechanism for providing information, technical assistance and support to businesses. Its purpose is to help reduce the environmental impact of industry by incorporating environmental management systems, through five lines of strategic action: educational, technological, legislative, administrative and economic. Environmental diagnoses have been performed for 218 SMEs in nine productive sectors: foods and beverages, textiles and clothing, furniture and wood products, paper, cardboard and printing, chemical products, rubber, ceramics, glass and minerals, metallurgy and metal-working, machinery and other industries.

### 3.3. The Mamonal Foundation

The Mamonal Foundation was awarded the National Environment Prize by the MMA in 1998, in recognition of its extensive efforts on behalf of environmental protection. The Foundation has 45 member companies, in the petrochemical, manufacturing, fisheries, electrical goods and other sectors (firms engaged in security, hygiene, shipbuilding, free zones. Some of them are also associated with the Responsible Care programme coordinated by ANDI).

The Foundation has three principal objectives: improving the environment in the Foundation's area of influence, protection for industries (physical security) and social and community development. Its activities in the environmental area, which the Foundation has been pursuing since its creation, seek in particular to reduce the dumping of pollutants into the Bay of Cartagena, in line with the Cleaner Production Cooperation Agreement with the MMA and Cardique.

The Foundation performs a number of functions under the Cooperation Agreement: it is active in training, implementation, monitoring and control of commitments under that agreement; it conducts environmental audits of companies; it arbitrates at informal environmental hearings between businesses and the community. With respect to environmental standards setting, it tries to ensure that companies come in under the maximum limits, for example with respect to discharges and emissions.

The following activities have been carried out under the agreement, with support from the Foundation:

- Environmental diagnoses of 42 companies,
- An emergency awareness and preparedness programme at the local level (APELL manual),
- Classification of environmental quality of air, water and soil resources in the area of influence surrounding the Mamonal industrial zone (to be delivered shortly),

- Feasibility study for the handling of special industrial wastes (to be delivered shortly),
- Environmental training for businesses, communities and universities,
- Preparation and implementation, as a pilot project, of the environmental technical data sheet (an inventory of natural resources used by businesses), jointly with the MMA and IDEAM,
- Restoration programme for mangrove swamps and forestation in the zone,
- Management of recyclable and/or reusable solid wastes.

### 3.4. Responsible Care Colombia

The Responsible Care Programme was conceived by the Canadian Chemical Producers' Associations (CCPA), and has expanded to the point where it now involves the chemical industries of more than 40 countries. It seeks to serve as an effective tool for environmental management. Its strategy is flexible, and allows each company to meet its individual needs without compromising the environment, through a programme that embraces the entire chemicals sector. Industries participating in this movement believe firmly in the possibility of contributing to sustainable development.

In Colombia, this process has been coordinated and steered by the National Industry Association (ANDI.), the Colombian Association of the Plastics Industry, and the Colombian Safety Council (CCS).

The 51 industrial firms subscribing to this initiative have adopted "guiding principles", and are making a permanent effort to internalize "management practice codes" and to adopt the "performance monitoring and self-evaluation system"[37].

Two of these six management practice codes are related to Cleaner Production. Code No. 4, " pollution prevention", is designed to achieve permanent reductions in the amounts of pollutants discharged from companies' plants and installations into the air, water or soil. The Responsible Care Colombia programme provides member companies with guidelines for environmental stewardship and performance improvement, targeted particularly at reducing emissions, discharges and wastes and cutting back on thermal and electric energy consumption.

Industrialists have been moving progressively towards the use of raw materials that are less harmful to the environment, and have been developing and using cleaner processes for manufacturing their products. Efforts have focused on reducing emissions and minimizing the generation of wastes, addressing the problem from the concept both of new industrial facilities and the modification of existing ones. As well, it involves the proper treatment of residual materials and their safe transport, so as to ensure that environmentally harmful discharges are kept to a minimal.

Code No. 5 (product stewardship) seeks to reduce the health, safety and environmental risks inherent in products, thereby satisfying the requirements of clients and users for both safer and environmentally sound products. Product stewardship is respected at all stages of the product life cycle, i.e. it begins with the initial conception and design of the product, continues throughout its production and distribution for use, and remains in effect until final disposal.

[37] See ANDI, Acoplásticos and CCS, 1998.

### 3.5. The Florverde programme of Asocolflores

The Colombian Association of Flower Exporters, Asocolflores, has been engaged since 1996 in developing the Florverde programme; by 1998, 73 companies were participating in the programme.

Florverde is an integral strategy designed to optimize resource use over the long term, with a view to improving the profitability and competitiveness of companies in the Colombian floriculture sector, within a concept of sustainable development. The programme calls for: i) promoting the principles of Cleaner Production, ii) seeking continuous improvement (incremental approach), iii) fostering a technical culture that involves measuring and recording environmental variables, iv) promoting communication within and among businesses and with government, v) establishing sector goals, and iv) complying with legislation. The programme has a number of execution instruments:

- Code of conduct (best-practice manual): this is an environmental and social guide for flower growers, containing policies, goals, practical improvements and a checklist for each item.

- Specialized studies and advisory services: specialists in every area provide diagnostic services so that companies can gauge their own performance against an industry yardstick. On the basis of such a diagnosis, each firm will establish a committee to devise and monitor a company action plan.

- Case studies: the publication of successful examples of environmental stewardship has shown that protection of the ecosystem and investment in workers' welfare produces benefits for the company as well.

- Florverde Committees: the creation of discussion forums within companies, at the local, regional, and association level, to promote the exchange of experiences and the identification of eco-efficient solutions.

- Environmental management systems: Florverde disseminates ISO standard 14001, as a general guide for management organization. Environmental management systems are a tool for methodically addressing environmental issues at the company level.

- Benchmarking system: this allows the quantification of consumption, levels of saving and programme effectiveness in each company and for the sector as a whole.

Some of the results obtained to date include:

- Water: optimization of irrigation systems and rationalization of water consumption, based on the real needs of plants.

- Soils: optimization of use and rationalization of fertilization based on soil monitoring and knowledge of its physical and biological properties.

- Pesticide management: reducing the volume of pesticides consumed, and promoting biologically sound inputs and less toxic products authorized in Colombia.

- Wastes: reduction of wastes and conversion of existing disposal methods, and inter-sectoral efforts to define sustainable options for disposal.

- Care of the landscape: reforestation with native species and the creation of "green fences" for the embellishment of fields and the encouragement of biological controls.

Asocolflores also promotes scientific research and technological development for the floriculture sector, by contracting for research by public and private universities and private research and development centres, on issues of interest or concern to flower growers. Many of these projects are related to environmental issues, such as biological pest control, phytosanitary control, integrated pest management, characterization of different types of winter protection and climate management, composting of wastes and vermiculture, designing equipment for automated pesticide application, characterization of equipment for sulphur sublimation, etc. Currently, the association is reorganizing its sponsorship of R&D and defining priority issues, grouped under sanitation, production, post-harvest and soils, irrigation and fertilizing.

# 4. BUSINESS PROGRAMMES AND PROJECTS IN CLEANER PRODUCTION[38]

## 4.1. Manufacturing industry programmes, projects and technologies

The companies interviewed in the Colombian manufacturing sector are not a representative sample of the sector as a whole, but rather of those companies that are working on Cleaner Production. It is clear that this group includes not only those discussed below, which are basically individual cases, but must also cover firms associated with the various initiatives and programmes that have been referred to throughout this document, such as those participating in Responsible Care Colombia, the Mamonal Foundation, Cecodes, Asocña, Asocolflores, CERCAR, the Environmental Services Window and those that have been financed by Colciencias.

All of these companies show a great commitment to Cleaner Production and to sustainable development. Their efforts in these fields are many, ranging from implementing environmental management systems (ISAGEN) to developing clean technologies (REXCO). Some perform a complete analysis of the product life cycle (Cartón de Colombia), seeking constantly to reduce environmental impact and pollution levels at all phases of the cycle. With respect to Cleaner Production, and using the CNPMLTA focus, we find in each category examples of sound practices (Asocolflores, the flower growers association), product change (companies in the plastics and rubber sector, with technical assistance from ICIPC), process change (companies in the electroplating industry of Medellin, with advisory services from the UPB), and clean technologies (ES, Energía Solar).

Firms were interviewed in several sectors: food products, chemicals, oil, energy, pulp and paper, agro-industry, metallurgy.

### *4.1.1. Development of a clean technology. REXCO*

High-vacuum technology has many applications, including high vacuum metallizing for the application of thin films, for example of a decorative type. This is a totally clean technology that produces no toxic emissions: its wastewaters are recycled, and toxic elements (for sample paint) are separated for subsequent final disposal. This technology replaces the process of electroplating, which is highly polluting both of the water and the air. Electroplating in Colombia, because it is primarily a "garage" (micro and small enterprise) industry, does not observe the necessary environmental controls. All over the world, the electroplating industry coexists with high-vacuum

[38] According to the terms of reference of the United Nations project, this chapter corresponds to the inventory of industrial R&D activities, financed by the private sector.

metallizing. Part of the problem in securing the generalized adoption of metallizing is that it requires advanced technological know-how (it is a leading-edge technology) and costly equipment.

The REXCO company has as one of its members the International Physics Centre (CIF)[39], which has conducted research into thin-film semiconductors from which the high-vacuum industry has emerged. The company adapted the foreign technology and designed and build certain parts in the country, while the technological development was in the hands of the CIF, which enjoyed financial support from Colciencias.

#### *4.1.2. Development and application of an environmental management system. ISAGEN*

ISAGEN is a mixed enterprise, in which the public sector has a majority shareholding interest. It generates electricity and has a number of hydro and thermal power stations throughout the country.

The company's commitment to sustainable development is explicit through the formulation and approval by its Board of Directors of an environmental policy that is to be applied in all activities of the company. The company intends to be known as an eco-efficient business, and to produce and sell "clean energy". It is currently in the process of quality certification under ISO standard 14000, and already has an environmental management system in place. As well, all of its power plants have ISO 9002 certification from ICONTEC.

Within ISAGEN, environmental management covers a range of activities to identify, assess, prevent, minimize, mitigate or offset negative environmental impacts and to promote the positive impacts of the company's own activities; in this sense it amounts to preventive environmental management. Among the various areas involved in environmental management are: compliance with environmental legislation, environmental culture, participation in the environmental legislation process, applied research, environmental studies, and environmental management plans for all power generation stations.

#### *4.1.3. Life-cycle analysis for paper. Smurfit Cartón de Colombia*

This company analyzed the life cycle of the product, seeking to "close" the cycle and to minimize the environmental impact of each of its phases. Starting with its own forest plantations, the pulp mill has a chemical recovery system and an effluent treatment plant, and recycled paper is used in the pulping machine. The end product is paperboard and bags. After use, the paper and paperboard are collected for recycling, and other products are deposited in sanitary landfills. Carbon dioxide emissions from the plants and the sanitary landfills are offset by the capture of CO2 and the generation of oxygen in the forest plantations.

The company's commitment to sustainable development is an integral part of its business plan, and originates at the highest management level. It has a clear vision and policy with respect to environmental stewardship and Cleaner Production on all fronts. All of its staff have been trained and sensitized to the environmental impact that they may be causing. The company is a member of CECODES.

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[39] The International Physics Centre, CIF, is a private research institute based in Bogota. It is made up of 12 physics societies from Latin America, the United States and Spain. It has 132 members, 80 of whom are Colombian physicists and 52 foreign. The CIF has been selected by Colciencias as one of the country's research "centres of excellence", in the course of all the calls for tender to research centres and groups. Since 1995, it has been promoting the creation of a number of technology-based companies in Colombia.

Clean technologies are applied at several different levels: raw materials, processes, energy, products and recycling.

The substitution of raw materials has been pursued on several fronts: i) a forestry programme with sustainable production of long and short fibres from cultivated trees; ii) the production of TCF (totally chlorine free) paper, by replacing chlorine with hydrogen peroxide for bleaching the pulp; and iii) eliminating heavy metals by substituting organic for inorganic pigments in the inks used for printing.

Efforts to recycle and reuse products include: i) the use of black liquor as a fuel, and the recovery of 90 percent of chemicals; ii) the reuse of sawdust in tree nurseries; iii) the reuse of charcoal in the prefabricated blocks, as a filler material in the nurseries; and iv) the recycling of 120,000 tons of paper and paperboard each year.

In its productive processes, the company has made a number of changes of machinery and equipment during its existence, seeking continuously to incorporate cleaner technologies. In the energy area, there have also been several changes, most notably the conversion of coal-fired boilers to Castillian crude, and subsequently to natural gas, and finally replacement by a new boiler that uses natural gas. The treatment of effluents has involved optimizing operation of the lagoons, adding nutrients and increasing holding times, as well as adding aerating equipment.

There been several product changes: i) the weight of corrugated boxes has been reduced; ii) the weight of bags has been reduced (all without any negative effect on the quality or performance of products;) and the company produces totally chlorine free (TCF) paper.

Of all the companies interviewed, this was one that had the best-conceived and most highly developed integral programme for Cleaner Production, minimizing the environmental impact at all phases of the product life cycle. Moreover, a large portion of its scientific and technological developments is of its own innovation, such as the improvement and adaptation of tropical species of pine and eucalyptus for forest plantations, and the process for eliminating chlorine from the pulp bleaching stage.

#### *4.1.4. Development of new biodegradable products. GECOL-IDEAS*

The GECOL-IDEAS Company has developed a new line of cleaning products (for computers, clinics, industrial use, floors and automobiles) that is marketed under the name of Now Clean. The product is manufactured from natural saponins, without the use of surface-active agents, which means that it is totally biodegradable. The product for clinics also has the properties of a germicide, an antiviral agent and an odour remover. The industrial product can be used to treat industrial waters and black waters, to remove grease, bad odours, and to prevent the accumulation of toxic bacteria or micro-organisms.

This technology-based company was recently forced to close, as a result of the economic crisis affecting the country. Nevertheless, its founder (who possesses the scientific and technological know-how) is planning to restart production shortly with the support of other entrepreneurs and investors.

#### *4.1.5. Recycling and upgrading wastes. Ambiente y Medio*

The Ambiente y Medio company has designed and built a factory for recycling Tetra-Brik containers[40]. Using a biochemical process, the different layers that make up the package are

[40] Tetra-Brik and Tetra-Pak are similar containers, but with different trade names.

separated, so that each element (paper, polyethylene and aluminum) can be recycled separately. The technology itself is clean, and generates no wastes, and the processing waters are reused.

Patents are pending for this process in Colombia and Japan. The development has already been demonstrated in a pilot plant, and industrial-scale plants are now under construction in Pereira and in Curitiba, Brazil. The project has been supported by ZERI (the Zero Emissions Research Initiative)[41], in the area of patenting and commercializing the technology.

#### *4.1.6. Development of bioinsecticides. Biocaribe*

Biocaribe is a company dedicated to developing organic and biological products for agricultural pest control. It has developed bioinsecticides for crops that include flowers, coffee, vegetables and bananas, as well as for lawns and ornamental shrubs.

The company has received standing support from the Interdisciplinary Group for Molecular Studies (GIEM) at the University of Antioquia, which shares in the company's profits through royalties that are paid for commercialization of each product resulting from the research.

This biotechnology company has had to break several conventional paradigms: technological (R&D, quality control), economic, cooperative (with the University), legal, marketing. For example, joint work with GIEM has been a permanent learning experience for both sides, and they anticipate mutual benefits from this process of knowledge transfer. When working with living organisms, quality control is a key consideration, since they can change and become destabilized very easily. Basic science and technology companies face many problems, not only in developing knowledge but also in terms of economics and profitability. Many times the resulting product is successful from the technological viewpoint, but not in economic terms. When it comes to commercialization, given the fact that bioinsecticides require technical assistance in order to be applied correctly, Biocaribe has created several companies for distributing its products.

#### *4.1.7. Developing clean technology. ES Energía Solar*

ES Energía Solar is a company that makes solar collector panels (solar-energy water heaters), thermal tanks and heat pumps. Solar energy technology is widely available internationally, and is recognized as a clean technology for generating electricity. ES Energía Solar has made several technical modifications, such as substituting materials to optimize heat transfer.

The company's strength lies in its ability to combine its knowledge of solar energy with its expertise in hydraulic, mechanical, electrical, electronic and civil engineering, to undertake complex projects. Its heaters are competitive both in technology and pricing terms. In addition to the positive environmental impact from using clean technology, savings are generated through reduced energy consumption and low maintenance costs (operating costs are in fact zero).

#### *4.1.8. Closed-cycle production: waste re-utilization. Sucromiles*

The Sucromiles Company began work on Cleaner Production techniques in 1971 and since then has been progressively incorporating clean technologies into its production processes. It has sought to reduce emissions and to treat them whenever they create foul odours (through the design and

[41] The ZERI initiative was launched in 1994 by the United Nations University in Tokyo. To date it has held four international congresses. The fifth congress will take place in Colombia in the three departments that make up the coffee-growing region (Caldas, Risaralda and Quindio). See El Tiempo, Lecturas Dominicales, September 12, 1999, pages 6-7.

construction of a biofilter for treating hydrogen sulphide, together with the Biotec Corporation[42].). It has sponsored a number of water treatment projects, including one for separating wastewater flows according to their organic load, and subsequently decontaminating them in two treatment lagoons (for more efficient removal of the organic load it has been collaborating with the Environmental Sanitation and Biotechnology Programme of the Universidad Javeriana[43]). The biogas generated is recycled for use as a fuel in the boilers. As well, a composting plant is being developed to use the output of the water treatment plant, and other residues and wastes produced in the process.

#### *4.1.9. Process optimization in 12 electroplating firms*

This project, financed by Colciencias at the Universidad Pontificia Bolivariana (UPB), involves 12 firms in the electroplating business from the metropolitan area of Medellin in an effort to recover and reuse wastewaters that have a high chemical content (copper, zinc, nickel, tin, chromium, iron, gold, silver and phosphates).

Working through the Environmental Research Group, the UPB provided advice on optimizing the processes in these 12 electroplating firms. After performing a chemical analysis of the wastewaters at each firm, the researchers designed alternative processes for recovering the components from the water and recycling the water itself. With the process finally selected, a recovery rate of between 60 percent and 90 percent has been achieved, and water savings amount to some 15,000 cubic meters per month, thanks to efficient recycling.

The second stage of the project calls for an evaluation of technologies for recovering raw materials, through changes in the recovery processes themselves, and for treating wastewater.

The companies participating in this project are Electrocontrol, Arbar, Gameco, Algamar, Ideace, Incametal, Multiherrajes, Indurrajes, Herrajes Gaher, Industrias Vera, Simesa, and Torres Colombiana.

This case is an example of the kind of technical assistance projects conducted by PROPEL, ACERCAR, CNPMLTA and other technical services institutions.

### 4.2. Engineering consulting firms

There are several kinds of firms in this field: those that provide consulting services exclusively, particularly environmental studies and process audits for quality certification; those that engage in consulting, evaluation and technology negotiation; those that are involved in designing and assembling engineering equipment; and those that manufacture equipment as well as providing consulting services. Only a few firms are mentioned here, and they are definitely not a representative sample. Rather, they are considered of interest because of the different activities they conduct and because of their real and effective commitment to the environment.

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[42] This project was financed by Colciencias, with the goal of constructing biofilters for controlling the impact of hydrogen sulphide (a rotten-egg smelling acid) emissions in the effluents of anaerobic wastewater treatment plants, in Levapan and Sucromiles. See section 6.2.3 on the Biotec Corporation.

[43] The research project consists of evaluating a combined system of macrophage microalgae for treating industrial wastewaters. The project is still at the laboratory stage, with financing from Colciencias. The second phase has now been undertaken, with the intention of building a pilot plant within the company's facilities. The algae in turn produce biomass that serves as feed for the composting plant. See section 6.1.5 on the Universidad Javeriana.

### *4.2.1. Engineering and manufacturing. TEPSA*

The TEPSA company has three divisions: engineering, environment and plastic equipment. This company follows a philosophy of responsible care, Cleaner Production and minimizing effluents at source, for all its products. TEPSA offers:

- Project engineering, plant design, process re-engineering, and industrial optimization services,
- Design, construction, assembly and operation of treatment plants for drinking water, industrial water and domestic and industrial wastewater,
- Treatment of fugitive and corrosive gaseous emissions,
- Recovery and treatment of contaminated soils and proper disposal of industrial wastes,
- Manufacture of reactors, washing towers, processing tanks, demineralizers, softeners, filters, filter press plates, using thermoplastic materials that are resistant to conventional corrosion problems,
- Operational risk analysis (HAZOP, hazard and operability study).

Two of its most recent products, with a significant positive environmental impact, are:

- Modification to the productive process for re-using water in jeans assembly plants. Jeans laundries are heavy consumers of water, and their discharges are highly polluting.
- Industrial wastewater treatment plant for Sofasa-Toyota. The work performed for this factory covered several aspects: a plant was constructed to produce drinking-quality water for industrial use, water consumption in productive processes was reduced, chromium consumption was eliminated as a water pollutant from the productive process, and an industrial wastewater treatment plant was built and operated by TEPSA.

### *4.2.2. The PROPEL Corporation*

PROPEL is the Spanish acronym for "Promotion of Eco-Efficient Small and Medium-Scale Enterprises in Latin America". It is a non-profit regional entity created in 1991 at the initiative of the Swiss Foundation for Sustainable Development in Latin America (FUNDES). It also has funding from the Swiss Government's international technical cooperation programme, through COSUDE. While PROPEL is an NGO it was classified as a business, since it offers consulting and advisory services to businesses and charges a fee for them. It is a member of the Latin American Business Council for Sustainable Development.

The Corporation is active in eight countries of the region: Colombia, Mexico, Bolivia, Ecuador, Chile, Costa Rica, Guatemala and El Salvador, either on its own or in association with other entities and individuals. Its mission is to promote small and medium-scale enterprises in Latin America and to make them more competitive and productive, through eco-efficient solutions:

- Adopting cleaner technologies,
- Reducing the consumption of resources and energy,
- Minimizing wastes and emissions.

None of these solutions requires the entrepreneur to invest in machinery and equipment. In principle, according to the Corporation's philosophy, it does not support or undertake "end-of-pipe" solutions. Its services are aimed at optimizing processes and applying sound manufacturing practices, with a view to achieving Cleaner Production. In 1998 it provided services to 197 firms (in the countries mentioned above), in the tanning, jeans pre-washing, metallurgy, electroplating and ceramics industries, and for ecologically sound coffee processing. It expects to serve some 220 companies in 1999.

PROPEL's programmes include:

- Structural and economic diagnosis of each sector.
- Analysis of the socio-cultural characteristics of entrepreneurs,
- Experimental implementation of proposals for improvement, and evaluation of results,
- Strengthening training programmes for business associations,
- Advice on developing innovative solutions and working together with the environmental authorities.

In the environmental stewardship area, it performs environmental impact studies and produces environmental management plans, as well as advising on the preparation of environmental documentation such as discharge declarations and technical plans eligible for tax incentives for investment in clean technologies.

PROPEL carries out many of its advisory programmes with the support of the environmental authorities (DAMA, CVC, CAR, MMA, CRQ, Cortolima, Copoboyacá) and multilateral bodies such as the World Bank and the Inter-American Development Bank.

#### *4.2.3. Engineering design and assembly. INDISA*

This company is a specialist in mechanical design and assembly. It exports approximately 50 percent of its engineering and equipment design services. The company has a declared policy of working for the environment, and it applies the Cleaner Production concept in all its projects, seeking to minimize emissions, effluents and wastes. Its principal areas of endeavour are:

- Environmental controls, particularly for air and more recently for water,
- Switching from heavy fuels to natural gas,
- Industrial wastewater treatment and in-plant water recycling.

Some of the many entities that have been assisted are the Metro of Medellin, the Olaya Herrera Airport, the Leona Brewery and several cement companies.

#### *4.2.4. Engineering consultancy. HIDRAMSA*

Hidramsa, an engineering consulting firm, works primarily in two areas: civil engineering, especially hydraulic, and environmental engineering. Through its environmental division it offers the following services:

- General advice on environmental issues,
- Environmental diagnosis of alternative solutions,
- Environmental impact studies,
- Environmental inventories,
- Air, water and soil quality analysis,
- Designing environmental management plans, including measures for prevention, mitigation, correction and compensation of the effects caused by projects,
- Risk analysis,
- Environmental education and awareness workshops.

The company has developed strengths in environmental education (for which it can call upon professionals in other disciplines), environmental impact studies and environmental audits for companies seeking ISO 14000 certification. It is now moving into a new area of work relating to ecological insurance, designing methodologies for assessing environmental intangibles and measuring environmental risks and contingencies.

This company has provided advisory services to the public utilities of Medellin, and is currently undertaking an environmental impact study for the Bogota Metro.

## 5. PROGRAMMES AND PROJECTS AT UNIVERSITIES AND RESEARCH CENTRES AND CLEANER PRODUCTION TECHNOLOGY DEVELOPMENT

Universities and technology research and development centres have excellent and recognized capabilities to conduct research and to undertake successful development, in the laboratory and occasionally at the pilot plant level. Nevertheless, there is still a wide gap to be filled before these developments can be put into industrial-scale production. When projects are undertaken from the outset on the basis of university-company participation, the prospects for subsequent application will be greater[44].

### 5.1. Public and private universities

#### *5.1.1. Universidad Pontificia Bolivariana*

The Universidad Pontificia Bolivariana (private), through its Research Centre for Integral Development (CIDI), has established the following groups and their principal areas of work on Cleaner Production:

[44] This does not mean that all research projects must be undertaken jointly. There are fields of basic research where direct application of the results cannot be expected.

- Environmental Research Group, GIA. It conducts research in three broad areas: i) air (air quality studies, pollutant simulation); ii) water and processes (biological treatment, sludge, water reuse, water quality, absorbents, pollution prevention, life-cycle evaluation); and iii) sustainable development (environmental stewardship and education, environmental management plans). It is also active in the area of training and services. It recently sponsored a consulting project to optimize processes for 12 electroplating firms, in order to reduce water consumption and increase recycling in their production processes[45].

- Energy and Thermodynamics Group. This group has been recognized as a Centre of Excellence in Colciencias calls for tender to groups and centres. It has a lengthy portfolio of projects with a positive environmental impact, and a solid record in the development of clean technologies. Some examples include: i) development of a clean technology for coal gasification[46], conducted jointly with the University of Antioquia and the National University of Medellin, and with the financial support of Minercol, the former Ecocarbón; ii) redesign of an air conditioning system that uses no liquid refrigerant (CFC) and that consumes less energy, conducted for the Facini company[47]; iii) thermoacoustics: sonar-based refrigeration, and subsequent development of a thermoacoustic refrigerator; iv) energy resource management by objectives. All of these projects have received financial support from Colciencias. As well, the group provides advisory services on the rational use of energy, and can point to more than 100 successful cases.

- New Materials Group. Working on the reuse and upgrading of solid wastes, such as the recycling of reinforced plastic wastes.

- Biotechnology Study and Research Group. This group focuses primarily on the use of wastes, such as: i) recovering heavy metals from fluids through the use of yeasts; ii) use of sisal processing waters for producing stable and biodegradable surface-active agents; iii) use of beef hearts and brains to produce medical drugs and as a microbiological culture medium. It has a pilot plant, and has developed some capacity at the industrial scale.

### *5.1.2. University of the Andes*

The University of the Andes (private), through the Departments of Industrial, Civil and Mechanical Engineering of its Faculty of Engineering and the Department of Biological Sciences of its Faculty of Sciences, conducts work in various areas of Cleaner Production R&D. The most active centres are:

- Microbiology Research Centre, CIMIC. This centre has three lines are research: environmental microbiology, agricultural microbiology and industrial microbiology. A large part of its research is performed for the productive sector, such as Ecopetrol (specifically ICP), Levapan, Occidental de Colombia, Cenipalma. In the area of environmental microbiology, for example, it has conducted research into the biodegradation of phenols, hydrocarbons and activated sludge[48]. In agricultural microbiology it has conducted research into the complex rotting process of palm heartwood. All of these projects have a positive environmental impact.

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[45] See Section 5.1.1 for a description of this experience.
[46] The full title of the project is "fluid bed coal gasification".
[47] The full title of this project is "air conditioning by dehumidification with drying agents".
[48] ICP projects are explained in detail in Section 5.2.9.

- Environmental Engineering Research Centre, CIA. Its areas of research include municipal wastewater treatment plants (anaerobic digestion) and composting of the sludge from these plants for use in agriculture.

- Environmental Studies Centre. Works in the areas of alternative energies (particularly wind energy), recycling (plastics). Most of its research has been in the form of Master's thesis projects.

- It should be noted that the Industrial Engineering Department offers an optional course on Cleaner Production at the undergraduate level. The department also conducts research on environmentally friendly product design (eco-design) and on life cycle analysis (LCA) for products. These tools are of great help in any Cleaner Production initiative. In order to move further into the field of Cleaner Production at the University, it is working with the University of Lund (Sweden) on a number of initiatives in this area.

### *5.1.3. Universidad del Valle*

At the Universidad del Valle (public) two groups working on environmental issues were interviewed:

- Environmental Biotechnology Laboratory. Working on the biological treatment, aerobic and anaerobic, of industrial and municipal wastewater. This research group was one of the pioneers in Colombia in terms of adapting and applying these technologies. It has conducted a number of projects with businesses and municipalities. It was also one of the sponsors of the Environmental Biotechnology Network.

- Institute for Research and Development in Potable Water and Basic Sanitation and Water Conservation (CINARA). Works primarily on slow sand filtration (multiple stage filtration, FIGME) in tropical environments, for rendering water drinkable. This technology is in use in various rural communities and small towns throughout the country and abroad (in Latin America, Africa, Southeast Asia). The technology is considered to be clean, since it is based on a physical and biochemical process without any chemical additives. At present several technology development projects are underway, with a primary focus on producing drinking water: i) combining slow filters and fast filters for treating water; ii) solar water disinfection, a technology that has already been tested and is now being successfully used in small communities; iii) using solar radiation to produce drinking water (photocatalysis) and also for treatment of wastewater, iv) treatment of domestic wastewater by biological methods; v) anaerobic filters combined with phytopedological filters for removing organic materials and heavy metals; and vi) reusing wastewater for fish raising and agriculture.

### *5.1.4. University of Antioquia*[49]

The University of Antioquia (public) has strengthened its position as a research institution in recent years, and has provided several kinds of support to researchers, in terms of financing, human resources, training, administrative support and infrastructure. Space does not allow all of the Cleaner Production projects being pursued at the University to be discussed here. This report will limit itself to introducing the groups and Centres according to their respective lines of research, and in a few cases will refer to projects of major impact, especially those carried out in partnership with business.

[49] See Universidad de Antioquia, Research Catalogue, 1998.

- Corporación Ambiental ("Environmental Corporation"). This is a virtual project management office, the purpose of which is to promote the University's capacities and match supply with demand for such services. It provides both extension and consulting services, and works on an interdisciplinary basis. It has defined three areas of research: i) integrated study of natural ecosystems, ii) integrated urban landscape studies, iii) clean technologies and sustainable development. Project execution is the responsibility of various research groups within the University.

- Environmental Research Centre, CIA. This centre promotes research in the faculty of engineering and embraces a number of groups:

  - Catalysts and absorbents group. Its lines of research are: i) eliminating heavy metals from water, ii) synthesis and characterization of molecular sieves, and iii) removal of pollutants by ion exchange and adsorption. Several of its projects are being financed by Colciencias.

  - Environmental engineering and management group. Its lines of research are: treatment of wastewater, integrated solid waste management, air quality control, occupational health, environmental management and modelling. Most of the projects conducted by this group are funded by the institutions that contract the work, such as Cornare, Refinería Nare, Colanta, Isagen, Fábrica de Licores de Antioquia, and the Government of Antioquia.

  - Science and technology group on gas and the rational use of energy. It is pursuing the following lines of research: i) fuel properties, ii) gaseous fuel combustion, iii) energy conversion efficiency of natural gas, iv) impact of altitude and hygrometry on gas combustion systems, v) interchangeability of gases and substitution between energy sources, vi) technological innovation in equipment and systems, vii) rational use of energy in industry and transport, viii) energy economics, and ix) energy outlook.

  - Pyrometallurgy and materials research group. Its main lines of research are: i) lost wax, ii) eco-efficiency, iii) thermal treatments, iv) new materials and processes. In the eco-efficiency area, this group achieved improved eco-efficiency for the iron foundry sector by first redesigning a cupola furnace and an induction furnace, and subsequently building a pilot-stage prototype of the new cupola furnace. This project has been financially supported by Propel, Fedemetal and UNIDO-UNDP.

  - Research group on ceramics, environment and extractive metallurgy. Its priorities include the following lines of research: i) biohydrometallurgical processes, ii) recovery of slag from steel, iii) maturing of clays, iv) refractory ceramics, v) desulphurization of coal. It is currently working on two projects, one for recovery and use of steel slag, with funding from Simesa, and the other for recovery of gold from refractory clays in the municipality of Marmato, through the use of micro-organisms.

- Carbochemistry and catalysis group. Its lines of research include: i) coal oxidation at low temperatures, ii) gasification of carbonaceous materials, iii) obtaining activated carbon, iv) controlling NOx and SOx by the use of activated carbon, v) producing humic modifications through the use of carbon, vi) carbon dioxide conversion. This group is participating in the coal gasification project, together with UPB and the National University at Medellin[50]. All areas of its work have a positive environmental impact, in particular the project on coal gasification, which is a clean technology. The last two lines are being developed jointly with the GIEM.

[50] See section 6.1.1.

- Environmental catalysis group. Its lines of research include: i) pollutant catalysts, ii) synthesizing molecular sieves, and iii) zeolitic catalysts in fine chemical processes. The second line is intended ultimately to produce chemicals or fuels through environmentally clean processes.

- Interdisciplinary group for molecular studies, GIEM. Its lines of research include: microbiology, entomology, bioassays, natural bioactive compounds, instrumental quantification and the spectrum of biological action and transformation of organic materials. Most of its projects are carried out for firms and associations in the productive sector, for example: Banacol, Biocaribe[51], Asocolfores, Setas Colombianas, Cervecería Unión, Analac. Some of the results of these projects have included the production of bioinsecticides, natural fungicides, nematicides of plant origin; the use of nicotine extract for pest control; and the use of agro-industrial wastes as a source of raw material for producing earthworm compost.

The CIA and the carbochemistry and catalysis group are considered groups of excellence, while the last two groups are consolidated under the Colciencias classification of groups and centres.

#### *5.1.5. Pontificia Universidad Javeriana*

The Universidad Javeriana (private) has a few groups working in the area of environmental technology, including:

- Environmental sanitation and biotechnology programme. The projects carried out by this group relate to low-cost biological alternatives for treating wastewater. They are remedial, rather than preventive, in nature and have so far been limited to the laboratory scale: they have yet to be tested in pilot plants or at an industrial scale.

- Institute of Environmental Studies for Development, IDEA. Its objectives are:

  - ♦ To produce and transmit scientific knowledge with a systemic, interdisciplinary and participatory focus, targeted at resolving the country's environmental problems within a context of sustainable development; and

  - ♦ Coordinating the development of environmental research at the University and promoting inter-institutional co-operation to support and reinforce the scientific community concerned with this issue.

IDEA's lines of research are: environmental management, sustainable development, appraisal and use of biodiversity, and environmental information, monitoring and evaluation systems. Its projects fall under programmes dealing with the equatorial Andes, tropical jungle, coastal systems and human settlements and urbanization. IDEA has developed a few projects relating to clean technologies, through Master's thesis work.

#### *5.1.6. National University of Colombia[52]*

The National University of Colombia (public) is headquartered in Bogota, and has research centres and various groups associated with its faculties that are conducting research into environmental issues and Cleaner Production.

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[51] See section 4.1.6.

[52] The National University of Colombia has campuses in the cities of Bogota, Medellin, Manizales, Palmire, San Andrés, Arauca and Leticia.

- Biotechnology Institute, IBUN. This falls directly under the Vice Rector of the Main Campus (Bogota) and works jointly with the faculties of agronomy, sciences, engineering and medicine. The Institute has several areas of research, including the study of genetic resources and environment and the field of agricultural biotechnology. In the first area, it has a research programme on eco-toxicology and on the aerobic treatment of residual wastewaters, which it is carrying out jointly with the IEI. In the second area, it conducts programmes of research in biopesticides, phyto-improvement and production of Andean crops and the molecular biology of plant viruses. The biological control programme has been focused from the outset on producing biopesticides based on native bacteria of the species *Bacillus thuringiensis*, which are active against insects that attack various crops such as cotton, rice, corn and sorghum. Under the phyto-improvement programme, a project is underway to produce a virus-free potato seed.

- Assay and Research Institute (IEI). Part of the Civil Engineering Department of the Faculty of Engineering, it has conducted research in the environmental area. It currently has two lines or programmes of research: evaluating toxic pollution in wastewater, through bioassays, and microbiological evaluation of anaerobic reactors. Under the first programme it has two projects underway: to develop and validate a set of toxicity tests to determine the toxicological quality of drinking water and surface waters; and to evaluate the toxicity of industrial effluents through bioassays. Under the second programme, it has been running a project jointly with IBUN to characterize and quantify bacterial populations in sludge from anaerobic treatment plants. It is currently conducting a project for the microbiological and physical-chemical characterization of sludge used in anaerobic treatment plants for the brewing industry.

- The Chemical Engineering Department of the Faculty of Engineering has two lines of research of interest to this study, in coal and biochemical engineering. Under the first line, it is conducting work in coal liquifaction and gasification and the characterization of coals. Under the second, it is working on fermentation with immobilized cells, on the design and construction of bioreactors, and on the production of bioinsecticides.

- The Department of Agricultural Engineering, Faculty of Engineering, is conducting research into soil conditioning and sustainable management, to find appropriate ways of using and conserving water and soil resources with a view to sustainable development.

- In the Faculty of Sciences, and particularly in the Chemistry Department, there are groups working on environmental chemistry, specifically on the evaluation and removal of heavy metals from industrial wastewater.

The National University campus at Medellin, and in particular the National Mining Faculty, has several environmental research centres. In particular, there is the research group on clean technologies, CIMEX, and the research group on environmental management. The CIMEX group is working on mineral resources.

In conclusion, it may be said that there are several academic initiatives now underway that include the concept of Cleaner Production, in engineering and agronomy faculties, and in the Environmental Studies Institute, IDEA. But there is no university-wide working group nor any consolidated portfolio of research and services under the topic of Cleaner Production. Considering that the National University is the largest and most important public university in Colombia, it is necessary to examine its future development plan and to see what lines of R&D in Cleaner Production and environmental technologies are contained in it.

In recent months, The National University of Colombia has concentrated its efforts on putting together its new Global Development Plan (1999-2003). This plan is intended to consolidate the University's mission, which is defined in general terms by Decree 1210 of 1993, and in this way to give direction to its management, facilitate its organization, and enable the entire University community to mobilize around common purposes.

In formulating the plan, the University used a variety of coordination and consultation mechanisms, prepared and re-created various scenarios, and ensured ample opportunities for the different campuses and faculties to consolidate their own plans and focused their vision in a manner consistent with the global plan. By reaffirming local and regional aspects, in the context of a national plan, the University as a whole should be in a better position to meet the challenges implied in its mission.

The University's Global Development Plan for the period 1999-2003 is centred on five strategies, which are the result of a analysis of the situation and the current challenges facing the University and of the policies that have been built around its central functions: education, research and extension work.

These five strategies are as follows:

- National presence,
- Internationalization,
- Quality and relevance,
- Efficient management,
- Equity and social harmony.

These strategies are intended to give effect to the central objective, as well as the specific objectives in the University's mission, through its programmes and sub-programmes.

In this sense, the National Presence Strategy recognizes that one of the major concerns of contemporary societies is the high percentage of people living in poverty. The country's social situation is critical: not only are poverty levels high, but conditions are made worse by high levels of unemployment and the lack of opportunities for the most vulnerable sectors. Various bodies have been stressing the idea of promoting a form of development that pays more attention to the quality of life, the environment and human development, and that will produce solutions without upsetting the balance of life on the planet.

The programme for promoting and monitoring strategic academic programmes and areas of study will thus serve as a kind of observatory for the forms and processes used by the University in all dimensions of its work (education, research and extension), with respect to its Fields of Action and Strategic Programmes[53], among which the environmental component figures as No. 2:

[53] First Inter-Campus Academic Encounter (Medellin, October 1998).

| FIELDS OF INSTITUTIONAL ACTION | STRATEGIC PROGRAMMES (PRES) (1999-2003) |
|---|---|
| 2. Environment | 2.1 Ecosystems, biodiversity and conservation<br>2.2 Environmental management<br>2.3 Non-renewable natural resources<br>2.4 Water and soils<br>2.5 Environmental education and awareness<br>2.6 Clean and environmentally sustainable production<br>2.7 Environment, civilization and culture<br>2.8 Policy, legislation and ethics |

### *5.1.7. Industrial University of Santander*

The Industrial University of Santander (public) has several research groups working on issues relating to Cleaner Production, in various areas such as energy, mining, coal, petroleum and industrial biotechnology. We shall refer specifically to only one of these groups, which has achieved significant success in the area of technological innovation (patents):

The Centre for Innovation in Industrial Biotechnology, CINBIN. Its principal objectives are:

- To seek alternative solutions to pollution problems by finding new uses for agro-industrial wastes.
- To assess the importance of micro-organisms as bioproducers of substances of industrial interest.
- To measure the microbial capacity in fermentation and complete and incomplete oxidation processes.

The Centre's main lines of research are:

- Biodegradation of polluting wastes into socially useful products.
- Bioconversion of solid wastes.
- Bio-remediation of waters and soils[54].
- Production of healthful micro-organisms, biopolymers, biosurfactants, microbial biofilters and bioinsecticides.

[54] CINBIN took part in research of the Colombian Petroleum Institute (see Section 6.2.9) on degradation of hydrocarbons in wastewater, by developing microorganisms that would "eat" the hydrocarbons in the water.

## 5.2. Scientific research and technological development Centres[55]

### *5.2.1. The National Centre for Cleaner Production and Environmental Technologies, CNPMLTA*

The National Centre for Cleaner Production and Environmental Technologies, CNPMLTA, is a non-profit, mixed corporation governed by private law. Its founders and sponsors are companies, associations, government institutions, universities, environmental authorities and NGOs. Its growth and development have also been supported by the Swiss government through the EMPA (Swiss Federal Institution for Materials and Technologies Research and Testing), which has made its knowledge and expertise available to the Centre.

The CNPMLTA's mission is to introduce and disseminate the concepts of eco-efficiency, Cleaner Production and environmentally sound technologies, in ways that will strengthen both the private and public enterprise sectors.

The Centre conducts various services and activities:

- Technical assistance in Cleaner Production for businesses, minimizing wastes at source, environmental management systems, life-cycle analysis, introduction of eco-efficient methods, risk analysis.

- Information on environmental technologies, exchange of experience with other countries, establishing contact between businesses, links to existing data banks on environmental hardware and software, and dissemination of information through publications, seminars, workshops, conferences and discussion groups.

- Financial advice in preparing and submitting environmental investment projects, securing sources of funding, both domestic and international, and developing ways to apply environmental incentives, among others.

- Personnel training through workshops, courses, seminars, professional exchanges with businesses and foreign universities, and practical training, among others.

- Dialogue with national and regional governments about policies, laws, regulations and standards in the environment area, and their enforcement. Identification of obstacles to Cleaner Production, design of alternatives and promotion of voluntary compliance with environmental standards.

- Special projects: for example, the National Industrial Wastes and By-products Exchange - BORSI[56], which was created to promote the commercialization and exploitation of such products as a way of developing new economic activities, generating employment and reducing environmental impacts. Commercialization is intended to encourage the sale of industrial wastes and by-products, through the broad dissemination of information on supply and demand.

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[55] The IDEAM has been conducting significant work through its Science and Technology Office in designing and implementing the Environmental Information System component relating to production technologies in use and alternative cleaner technologies and their relationship to resource use in every sector of the Colombian economy. It carries out its mission through two basic programmes, one of which is for evaluating technologies and production systems and diagnosing resource use and management. This information may be consulted at the Institute's Web site.

[56] More detailed information on BORSI can be found at www.borsi.org

Exploitation calls for the recovery, recycling and re-introduction, into the existing economic chain and/or new industries, of wastes that can be upgraded in terms of greater value added.

In its first year of operation, more than 25 technical assistance projects have been carried out (diagnosis and/or implementation), three products have been ISO 14000 certified, more than 500 people have been trained, 38 requests for information answered, and about 15 financial or taxation consultations, and several special projects have been carried out.

The Centre has worked in the following areas: textiles, metallurgy, food and beverages, dairy products, paper, mining and cement.

### *5.2.2. Corporation for Construction Research, Innovation and Technological Development - CONSTRUIR*

The Corporation for Construction Research, Innovation and Technological Development – CONSTRUIR, is a non-profit, mixed-capital entity created under the auspices of the Universidad del Valle, Sena and private companies. It operates from premises within the University.

Under its mandate the Corporation seeks to contribute to development of the construction sector, to develop new products that are can be marketed at a profit, to create new enterprises, generate employment, resolve housing problems with suitable materials and techniques, and help to preserve the environment. The Corporation's R&D focuses on studying, designing and producing high-quality, low-cost construction materials, based on industrial wastes and construction rubble (eco-materials). It also provides consulting and technical advisory services, training and documentation.

Some of the projects sponsored with participation of the productive sector are:

- Processing of modified yucca starch as an additive to concrete and mortars.
- Producing cement on the basis of the ash residue from burning sugarcane bagasse in thermoelectric stations and industrial boilers.
- Mounting a production line of masonry bricks made from industrial wastes and construction rubble[57]. Patents on the technology for producing these bricks are pending in the USA and in Colombia. The technology is considered clean, because it uses wastes and CO2 as an agglomerant or binding agent. The project was financially supported by Colciencias.
- Reuse of sludge from waste channels and water treatment plants for producing construction materials.

One area of work that will take on great importance in the near future is the use of sludge from wastewater treatment plants in the manufacture of construction materials.

### *5.2.3. Biotec Corporation*

The strategic objective of the Biotec Corporation is to develop and apply microbial and plant-based biotechnologies that can be exploited in the bioindustrial chain, through knowledge and sustainable use of the biodiversity of Colombia's Pacific region. Biotec has developed an agenda for innovation in which it has identified five priority fields or niches: certified tropical fruits and plants, bioremediation, exploitation of organic by-products, organic agriculture and natural tropical products.

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[57] See El Tiempo, August 30, 1999.

Among the most interesting projects that Biotec has underway are: i) development of a protocol for producing certified clean grapevines, ii) development of a protocol for micro-grafting of soursop trees [*guanábana*], and iii) design and construction of a biofilter for removing hydrogen sulphide from the effluents of industrial wastewater treatment plants. In this last case, a laboratory prototype has been built, and pilot-scale filters have been set up at Levapan and Sucromiles, two local industries[58].

### *5.2.4. Colombian Institute for Training and Research in Plastics and Rubber - ICIPC*

This institute has four major lines of activity:

- Technical assistance (continuous improvement programme),
- R&D projects and product design,
- Technical services (testing and assays),
- Training.

In terms of clean technologies, ICIPC has developed a blending process with partial substitution of lampblack, besides incorporating lampblack directly into the latex. This produces less environmental impact (atmospheric pollution), saves energy and improves the properties of the blend. This is a patentable technology.

The Institute's philosophy calls for it to apply clean technologies, to which end it promotes efficient production from the viewpoint of inputs, energy and waste reduction. In this respect, much of its work has focused on designing items that require less consumption of materials through greater process efficiency.

It has worked on changing product design for companies such as Electrocontrol (light fixtures), CONAVI (wireless telephones), Colgate-Palmolive and Cervecería Unión. In the area of process improvement, it has developed projects for Pavco, Industrias Estra, Compañía de Empaques, Flexiplast and Coldeplast, among others.

### *5.2.5. Corporation for Biological Research, CIB*

The Corporation for Biological Research is one of the Centres of Excellence selected by Colciencias. Its research is heavily focused on health. Recently, the CIB has been conducting research on plant biotechnology with applications to agriculture, especially by developing bioinsecticides using the *Bacillus thuringiensis* to combat pests that attack cotton and corn. This project was financially supported by Colciencias.

Development work was initially done at the laboratory level. Subsequently it constructed its own pilot plant and began testing at that level. For industrial-scale manufacture of these products, an agreement has been signed with the VECOL Company, which has the capacity to produce at an industrial scale. The Corporation will receive royalties from sales of the bioinsecticide. The use of *Bacillus thuringiensis* to fight pests is common around the world: what was new here was to select the strain, from among 38 existing bacteria, that was most appropriate and efficient for attacking the problem in question.

[58] See section 5.1.9 on the Sucromiles Company.

### *5.2.6. Sugarcane Research Centre - CENICAÑA*

The objective of the "green cane" programme is to develop production systems for the harvesting of green sugarcane that will maintain or increase levels of productivity and profitability in the sugar industry. The challenge is to take advantage of the opportunity to avoid burning the cane, without increasing unit production costs for sugar. The green cane programme was actually launched before signature of the Cleaner Production Cooperation Agreement for the sugar sector between the MMA, the Regional Autonomous Corporations of Valle del Cauca, the associated sugar mills (11) and the community of Palmira.

Burning sugarcane before and after harvest has become a universally accepted practice since World War II. This change in the production system reflected the shortage of manpower, the high incidence of stalk-boring insects and the spread of cane diseases. In the Colombian sugar industry, burning cane led to an expansion in milling capacity; the gathering step was mechanized and higher-capacity wagons were designed. The cane fields were adapted to allow semi-mechanized harvesting (manual cutting, mechanical gathering) and new varieties were planted that had straighter stocks, with higher sugar content; these matured earlier and produced higher yields.

In recent decades the development of clean technologies has led to the gradual elimination of burning, and a return to cutting the cane when green. Under Colombia's current environmental legislation the burning of sugarcane will be prohibited after the year 2005. Through the Cooperation Agreement signed in November 1996, the sugar industry undertook gradually to switch over its productive practices and adopt technological packages for planting, harvesting and processing sugarcane without burning. Environmental regulations required the switch to green harvesting, and at the beginning of January 1997 rules came into effect that eliminated burning and re-burning in certain areas classified as restricted or "no-burn".

Under the circumstances, if it is not to become unprofitable, the industry will have to develop and propagate varieties that are adapted to the new system; it will have to adapt fields and transportation equipment for harvesting with combines wherever possible; farming practices will have to be modified with respect to irrigation, fertilizer and management of post-harvest wastes; and new ways will have to be found for effectively controlling the spread of pests and diseases. Over the longer term, the development of technology and improvements to the production systems will enhance the advantages of green cane, including the industrial use of post-harvest wastes.

The following has been achieved to date:

- An optimal field design for growing green cane has been selected. It includes various aspects relating to irrigation, size of field, drainage, length of furrows, etc.

- With respect to waste disposal, a problem that is considerably increased by cutting cane when green, various alternatives are being examined: digging it into the soil directly, or grinding it and incorporating it into the soil, among others. For grinding the wastes, a new machine is being designed, since existing machines available on the market are not adapted to Colombian conditions. To date, two efficient designs have been produced, and they are now being tested experimentally.

In the face of alternative methods for harvesting green cane, either manually or mechanically, manual harvesting has been selected as preferable: in the first place, because the use of harvesting machinery has a significant labour-displacement effect, and secondly because manual harvesting and stripping of leaves from the stocks improves the yield of sugar at the end of the process.

### *5.2.7. National Coffee Research Centre - CENICAFE*

The National Coffee Research Centre is a scientific research programme (R&D unit) of the National Federation of Colombian Coffee Growers, Fedecafé. The Centre was created in 1938, and since its beginnings has been concerned with sustainable development. In particular, its first research efforts focused on soil conservation, an issue that continues to be of high priority to Cenicafé, given the fragile nature of our soils and their high tendency to erosion[59].

Following is an explanation of the research and development projects that have been recognized in Colombia as having the greatest environmental impact[60]:

- Ecological Processing of Coffee and By-products - BECOLSUB[61]. The wet processing of coffee is typical of the Colombian industry, and has historically involved the use of great volumes of water. In order to find technical solutions for reducing water use and contamination, without affecting the traditional quality of Colombian coffee, Cenicafé launched a scientific research programme that over the last two decades has developed technologies to meet this ecological challenge. Currently, Colombian coffee growers can adopt a series of technological solutions at each step of the process. Taken as a whole, they constitute an optimal solution to the problem of environmental pollution in the country's coffee growing regions.

The BECOLSUB technology was delivered to Colombian coffee growers in early 1996. It consists of an ecologically sound processing module that includes de-pulping without water, mechanical removal of the mucilaginous layer, and washing with minimum water use. It also allows for the use of by-products, such as the pulp, to produce organic fertilizers[62], and the mucilage, as hog feed. In BECOLSUB, research has produced a veritable ecological revolution, since it reduces water consumption by 95 percent and avoids 92 percent of the potential pollution from coffee processing.

Today BECOLSUB is available in several modules (300,600, 1000 and 3000) that have the capacity to process different quantities of coffee.

The right to use this patented technology is provided free of charge to regional factories, and allows coffee growers to buy equipment certified by the National Federation of Colombian Coffee Growers. The price is determined by the market, and the Federation contracts for quality control. The equipment has been exported to several countries in Latin America and Africa, and royalties have been charged in these cases. This machinery represents a clean technology, and has therefore been declared exempt from VAT by the Ministry of the Environment.

- Development of a rust-resistant coffee variety, "Colombia". Aware of the risk that coffee leaf rust might be introduced to the American Hemisphere, the National Federation of Coffee Growers undertook pre-emptive research to ensure that the country would be prepared before the possible onslaught of this disease. Cenicafé therefore launched a research project in the late 1960s to develop a genetically rust-resistant variety of Colombian coffee.

This was not an easy task, since the fungal pathogen in question exhibits at least 40 physiologically different strains, it has a life cycle of only 30 days, and it attacks all varieties of *Coffea arabica* (a perennial bush that under normal conditions should produce economic yields for at least 20 years).

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[59] Cenicafé, 1993.
[60] Cenicafé, 1999.
[61] See El Tiempo, August 17, 1999.
[62] Cenicafé has also developed a technology that accelerates the decomposition of the pulp (which can be mixed if desired with the mucilage) to produce a worm compost that serves as an organic fertilizer.

Other countries had already failed in the search for varieties that would retain their resistance for more than one year.

Scientists at Cenicafé proposed an ambitious project targeted at developing a coffee variety that would be resistant to the highly variable rust pathogen for at least ten years. The research strategy followed by Cenicafé included performing thousands of genetic crosses. Their progeny were then studied in terms of their reaction to different strains of the pathogen, and they were subsequently tested under field conditions to verify their productivity, adaptation, the absence of defects in the bean, and most important of all, their quality in the cup.

After more than 20 years of research, Cenicafé published the results of its experiments and the corresponding statistical analysis, findings and conclusions, and the National Federation of Coffee Growers named the new product the "Colombia Variety". This new variety of *arabica* coffee is low-growing, highly productive, broadly adaptable to very different conditions in the Colombian coffee growing zone, and according to most national and international coffee experts it combines all the characteristics that define smooth Colombian coffee.

Planting of the Colombia Variety began in 1982, the very year in which the leaf rust was first detected in Colombia. It is now estimated that some 400,000 hectares have been planted in the Colombia Variety, which would represent the swiftest adoption ever of a new variety of a perennial species. Research into rust resistance in coffee is continuing, not only to deal with possible genetic changes in the pathogen, but also to seek further improvements in the new variety's characteristics. The progeny that represent the current Colombia Variety have been improved with respect to their bean size. More than 70 percent of Colombia Variety beans are now of a size typical of *excelso* coffee.

The environmental impact of the Colombia variety clearly lies in the fact that it avoids the use of pesticides to control leaf rust. Cenicafé produces the variety, while the coffee growers' committees are responsible for distribution and sales. There are no sales abroad.

- Integrated pest management: the berry borer. Colombia was formerly free of the coffee berry borer. Nevertheless, this insect, which has been present in the American Hemisphere since the beginning of the 20$^{th}$ century, gradually spread through all coffee growing countries, and in 1988 was detected for the first time in southern Colombia.

Cenicafé immediately launched a research project to develop an Integrated Pest Management (IPM) strategy to deal with the berry borer and to avoid possible damage to the coffee-growing ecosystem through indiscriminate use of chemical products. Currently, Colombia coffee growers can draw upon a body of knowledge developed by Cenicafé researchers that allows them to control this past in a rational, economical and ecologically sound manner.

Cenicafé has developed the basic know-how and practice for the biological control of the coffee borer by isolating, identifying and developing both small-scale and industrial systems for producing the entomopathogenic fungus *Beauveria bassiana*. It has also managed to introduce safely various parasitoids of African origins, which it has raised and released in quantity.

Researchers have also paid attention to methods of cultural and chemical control, and to developing standards for assessing damage and analyzing indices of infestation, as a basis for decision-making by coffee growers themselves. Thanks to these results, which have been obtained in a relatively short time, Cenicafé has been able to ensure the health of the coffee industry, while preserving wildlife and maintaining water quality in the coffee-growing zones.

- Integrated weed management. Integrated weed management calls for the timely and appropriate use of various systems of herbicide, together with a weed selector. The goal here is to reduce competition with crops from weeds, to conserve the soil and promote the establishment of "noble" or desirable ground cover, and to reduce costs.

The desirable ground cover selector is a simple tool containing a mixture of herbicides that will eliminate the plants that receive it, by merely touching the foliage with the impregnated portion of the tool. The equipment is very economical, can be assembled on-site, weighs 10 times less than conventional machinery and requires little time to apply, thereby reducing costs and environmental pollution and helping to preserve soil quality and biodiversity in the coffee growing zones.

In general terms, thanks to the scientific efforts of Cenicafé, the practices followed in the Colombian coffee growing industry make it possible to use agricultural inputs rationally, to produce a sustainable coffee yield, to reduce production costs and to respect the environment.

### *5.2.8. The Colombian Association for Agricultural Research - CORPOICA*

CORPOICA is engaged in two types of programmes (research at the national and regional levels), with their corresponding research lines and projects that fulfil specific functions within the research process.

At the national level, research is grouped into two areas:

- Strategic research. This consists of 10 programmes aimed at advancing science, providing access and promoting adoption of new technologies and new scientific methods of research, taking the findings of scientific progress to develop new methods and technologies both for research and productive purposes. These technologies do not always replace conventional techniques, but rather reinforce and reorder the ways they are applied, in order to increase agricultural efficiency and output capacity. Strategic research is intended to develop new methods and technologies applicable to agricultural production, based on the findings of basic research and scientific progress in general, and is therefore closely related to so-called new or leading-edge technologies. The areas of greatest interest for this assessment are: plant and animal biotechnology, integrated pest management, and integrated soil and water management.

- Production system research. This consists of eight programmes carrying out basic research for characterizing the systems in each region of the country, in order to enhance understanding of the country's biodiversity, its agro-ecosystems, and their strengths and vulnerabilities. This research is aimed at improving incomes for producers by reducing production costs, increasing yields and productivity, promoting protection of the ecosystem and making rational used of productive resources. One programme of interest for this study is that relating to agricultural and post-harvest machinery.

The regional research effort is aimed at resolving agricultural problems and meeting the real technology needs of producers in their respective areas. This research is conducted in local as well as regional centres, where there are four programmes: agriculture, livestock, production systems and technology transfer. Their work seeks to define and conduct locally-relevant basic research as well as adaptive research on various existing technologies; to analyze production systems in the area from the biological, agro-ecological, climatic and socio-economic perspective; and to take the steps necessary to ensure that the technology will be transferred to producers within the region.

Following are brief summaries of some of the successful research projects that CORPOICA has carried out and that, because they have a positive environmental impact, are considered clean technologies for use in agriculture and agro-industry.

In the post-harvest area of rural agro-industry, one of the most interesting projects for purposes of the study is the development of more efficient ovens for producing *panela* or raw brown sugar. From the environmental viewpoint, better combustion reduces energy consumption (in this case firewood) and reduces emissions. This technology was developed specifically by CIMPA, the Panela Research and Improvement Centre. This technology has been marketed in several countries of South America, Central America and the Caribbean, with the provision of training and technical assistance.

In this same line of research, a project is underway to modernize the production of *bocadillo* or guava jelly, especially in the Barbosa area of Santander, while at the same time improving energy efficiency and controlling emissions.

In the soils programme, a project has been undertaken to adapt the bacterium *Rhizobium* to local conditions as a nitrogen-fixing agent. It is useful particularly for leguminous crops, where it reduces the consumption of inorganic fertilizers. As a result of this project, CORPOICA today has a *Rhizobium* production plant in operation.

In the farm mechanization area, work is underway to introduce zero or reduced tilling, and to promote living screens or fences and windbreak systems. As noted earlier, Colombian soils are very fragile and disk ploughing, apart from compacting the soil, turns it over in such a way that much of its organic matter is lost. This is one of the major causes of soil erosion and degradation, as well as of water pollution. A number of pilot projects are being conducted in Nariño, Santander and Antioquia, blending various types of tilling. Results obtained to date have been satisfactory. The ultimate benefit will be even greater, although it must be recognized that these systems can increase the incidence of pests and weeds, and that herbicides and pesticides will have to be used. Soil restoration will depend not only on changing tilling systems, but also on incorporating organic fertilizers, introducing conservation practices, and changing land use (in certain parts of the country), and other measures.

Biological control, as part of the R&D strategy, is a relatively recent phenomenon at CORPOICA. At the moment the only technology under development is one for controlling pests in sugarcane fields. It is now ready for industrial-scale introduction, and this will be done through VECOL.

In the livestock area, there are two projects of major environmental impact. The first is to design a new anaerobic bioreactor for treating hog manure. The second involves production of compost from poultry droppings after they have been treated, stabilized and enriched with other components. These two developments will have a positive impact on solid waste management, either through degradation or utilization, in water and soils.

#### *5.2.9. Colombian Petroleum Institute -- ICP*

The Colombian Petroleum Enterprise (Ecopetrol), has an R&D division known as the Colombian Petroleum Institute. Its strategic areas of research focus on production, refining, transportation, gas, materials engineering and environmental protection. The ICP provides services to Ecopetrol as its principal client, as well as to other entities in the hydrocarbons sector. The Institute has a permanent collection of geological samples to preserve the knowledge of Colombia's subsoils.

The ICP has three "impact" or technical divisions, engaged in exploration and production, processes and products (refining and petrochemicals), and complementary technologies; and three support areas (services, technological management and commercialization).

With respect to environmental management, the complementary technologies area is the most relevant. It in turn runs several coordination programmes:

- Environmental affairs,
- Biotechnology,
- Materials technologies,
- Equipment development,
- Interface phenomena and rheology.

These coordinating programmes manage the following technologies or lines of research:

- Upgrading of hydrocarbons,
- Transportation and treatment of hydrocarbons,
- Load and product homogenization,
- Treatment of industrial waste waters,
- Integrated soils and solid waste management,
- Bioproducts and bioprocesses,
- Combustion, emissions control and air quality,
- Integrity and behaviour of materials,
- Development of special equipment,
- Environmental administration.

The most successful and marketable projects (those that are part of what the ICP identifies as its technological offer) are:

- Biological treatment of phenols in wastewater. This is a biotechnology system that allows industrial processing waters to be decontaminated without generating ecologically harmful residues. It relies on the action of micro-organisms that use the phenol as a source of energy. The phenol is converted into water, carbon dioxide and biomass, compounds that are harmless to the environment. These micro-organisms are also able to break down hydrocarbons and sulphur remaining in the water, so that the quality of the final effluent is improved considerably. The project was developed at the Cartagena Refinery, and has been cited in particular by the MMA and CARDIQUE (Corporación Autónoma Regional del Canal del Dique). The technology can be used for treating contaminated waters from various industrial processes, including plastics, resins, petrochemicals, coking, pharmaceuticals and of course oil refining.

- Accelerated biodegradation of oily sludges. This involves the controlled addition of a certain quantity of sludge to a blender in the form of a rotating sieve. This pre-homogenizes the mixture with yellow and/or black earth and/or fill of an organic type so as to reduce the initial concentration of oil in the sludge. Nutrients and acid modifiers are added. The mixture is fed through a worm gear that keeps the sludge in constant motion, and the microbial culture, enriched by the nutrients, is then

added by semi-continuous spraying. This technique makes it easier to remove hydrocarbons from the sludge produced in water treatment plants, tank bottoms, and holding ponds. One of its advantages is that the time needed for bio-removal with this technique is reduced by a factor of four, compared with air-stimulated biodegradation, and by a factor of 16 in comparison with natural biodegradation.

- Method for detoxifying solutions containing nickel, vanadium and barium, using a biosorbent of fungal origin. This method involves the passive removal of metals, through a dynamic filter prepared from a biomass with affinities for the metals to be removed. The biomass is placed in a supporting medium, and is then brought into contact with the contaminated effluent, under operating conditions that can be either static or dynamic, semi-continuous or continuous. It is used in treating industrial effluents, and can also be applied in other fields where heavy metal contamination is a problem (tanning, metallurgy) and for treating black water. Its advantage lies in the fact that it is a dynamic filter, which means that it can continuously increase its biomass and hence the volume of elements retained.

- Biofilters. This process uses mangrove plants as biofilters for water purification. The importance of this species lies in its ability to retain organic and inorganic loads, the nutrients it contributes to the medium in which it is growing, and its capacity for fixing micro-organisms to supplement the biodegradation process. In addition, a mangrove swamp provides sheltered habitat support for aquatic fauna. The use that Ecopetrol - ICP has made of mangrove as a biological filter won special mention in the National Ecology Awards 1995 from the Financiera Eléctrica Nacional (FEN).

- Laminar-flow biological filter for removing pollutants from industrial effluents. This product is based on use of a laminar-flow biological filter consisting of a mixture of materials in alternating layers that support a heterogeneous population of micro-organisms. The filter allows the removal of organic and inorganic materials that are present, suspended or dissolved, in many wastes from the petroleum industry. It is used for detoxifying wastewater flows and industrial effluents. The system has the capacity to respond to changes in the characteristics of the effluent being treated, so that it can remove a broad spectrum of organic and inorganic pollutants. In addition, the investment costs for its implementation are low.

- Emulsions. The emulsion technology developed by ICP makes it easier to handle, transport and burn heavy hydrocarbons. The technique provides a system of very low viscosity that increases the pumping capacity in the pipelines, releases dilutants, cuts pre-heating costs (they can be handled cold) and reduces atmospheric pollutants in the case of combustion (lower emissions, fewer particles, less volatility).

Emulsion technology is aimed at achieving greater yield and efficiency in the combustion, dehydration and transport of crude oil, the restoration of areas affected by oily sludges, controlling strata permeability and recovering hydrocarbons. ICP has developed and patented two emulsions: ECA, (Spanish acronym for "emulsions, fuel oil (or crude) and water"); and CCTA (Spanish acronym for "pulverized coal, asphaltene, fuel oil, surfactant and water"). ECA has been used at the Barrancabermeja refinery, where the emulsion is produced and subsequently used as a non-conventional fuel. CCTA is a non-conventional fluid fuel that is easy to handle and is highly stable.

It represents a world-scale innovation. It was financed by FONIC (National Coal Research Fund) and Colciencias[63].

CCTA is obtained by disbursing coal and/or asphaltene in water, and adding this mixture to another emulsion of fuel oil and water. CCTA can be used as a fuel in thermal power plants, steel mills and cement factories. As well, it can be used to control permeability of deposits in secondary-recovery operations. It has several advantages: i) when it is used as a fuel it is well adapted to facilities that burn coal or fuel oil as an energy source, it produces fewer emissions of particulate matter, and it reduces the frequency of maintenance on burners and filters; ii) when it is used to control permeability, it can produce savings of 50 percent compared to other existing products.

- ECO-STAB-1. ECO-STAB-1 is an asphaltic emulsion that, once applied, provides an impermeable covering and, thanks to its chemical composition, allows the seeds incorporated in it to germinate. In this way it offers a solution to problems of instability on steep, erosion-prone slopes.

The vegetation cover that is generated serves the following purposes, among others: i) its foliage intercepts rainfall, reducing the risk of runoff and infiltration; ii) its roots absorb moisture from the soil, which is transmitted to the atmosphere by transpiration; iii) the roots and foliage insulate the soil from the forces of traction caused by rainfall runoff; and iv) the roots reinforce the soil by increasing its resistance to sheering and to the forces of erosion.

The advantages of this technology are that the resulting ground cover will continue to produce seeds and shoots through successive generations, thereby stabilizing the slope. Erosion can be completely avoided in this way, since the leaves reduce the velocity of raindrops, slow down runoff and avoid laminar erosion. The deep roots also eliminate rills and furrows.

Some of the projects under development by ICP in the Cleaner Production area are:

- Biorefining: removal of heavy metals and sulphur from crude oil. The ultimate objective is to improve the quality of crude through the generation of value added, as well as to reduce emissions and conventional refining costs. Development has already been completed at the laboratory level, and it is now being tested in pilot plants. This is a totally new field internationally, and one where ICP is in the vanguard of research.

- Bio-treatment of ammonium nitrate, sulphur and other chemicals in industrial waters.

- Micro-organisms that can assist in recovering crude oil from wells.

- Production of biosurfactants, for use in bioremediation, transport of heavy crudes and cleaning tank bottoms.

[63] The full name of the project is: "preparation, transportation and combustion of emulsions and dispersions Phase I", "Preparation, transportation and combustion of emulsions and dispersions of heavy hydrocarbons and pulverized coal Phase II." The Industrial University of Santander was involved in the first phase

# 6. INTERNATIONAL TREATIES AND TECHNICAL COOPERATION AGREEMENTS IN CLEANER PRODUCTION

The international environmental conventions, both multilateral and bilateral, to which Colombia is a party, provide a wealth of opportunities through the commitments that our country has accepted. While these agreements are not specific with respect to the technologies that signatories are to adopt, the authorities of each country are in a position to use these texts and commitments as an opportunity for development and promotion of Cleaner Production and environmentally friendlier or technologies.

Following is a discussion of these conventions and their corresponding protocols, and the opportunities they present for Cleaner Production and technologies.

## 6.1. Vienna Convention for the Protection of the Ozone Layer

The parties undertake, in accordance with the means at their disposal and their capabilities, to adopt appropriate measures to control, limit, reduce or prevent human activities should it be found that these activities have or are likely to have adverse effects resulting from modification or likely modification of the ozone layer. The Convention therefore has a preventive and precautionary focus.

Annex I(4) of the Convention lists substances of both natural and anthropogenic origin that have the opportunities to modify the chemical and physical properties of the ozone layer.

- Carbon substances: carbon monoxide CO, carbon dioxide $CO_2$, methane $CH_4$, non-methane hydrocarbon species.
- Nitrogen substances: Nitrous oxide $N_2O$ and nitrogen oxides NOx.
- Chlorine substances: Fully halogenated alcanes CFC-11, CFC-12, CFC-113, CFC-114, CCl, etc.), partially halogenated alcanes ($CH_3Cl$ (natural source) $CHF_2Cl$, $CH_3CCl_3$, $CHFCl_2$, etc.).
- Bromine substances: Fully halogenated alcanes such as $CF_3Br$ that serve as a source of BrOx.
- Hydrogen substances: Hydrogen $H_2$ (natural source), water vapour $H_2O$ (natural source).

The Convention is not explicit as to the manner in which these substances are to be dealt with, but it does specify a preventive and precautionary approach, principles that are consistent with the objectives of Cleaner Production. The Montreal Protocol is yet more specific then the Convention itself.

### *6.1.1. The Montreal Protocol*

The Montreal Protocol on Substances that Deplete the Ozone Layer (and its corresponding amendments) is a follow-up document to the Vienna Convention that is more explicit with respect to substances and time limits. For example, it provides that substances known as chlorofluorocarbons (CFCs) are to be totally eliminated. Here the approach is not preventive but rather suppressive, and makes mandatory the use of alternative substances and new technologies for refrigeration, for example. Such measures are also contemplated in the vision of Cleaner Production, or in more demanding initiatives such as the "zero emissions" programme. In 1996 and 1997, Colombia drew up a programme of industrial conversion in the production of refrigerators and air conditioners, thereby applying the principle of replacing CFCs to the country's most important producers of these

domestic appliances. The duration of the initiative was limited to the availability of funding from international sources in support of the Montreal Protocol. Currently, according to the Colombian International Cooperation Agency, ACCI, negotiations are under consideration that would allow the country to proceed with a second phase of its efforts to protect the ozone layer.

## 6.2. United Nations Framework Convention on Climate Change

The principal objective of this Convention is to stabilize concentrations of greenhouse gases in the atmosphere at levels that will prevent human activities from interfering harmfully in the world's climatic system. This level of stabilization must allow for sustainable development and application of the precautionary principle.

In Article 4(c), the parties undertake, among other things, to "promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors"; and, in clause (f), "to take climate change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions, and employ appropriate methods…". This convention is regulated and further developed by the Kyoto Protocol.

### *6.2.1. The Kyoto Protocol*

The Kyoto Protocol to the United Nations Framework Convention on Climate Change is a document that calls for measures such as cooperation in the development, application and dissemination of environmentally sound technologies related to climate change. It establishes quantifiable objectives for the limitation and reduction of aggregate anthropogenic emissions, expressed in terms of their carbon equivalent.

Annex A lists these substances and gases, and the economic sectors and activities and industrial processes that produce them. Each signatory must continue to develop or put into practice an indicative list of policies for promoting sustainable development and fulfilling its obligations to limit or reduce emissions. Colombia did not undertake any quantifiable commitments.

Article 2 refers to preventive measures directly related with Cleaner Production and environmentally friendly technologies, such as:

- Enhancement of energy efficiency in relevant sectors of the national economy.
- Promotion of sustainable forms of agriculture in light of climate change considerations.
- Research on, and promotion, development and increased use of, new and renewable forms of energy, of carbon dioxide sequestration technologies and of advanced and innovative environmentally sound technologies.
- Promotion of policies and measures which limit or reduce emissions of greenhouse gases not controlled by the Montreal Protocol.
- Limitation and/or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy.

## 6.3. Bilateral cooperation agreements

The Colombian International Cooperation Agency (ACCI) has no bilateral (government-to-government) technical cooperation agreements that relate directly to the issue of Cleaner Production or to cooperation in the development and transfer of clean technologies.

The approach taken by Colombia and countries interested in technical cooperation has been to develop discrete projects. A number of projects addressing issues in the environmental area are now being executed by particular entities in specific areas. The following projects relating to environmental technology development can be classed under the heading of Cleaner Production.

| Project Name - Description | Executing Entity | Government / Agency |
|---|---|---|
| Reducing pollution from gold mining in the Bucaramanga region (Introduction of the environmental variable in the extractive process). | Corporación Autónoma para la Defensa de la Meseta de Bucaramanga CDMB | Germany |
| CERI project in energy and mining. | Ministry of the Environment | Canada |
| Plan Sierra (control and management of buffer zones of the Sierra Nevada de Santa Marta national nature park). | Ministry of the Environment | European Union |
| Diagnostic study and management of underground waters. | Ingeominas | United Kingdom |
| Carbon fixation and reduction of greenhouse gases (preliminary inventory of greenhouse gases). | Ministry of the Environment | GTZ (Germany) |
| Cooperation Agreement for Development of Environmental Management Systems and Clean Technologies. | Ministry of the Environment | ICT - Instituto Catalán de Tecnología |
| Characterization of all hazardous solid waste generating industries in Santa Fe de Bogotá.<br><br>Identification of alternative technologies for the soap-making, oils and fats, electroplating and textile industries[64].<br><br>Training in prevention, mitigation and control of environmental impacts. | Departamento Administrativo del Medio Ambiente Santa Fe de Bogotá – DAMA | Japan, JICA |

[64] A more detailed explanation of these programmes is found in Section 3.2.

| Project Name - Description | Executing Entity | Government / Agency |
|---|---|---|
| Alliance for the Environment (funding for environmental programmes, including Cleaner Production, of the Ministry of the Environment) | Ministry of the Environment | United States |
| Technical assistance for the National Centre for Cleaner Production and Environmental Technologies (CNPMLTA) | CNPMLTA | BAWI - Swiss Federal Agency for External Economic Affairs and EMPA - Swiss Federal Institute for Materials Research and Testing |

As will be appreciated, many individual activities, while they involve the concept of prevention and conversion, are dependent on the continuing availability of funding through international cooperation. Initiatives of this type are important as demonstration projects that can subsequently be replicated elsewhere in the sectors or activities for which they were designed, as is the case with DAMA. There are also other, broader and longer-term international cooperation initiatives such as the agreement with the Swiss government that gave a boost to the CNPMLTA.

It should be noted that the Alliance for the Environment provides funding for use under the 1998-2002 Development Plan of the present government. In this case, the Ministry of the Environment is responsible for deciding the use of these resources, in accordance with the National Cleaner Production Policy.

## 7. PROGRESS IN THE CERTIFICATION OF ENVIRONMENTAL MANAGEMENT SYSTEMS

In order to analyze the relationship between Environmental Management Systems and their ability to promote Cleaner Production, and thus to determine the capacity of a country, Colombia in this case, to develop cleaner technologies, some further precision is required with respect to the relationship between EMS and Cleaner Production.

It is clear that environmental management systems have existed and continue to exist without any certification process. In fact, it is recognized that many organizations follow practices for managing environmental issues and Cleaner Production projects although they are not systematized or recorded in any manual of procedures. This is the role of the EMS, to systematize these practices, to make them more efficient and effective, and to extend their impact throughout the business.

There are currently 5 major certification standards recognized around the world. These are: BS 7750 (British), CSA Z750-94-A (Canadian), IS 310:1994 (Irish), EMAS (European Union), ISO 14000 and 14001 (International Standards Organization). An EMS is by definition[65] "the organization of the structure, responsibilities, practices, procedures, processes and resources for determining implementation of a business's environmental policy" and Cleaner Production[66] is "the continuous

[65] British Standards Institute (BSI), 1994.
[66] UNEP, Industry and Environment Volume 17, No. 4, 1994.

application of a comprehensive and preventive environmental strategy for processes and products with the object of reducing the risk to human beings and the environment". Zwetsloot (1995) says that "just as with Cleaner Production programmes, EMS must imply continuous improvement with respect to a basic starting point." In this manner, EMS and Cleaner Production are not inconsistent or opposed to each other, but rather are convergent and complementary.

The World Trade Organization and the European Union today recognize the ISO as the principal standard for quality certification.

## 7.1. Possible EMS barriers to Cleaner Production

There are some significant barriers to introducing Cleaner Production in industrial firms[67]. Nevertheless, there is a great body of literature on how to overcome these barriers[68]. What is important to understand is that EMS can also be a barrier to introduction or continuation of Cleaner Production programmes. Two examples will illustrate this point:

- The resources[69] (in terms of financing, personnel and time) demanded for implementing an EMS are considerable. In many cases, these resources must be drawn from the same source as those for Cleaner Production programmes. Personnel responsible for occupational health, industrial safety and environmental issues will normally be responsible as well for EMS issues. When a Cleaner Production programme is already underway, it will generally have to share EMS resources and be conditioned by them.

- It may also be argued that an EMS has an inherent tendency to reduce capacities for improving the system itself[70]. This would mean that in real terms the commitment to continuous improvement will not exist, if it is converted into a system for "doing more of the same", instead of for doing things consistently better.

These arguments do not necessarily lead to the conclusion that EMS discourages Cleaner Production. Many writers believe that the above arguments are valid only for some non-certifiable EMS programmes or those for which no recognition is being sought. Moreover, these problems are recognized by the groups developing EMS, such as ISO 14001[71], and they have provided mechanisms, as discussed below, to prevent these negative effects in the implementation of EMS.

## 7.2. The importance of EMS standards for Cleaner Production

EMS, and in particular ISO 140001, has an element of continuity that can act as an engine and catalyst for Cleaner Production programmes. This is the principal of "continuous improvement" which lies at the basis of the system[72]. Zwetsloot (1995)[73] says that "Cleaner Production systems by themselves are no guarantee of continuous improvement in a company's environmental performance. Thus, Cleaner Production initiatives must be integrated into a systemic or integral management

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[67] Freeman: 102, 123, 132.
[68] *Ibid.,* 103, 123 and Huisingh (1989): 2.
[69] See Netherwood in Welford (Ed.): p. 39.
[70] Halme, M. IIIEE Seminar, Nov. 1996.
[71] Starkey: in Welford (Ed.): 60, gives a detailed discussion of the objectives of standardization.
[72] *Ibid.*, pp 72-73.
[73] Zwetsloot, pp. 61-66, 1995.

approach. This means that Cleaner Production activities will continue to be a tool of EMS, where systems theory is used to systematize and structure management activities".

The benefit of systematization in this sense is that it is a way of introducing the concept of continuity into the corporate culture, or "the way things are done". Halme (1996)[74] declares that EMS can be of help to Cleaner Production with its concepts of continuity, systematization and integration of improvements in products and processes in other corporate functions. This integration effect initially promotes interaction in the commitment of the company's departments to the environmental process, leading to actions such as the marketing and promotion of environmental improvements, which in turn will create pressure for greater improvements.

It is important to stress the complementarity between EMS and Cleaner Production. EMS creates or mobilizes organizational and institutional resources that are essential for Cleaner Production.

## 7.3. Barriers to Cleaner Production

To identify clearly how the introduction of an EMS can promote Cleaner Production practices and the search and use of cleaner technologies, we must examine in detail the barriers to Cleaner Production within companies[75]. This topic includes a variety of issues of which only the most relevant are discussed in this paper.

- Lack of commitment to company guidelines. This is one of the reasons why the flow of resources for Cleaner Production initiatives can dry up. An essential condition for implementing an EMS is to have such a commitment from the outset, by promulgating a company-wide environmental policy sponsored at the highest levels of the organizational structure.

- Organizational structures that separate environmental decisions from those relating to production. The importance of having a team structure dedicated to EMS (to avoid barriers) has been clearly defined[76] as the key consideration for avoiding this divergence of decision-making when implementing an EMS.

- General lack of knowledge about sources of pollution and waste flows that might be susceptible to Cleaner Production solutions. Cleaner Production programmes are often specific to a given process or pollutant (for sample CFCs), rather than to the company as a whole. The EMS takes as its point of departure an environmental audit[77], which is by itself a catalyst for finding Cleaner Production solutions. These environmental audits are commonly performed in support of an EMS and they go hand in hand with corrective actions to meet the principle of continuous improvement, accepted in order to win and retain certification.

- Communication problems. Such problems can lead to a lack of environmental awareness among managers, workers, the authorities and the general public. Communication about environmental issues covering the entire organization is fundamental to EMS, just as resolving problems of Cleaner Production is the responsibility of the entire organization.

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[74] Halme, M. IIIEE Seminar, Nov. 1996.
[75] Freeman: 102, 123, 132 and Huisingh (1989): 2.
[76] Netherwood (in Welford Ed.): pp 38 & 48.
[77] Starkey's analysis of standards, pp 59-90, in Welford (Ed.).

In the context of the Second Regional Conference of the Americas on Cleaner Production, held in Bogota, October 5 to 7, 1999[78], an expert meeting was held with government representatives on guidelines for planning national strategies for cleaner technologies in the countries of Latin America and the Caribbean. That meeting included a workshop where participants presented their proposals with respect to four questions:

- What government policies and programmes are currently in place to promote Cleaner Production?
- What is the major impediment to industry's adoption of Cleaner Production?
- What new government programmes and policies are needed to stimulate Cleaner Production?
- What regional cooperation programmes could help to promote Cleaner Production?

Following are the results with respect to the second question. The most significant impediments to the adoption of Cleaner Production in industry are:

- Knowledge, information and environmental awareness,
- Financial resources and mechanisms,
- Resistance to change,
- Resistance to innovation and technological development,
- Low cost of resources,
- Lack of endogenous technology.

## 7.4. Colombia and EMS certification[79]

EMS and Cleaner Production share the goal of improving the environmental performance of businesses[80]. The environmental management systems available today for certification are aimed at combining what is produced with how it is managed in a systematic manner[81]. Several forms of EMS, such as BS 7750, EMAS and ISO 14000, have been developed to provide organizations with a working structure that will improve their environmental performance and bring it definitively within the scope of business planning, implementation, monitoring and control. It is important to note that they are aimed at preventing and reducing negative environmental impacts, as well as at achieving objectives of profitability and sustainability for the company over time.

The national agency that awards ISO 14,001 certification for EMS in Colombia, ICONTEC[82], had reported three companies certified as of September 15, 1999. ICONTEC limits its certification work

[78] As part of the commitment of the consultants undertaking this study, a preliminary version of this paper was presented at the conference.
[79] According to the UN terms of reference, this chapter corresponds to the inventory of Colombian companies that have obtained ISO 14000 certification, or that are in the process of doing so.
[80] Halme, M. IIIEE Seminar, Nov. 1996.
[81] After Halme, M. IIIEE Seminar, Nov. 1996.
[82] ICONTEC has certified 318 Colombian companies under ISO standard 9001 and 9002.

to ISO standards. The ISO 14000 certification process came into effect only recently (1995), and has been used in Colombia only since 1997.

| Code | Company |
|---|---|
| A001-1 | Tubotec S.A. |
| A002-1 | Techint Colombia |
| A003-1 | Cabot Colombiana S.A. |

The companies that have been certified are the manufacturing enterprises, Tubotec and Cabot, and the engineering and construction services firm, Techint[83].

On the other hand, three Colombian companies have been certified abroad under ISO 14000: Rohm and Haas, Laboratorios Baxter, and a banana company.

Information on companies pending certification was impossible to obtain from the certifying agency or from certification advisers, for reasons of commercial confidentiality. The little information available was gathered on the basis of surveys. The following companies are known to be in the process of certification:

- ISAGEN,
- PETCO, Petroquímica Colombiana,
- PROPILCO, Prolipropilenos del Caribe,
- HILACOL, Hilanderías Colombianas,
- 2 sugar refineries affiliated with Asocaña,
- 10 firms affiliated with CECODES.

As will be appreciated, this is a slow and complicated process, and one that has only begun in Colombia and its productive sector, which explains why the absolute number of firms certified in Colombia is very low. It must also be recalled that the certification process is costly and time-consuming, taking more than a year. Moreover, beginning the certification process is no guarantee that it will come to a successful conclusion and that the desired certification will be obtained.

While many companies working on Cleaner Production have still not begun the ISO 14000 certification process, a number have shown an interest in doing so. Several of them, moreover, are already ISO 9000 certified, and this gives them a launching pad for initiating the ISO 14000 process, because they already have the required corporate culture (written procedures, applied and understood by members of the organization).

It is also important to note that the Responsible Care programme is understood as an EMS, although it is not certifiable. In this way, 51 companies associated with Responsible Care Colombia can be

[83] The newspaper El Tiempo of September 16 reported that this company had obtained ISO 14000 certification.

included among the group of industries committed to and implementing environmental management systems.

## 8. THE OUTLOOK FOR CLEANER PRODUCTION TECHNOLOGIES IN COLOMBIA

Previous chapters of this paper examined the "state-of-the-art" with respect to Cleaner Production in Colombia and analyzed various sectors of the national economy to see what progress has been made in appropriating Cleaner Production concepts and technologies.

In order to provide as broad a picture as possible within the scope of the study, progress achieved in various entities and sectors, both public and private, was analyzed as the basis for presenting a panorama of the current status of cleaner technologies in Colombia.

Beyond a snapshot of the current situation, however, it is important for purposes of the study to look ahead at the trends for introducing Cleaner Production concepts and technologies in Colombia. The methodology described in section 2.5 was used to develop such an outlook.

The expert workshop was held at the facilities of ANDI. It was moderated by the Instituto Quinaxi, with participation by officials of the Ministry of Development, Ministry of the Environment, DAMA, Colciencias, ANDI, CECODES, CINSET, the University of the Andes and CNPMLTA. The group was thus broadly representative of opinion in the sectors involved with the issue of Cleaner Production in Colombia.

The workshop proceeded in two separate but interrelated stages. In the first, the group fleshed out the matrix for establishing the current opportunities for Cleaner Production in Colombia (developed by the Swiss consultant as part of the UNDESA study). The second stage involved working up the outlook analysis matrix preparation by the Instituto Quinaxi. Annex 12.5 includes copies of the materials delivered at the workshop.

During the workshop, various factors were examined and discussed for their importance and relevance before being subjected to rating, both for the outlook exercise and for the identification of opportunities. As a result of this discussion, the experts suggested including two new factors (12 and 13) for the outlook matrix, and splitting factor 23 into two aspects. With respect to the table of Cleaner Production opportunities in Latin America and the Caribbean, several proposals emerged from the discussion and were taken into account in refining the table.

### 8.1. Analysis of results

Following are the results of the trends analysis conducted on the basis of the ratings accorded by the experts to the different factors over the time horizons selected.

To gain a rough appreciation of the trends of the various factors selected as likely to encourage or discourage Cleaner Production it is useful to observe how their ratings move among the different levels over time. The first point that stands out from these trends is that none of the factors ranked by the experts holds negative implications for progress towards Cleaner Production.

From the following table presenting this global analysis by levels it will be seen that there is a strong shift over time from the "nil" and "low" levels to "medium" and "high", confirming an optimistic outlook for Cleaner Production.

### *Factor Ranking by Level: All Factors*

*% at each level*

| Year | High | Medium | Low | Nil | Total |
|---|---|---|---|---|---|
| 2000 | 0.6 | 14.1 | 52.0 | 33.3 | 100 |
| 2005 | 2.5 | 35.4 | 50.0 | 12.1 | 100 |
| 2010 | 14.5 | 48.3 | 32.6 | 4.6 | 100 |

Nevertheless, the heaviest concentration towards the end of the period is in the medium and low levels, suggesting that the experts do not harbour highly favourable expectations for Cleaner Production over the time horizons considered.

The factors were also considered in two groups, one relating to general and normative factors that are essentially the responsibility of the State, and the other to more specific factors within the purview of various institutions. This analysis produced the following results:

### *Factor Ranking by Levels: First Group*

*% in each level*

| Year | High | Medium | Low | Nil | Total |
|---|---|---|---|---|---|
| 2000 | 0 | 17.3 | 44.2 | 38.5 | 100 |
| 2005 | 3.8 | 35.9 | 44.8 | 15.5 | 100 |
| 2010 | 22.4 | 40.4 | 32.1 | 5.1 | 100 |

### *Factor Ranking by Levels: Second Group*

*% in each level*

| Year | High | Medium | Low | Nil | Total |
|---|---|---|---|---|---|
| 2000 | 1.2 | 11.2 | 59.2 | 28.4 | 100 |
| 2005 | 1.2 | 34.9 | 54.5 | 9.4 | 100 |
| 2010 | 7.1 | 55.6 | 33.1 | 4.2 | 100 |

When the factors are separated in this manner, it will again be seen that there is a clear trend towards the high and medium levels and away from the low and nil levels. This ranking confirms the optimistic outlook for progress towards Cleaner Production in Colombia over the time horizons selected.

To allow a deeper analysis of these trends, the groups of factors will now be broken down and examined individually.

**NATIONAL CENTRE FOR CLEANER PRODUCTION AND ENVIRONMENTAL TECHNOLOGIES**

**Prospective Evaluation Form, Expert Workshop**

**Project: Evaluation of Capacities for Developing Clean Technologies in Colombia**

| | FACTOR | YEAR 2000 | | | | YEAR 2005 | | | | YEAR 2010 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H | M | L | N | H | M | L | N | H | M | L | N |
| | | 3 | 2 | 1 | 0 | 3 | 2 | 1 | 0 | 3 | 2 | 1 | 0 |
| 1 | Development of Cleaner Production Policy | 0 | 5 | 7 | 0 | 1 | 9 | 2 | 0 | 5 | 6 | 1 | 0 |
| 2 | Stronger pro-CP environmental legislation | 0 | 6 | 6 | 0 | 3 | 6 | 2 | 0 | 7 | 4 | 1 | 0 |
| 3 | Stronger control mechanisms and institutions | 0 | 2 | 7 | 3 | 0 | 5 | 6 | 0 | 4 | 6 | 2 | 0 |
| 4 | Faster licensing procedures for CP | 0 | 0 | 4 | 8 | 0 | 2 | 5 | 5 | 2 | 4 | 5 | 1 |
| 5 | Progress in articulating government sectoral policies for CP | 0 | 2 | 7 | 3 | 0 | 7 | 5 | 0 | 4 | 5 | 3 | 0 |
| 6 | Proceeding with existing CP agreements | 0 | 5 | 7 | 0 | 1 | 9 | 2 | 0 | 4 | 5 | 3 | 0 |
| 7 | Signing of new CP agreements | 0 | 5 | 6 | 1 | 1 | 5 | 5 | 1 | 5 | 2 | 4 | 1 |
| 8 | Formulation and development of a pro-CP state procurement policy | 0 | 0 | 1 | 11 | 0 | 0 | 5 | 7 | 1 | 2 | 8 | 1 |
| 9 | Developing economic incentives for CP | 0 | 2 | 10 | 0 | 0 | 4 | 8 | 0 | 1 | 9 | 1 | 1 |
| 10 | Public awareness of environmental quality and CP issues | 0 | 0 | 7 | 5 | 0 | 2 | 10 | 0 | 1 | 7 | 4 | 0 |
| 11 | Formulating policies on products and consumers | 0 | 0 | 1 | 11 | 0 | 0 | 8 | 4 | 0 | 5 | 6 | 1 |
| 12 | Investor and shareholder influence on behalf of CP | 0 | 0 | 3 | 9 | 0 | 3 | 6 | 3 | 0 | 5 | 6 | 1 |
| 13 | Stakeholder influence on behalf of CP | 0 | 0 | 3 | 9 | 0 | 2 | 6 | 4 | 1 | 3 | 6 | 2 |
| | **SUB-TOTAL** | **0** | **27** | **69** | **60** | **6** | **54** | **70** | **24** | **35** | **63** | **50** | **8** |

***H - High*** ***M - Medium*** ***L - Low*** ***N - Nil***

**NATIONAL CENTRE FOR CLEANER PRODUCTION AND ENVIRONMENTAL TECHNOLOGIES**

**Prospective Evaluation Form, Expert Workshop**

**Project: Evaluation of Capacities for Developing Clean Technologies in Colombia**

| | FACTOR | YEAR 2000 | | | | YEAR 2005 | | | | YEAR 2010 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H | M | L | N | H | M | L | N | H | M | L | N |
| | | 3 | 2 | 1 | 0 | 3 | 2 | 1 | 0 | 3 | 2 | 1 | 0 |
| 14 | Pricing of natural resources and public services | 0 | 1 | 10 | 2 | 0 | 6 | 7 | 0 | 1 | 9 | 3 | 0 |
| 15 | Availability of funding for R&D | 0 | 1 | 7 | 5 | 0 | 1 | 8 | 44 | 0 | 3 | 10 | 0 |
| 16 | Availability of human resources trained and prepared for R&D | 0 | 1 | 12 | 0 | 0 | 6 | 7 | 0 | 2 | 9 | 2 | 0 |
| 17 | Technical assistance, information and training on CP | 0 | 1 | 11 | 1 | 0 | 10 | 3 | 0 | 2 | 11 | | 0 |
| 18 | Physical facilities for R&D | 0 | 1 | 8 | 4 | 0 | 2 | 11 | 0 | 1 | 5 | 7 | 0 |
| 19 | Facilities for industrial-scale production in Colombia | 0 | 1 | 9 | 3 | 0 | 4 | 9 | 0 | 0 | 8 | 5 | 0 |
| 20 | Possibilities for intellectual property protection | 1 | 1 | 6 | 5 | 1 | 3 | 8 | 1 | 1 | 4 | 8 | 0 |
| 21 | Comparative production cost levels in Colombia | 0 | 4 | 5 | 4 | 0 | 4 | 6 | 3 | 0 | 6 | 5 | 2 |
| 22 | Comparative production quality levels in Colombia | 0 | 4 | 8 | 1 | 0 | 8 | 4 | 1 | 0 | 10 | 2 | 1 |
| 23 | Quality and efficiency of after-sales service (maintenance, parts) | 0 | 3 | 7 | 3 | 0 | 4 | 8 | 1 | 1 | 7 | 5 | 0 |
| 24 | Prospects for new markets (Latin America and Caribbean) | 1 | 1 | 5 | 6 | 1 | 5 | 6 | 1 | 2 | 9 | 2 | 0 |
| 25 | Progress with environmental management systems | 0 | 0 | 12 | 1 | 0 | 6 | 6 | 1 | 2 | 9 | 22 | 0 |
| 26 | Progress with ISO 14001 certification | 0 | 0 | | 13 | 0 | 0 | 9 | 4 | 0 | 4 | 5 | 4 |
| | **SUB-TOTAL** | **2** | **19** | **100** | **48** | **2** | **59** | **92** | **56** | **12** | **94** | **76** | **7** |
| | | | | | | | | | | | | | |
| | **GRAND TOTAL** | **2** | **46** | **169** | **108** | **8** | **113** | **162** | **80** | **47** | **157** | **126** | **15** |

***H - High*** ***M - Medium*** ***L - Low*** ***N - Nil***

The first 13 factors, analyzed below, have in common the fact that they are the central and direct responsibility of the state, and progress on them will therefore depend on the interest that government takes in Cleaner Production. This means that there must be a political will to press ahead with the institutional efforts required to formulate policies and legislation. Success will therefore depend on the state's capacity for leadership, on its powers to mobilize and coordinate efforts, and on the results of institutional strengthening programmes.

1. Developing a Cleaner Production policy. The experts expect to see strong and steady progress in developing the priority aspects of a Cleaner Production policy. Primary responsibility here lies with the MMA.

2. Stronger environmental legislation relating to Cleaner Production. As in the previous case, the experts foresee gradual positive moves towards a proper legislative foundation for Cleaner Production. Again, the MMA will have to accept leadership in coordinating a participatory and consensus-building approach to this goal.

3. Stronger control mechanisms and institutions. The experts foresee the strengthening of control mechanisms, which are primarily the responsibility of the Regional Autonomous Corporations and local bodies. This is likely to happen only in the period between 2005 and 2010, i.e. beyond the time frame of their current responsibilities. All that can be expected of them at this time, therefore, is evidence of a willingness to proceed in this direction, rather than any specific decisions.

4. Streamlined licensing procedures for Cleaner Production. This factor sparked lively discussion in the workshop, but the general thrust was that it could be a useful instrument for encouraging Cleaner Production, in particular during the period 2005-2010. Primary responsibility here lies with the environmental authorities.

5. Progress in defining government sectoral policies for Cleaner Production. The experts noted a fairly strong and positive trend in government towards developing sectoral policies for Cleaner Production. The MMA will have to encourage this trend, as it has been doing in its recent negotiation of working agendas with the ministries of agriculture, transportation, mining and energy, economic development and health.

6. Pursuing existing cooperation agreements on Cleaner Production. The experts were confident that existing Cleaner Production agreements would be vigorously pursued, with successful results. They believe there is a clear interest among the various sectors in appropriating cleaner technology and in working cooperatively towards this goal.

7. Signing new Cleaner Production agreements. As with the previous factor, the experts see a highly positive trend, pointing to intense activity by the environmental authorities (MMA, DAMAs and CARs) in negotiating new Cleaner Production agreements.

8. Formulating and developing a state procurement policy that promotes Cleaner Production. The experts doubted that this tool would be of much importance during the period under analysis, but their responses suggested that there is some potential for promoting Cleaner Production by this means. Progress is likely to come in the form of individual institutional efforts, rather than through any general government policy.

9. Developing economic incentives for Cleaner Production. The experts do not foresee any significant change in the current status of economic incentives to the year 2005, given the

government's current fiscal situation. Beyond 2005, however, they expect to see moderate growth in economic incentives for Cleaner Production.

10. Public awareness about environmental quality and Cleaner Production. The experts expect to see a gradual but moderate increase in public interest in environmental quality and recognition of the importance of Cleaner Production, a factor that will encourage firms to enhance their image as practitioners of Cleaner Production.

11. Formulating pro-Cleaner Production policies for products and consumers. The outlook for this factor is moderately optimistic. Although no fundamental changes are expected, there should be greater interest in products resulting from Cleaner Production.

12. Investor and management interest in Cleaner Production. This factor is related to awareness of and commitment to Cleaner Production at the company management level. The experts anticipate a gradual shift from little interest to low or medium interest, and this should have a positive but limited effect on potential investment in Cleaner Production.

13. Influence of other stakeholders in favour of Cleaner Production. Here the experts expect a rather more positive trend than in the previous case. They foresee greater public awareness in general about the importance of the environment and the need for proper management and conservation. This tendency should ultimately encourage Cleaner Production, although its impact may not be very great over the time horizon in question.

Taken together, the ratings for these 13 points suggest that the outlook becomes more positive as the time horizon is extended towards the year 2010. The strong tendency towards the development of a Cleaner Production policy and a tougher legislative framework is encouraging, but is offset to some extent by the more modest outlook for economic instruments to promote Cleaner Production.

There is apparently a high interest in negotiating and pursuing Cleaner Production agreements, probably because implementation costs will fall to a large extent on various government agencies.

In any case, it may be said that the panel took a positive and optimistic view of the prospects for Cleaner Production in Colombia over the time horizon in question.

The next group of 13 factors refers to more specific variables relating to research and development, industrial-scale implementation and commercialization of Cleaner Production processes and products in Colombia. As noted earlier, these factors are less dependent on government initiative, although they are closely related to the factors in the previous group.

14. Pricing of natural resources and public services. The experts expect these prices to rise with the passage of time, but increases are likely to be limited to the low-to-medium range. The pricing factor is therefore not seen as a major incentive for Cleaner Production

15. Availability and utilization of funding for R&D. The experts are pessimistic on this score, and do not foresee any appreciable increase in funding for these purposes. The consultants consider the lack of emphasis on Cleaner Production research and development to be a major stumbling block, since R&D lies at the origin of many processes and products that could eventually be commercialized.

16. Availability of human resources trained and prepared for R&D. The experts expect a gradual increase in this factor, with a substantial improvement over the current situation by the year 2010. This is a critical factor for making progress with Cleaner Production, but the outlook is clouded by the issue of funding for R&D.

17. Technical assistance, information and training for Cleaner Production. This factor is expected to be strengthened considerably over the period, thanks to the consolidation and strengthening of CNPMLTA and other entities and information systems relating to this issue.

18. Physical facilities for R&D. A moderate improvement is expected in this factor, suggesting that better facilities will be available for conducting R&D. This would imply the earmarking of public and private funds for equipment, laboratories and pilot plants.

19. Industrial-scale production facilities in Colombia. The experts expect a slight improvement (between low and medium) in this factor, which is critical for commercializing R&D results.

20. Prospects for intellectual property protection. As in the previous case, there appears to be a slight tendency towards an improved system of intellectual property protection, with low-to-medium progress expected by the end of the period.

21. Comparative production costs in Colombia. The experts foresee a slight improvement in this factor over the period, probably in association with macroeconomic variables, i.e. a certain improvement in the competitiveness of Colombian products on international markets.

22. Comparative quality of Colombian products. As with previous case, a gradual improvement is expected in this factor, which is also essential for competitiveness. The tendency to improvement is considered higher, although it is still ranked as medium at the end of the period.

23. Quality and efficiency of after-sales service. This is another critical factor for commercialization and competitiveness. As in the two previous cases, there is a slight tendency to improvement over the period.

24. Prospects for new markets in Latin America and the Caribbean. This is an umbrella factor that covers several of those dealt with previously in isolation. It represents the panel's overall opinion about the potential for Colombia to commercialize clean technologies elsewhere in Latin America and the Caribbean. The experts believe that there are moderate trends towards the opening of new markets in this area, and they point to clear prospects (rated medium) for participating in international markets for Cleaner Production in the region.

25. Progress with environmental management systems. As in the previous case the experts foresee positive development for this factor, which is closely related to the previous one, rating it as medium at the end of the period. This factor is considered critical for the effective adoption of cleaner technology as a process of continuous improvement.

26. Progress with ISO 14000 certification. This factor is expected to show a progressive and considerable evolution over the period, moving from a current level of nil to a ranking of low-to-medium. Given the complexity of the process, this move is considered an important step forward on the way to Cleaner Production.

An overall analysis of these factors shows, as with the first group, a clear tendency in favour of developing Cleaner Production in Colombia, and a much more modest outlook for participating in new markets in the region over the period considered.

It is interesting to note that, in the experts' opinion, positive tendencies become much stronger in the period 2005-2010, compared with 2000-2005. This may have to do with their expectations about the time it will take for the country's economy to recover and for the growing international movement in favour of Cleaner Production to make itself felt.

As the experts see it, the most positive trends are to be found for the following factors, in order:

- First group (essentially State responsibilities):

    1. Passage of strong pro-Cleaner Production legislation.
    2. Development of a Cleaner Production policy.
    3. Signature of new Cleaner Production agreements.
    4. Stronger control mechanisms and institutions.
    5. Pursuit of existing Cleaner Production cooperation agreements and progress in articulating government sectoral policies for Cleaner Production (both factors rated at the same level).

As noted, this first group of 12 factors is essentially the responsibility of the MMA and the regional and local environmental authorities (CARs, DAMAs, municipalities). These are the factors that will form the basis for Cleaner Production in Colombia.

- Second group (involving participation and responsibility of various public and private stakeholders):

    1. Technical assistance, information and training on Cleaner Production.
    2. Availability of human resources trained and prepared for R&D.
    3. New market prospects (Latin America and the Caribbean) and progress with environmental management systems and certification, ranked at same level.
    4. Pricing of natural resources and public services.
    5. Comparative quality level of Colombian products.

Great importance is attached to educating and training human resources in research and development and to information and technical assistance on Cleaner Production. This is regarded as a signal of the need to strengthen and broaden CNPMLTA programmes in these fields and to create a human capital base with solid awareness and training in the field of Cleaner Production.

The experts believe that the pricing levels of natural resources and public services (ranked low to medium) could help to promote Cleaner Production. As well, they have a good impression of the quality of Colombian products, which could work in favour of Cleaner Production.

The catch-all factor called new market prospects shows a positive but moderate trend over the period considered, in the experts' opinion.

## 8.2. The opportunities for Cleaner Production in Colombia

Following are the results of the expert panel's rankings of the matrix of opportunities for Cleaner Production Colombia. The table was designed by the Swiss consultant, and the consulting group of Quinaxi added the last three indicators. Each consultant performed an independent ranking, and these results were then compiled and examined to see if there was a consensus. At the end of the workshop, each factor was discussed in an effort to arrive at a single, agreed ranking, and these are

included in the matrix as presented below. Indicators 1 and 6 were debated in the workshop, but no solid rankings were established.

| INDICATOR | RANKINGS | | | | |
|---|---|---|---|---|---|
| *1. Fuel & energy prices*[84] | Prices 25% or more below world level | Prices 10% or more below world level | No subsidy (between -10 and +10) | Prices 10% or more above world level | Prices 25% or more above world level |
| *2. Water & dumping charges* | **Very low or none** | Low | Normal | High and growing | Very high and strong growth |
| *3. Waste management charges* | **Very low or none** | Low | Normal | High and growing | Very high and strong growth |
| *4. Privati-zations* | None planned | Few | **Few but important** | Many, most already private | Almost all private in next few years |
| *5. Exports of industrial products*[85] | **Negative growth** | Stable | Moderate growth | Strong growth (more than 10% a year) | Strong growth in several sectors |
| *6. Destination of industrial exports*[86] | Less than 10% to EU and USA | Less than 30% to EU and USA | Between 30% and 50% to EU and USA | More than 70% to EU and USA | More than 90% to EU and USA |
| *7. Environ-mental regulations based on market instruments*[87] | None in practice | **Few in practice** | Several working in practice | Many in practice | Most environmental regulations |
| *8. Enforcement* | Regulations are generally not enforced | **Many regulations not yet enforced** | Half of regulations are not enforced | Most regulations are enforced | Nearly all regulations are enforced |

[84] Average prices of all hydrocarbons and energy.
[85] Industrial products or by-products.
[86] Value of exports.
[87] Internalization of environmental costs, tradable permits, compulsory reporting, pollution charges, etc.

| INDICATOR | RANKINGS | | | | |
|---|---|---|---|---|---|
| 9. *Direct promotion of Cleaner Production*[88] | No support | **Little support** | Moderate support | A lot of support | High priority |
| 10. *Cleaner Production Centres* | None | One Centre[89] with limited activity | **Several Centres with limited activities** | Several Centres with various activities | Many Centres with many activities |
| 11. *Demand for 'green' products* | **Not a criterion for buyers** | Market is limited and small | Market limited but growing | Important and strongly growing market | Very important criterion for buyers |
| 12. *ISO 14000 standard* | No firms | **Fewer than 5 firms** | Fewer than 25 firms | Fewer than 100 firms | More than 100 firms |
| 13. *Customs duties on clean technologies* | High | Moderate (less than 25%) | Low (less than 10% | **Preferential rate for clean technologies** | Zero rates and preferential conditions for clean technologies |
| 14. *'Green' lines of credit* | Special lines available at real interest rates in US$ above 25% | Special lines available at real interest rates in US$ above 15% | **Special lines available** | Special lines available at real interest rate in US$ below 15% | Special lines available with Cleaner Production requirements |
| 15. *Environ-mental risk assessment by financial & insurance institutions* | **Not considered for insurance and bank loans** | Formal assessment for insurance and bank loans | Assessed for insurance and bank loans | Considered in setting terms for insurance and bank loans | Has significant effect on terms for insurance and bank loans |
| 16. *Public pressure* | Just beginning | **Growing issue but not yet a high priority** | Important issue | Frequent issue with several pressure groups or compulsory reporting by companies | Priority issue, many pressure groups, and compulsory reporting by companies |

[88] Through capacity building, technical assistance, information systems, support for R&D in clean technologies, access to credit.
[89] Only in one sector or only one instrument, e.g. information or capacity building.

| INDICATOR | RANKINGS | | | | |
|---|---|---|---|---|---|
| 17. *Investments in science & technology as % of GDP* | Less than 0.3% | **Between 0.3% and 0.5%** | Between 0.5% and 0.75% | Between 0.75% and 1% | More than 1% |
| 18. *Number of environment-oriented undergrad-uate & post-graduate programmes* | Highly inadequate | | **Inadequate** | | Sufficient |

## 9. CONCLUSIONS AND RECOMMENDATIONS

### 9.1. Aggregate survey results

The surveys provided some aggregate results of interest:

- Awareness of national policy and CNPMLTA. Of those interviewed, including all types of entities, only 41 percent showed an understanding of the National Cleaner Production Policy, while 64 percent were aware of CNPMLTA.

- Environmental impact generated. In general, Cleaner Production activities are considered most important with regard to water resources, followed by air and solid waste management (equal rankings).

- The major factor leading entities to pursue Cleaner Production programmes is a commitment to sustainable development, followed (far behind) by considerations of cost reduction, legal requirements, and productivity enhancement. This ranking holds for companies and R&D centres alike. Few companies, however, feel pressure from international markets to undertake Cleaner Production, although this is an important factor for business associations and NGOs.

- The companies surveyed are truly committed to Cleaner Production, eco-efficiency and sustainable development. This commitment may arise from several sources: instructions from the parent firm (multinationals, for example), the company's own mission statement or strategy, ties to some regional or sector mechanism or association that supports and promotes Cleaner Production (for example, companies that are part of Cecodes or that have signed a Cleaner Production cooperation agreement). Of the 17 companies interviewed, 16 stated declared their commitment to sustainable development as one of the reasons for introducing Cleaner Production practices.

- The Cleaner Production programmes covered by the survey were: pollution control and reduction at source; remediation and restoration (understood as environmental technologies);

efficient use of resources; and substitution of raw materials. A preference was shown for efforts to control and reduce pollution at source, followed by those aimed at resource use efficiency.

- With respect to whether companies developed their own technologies or adopted existing ones, the percentages were very similar, with a slight edge in favour of self-development. In some of these cases, supplementary purchases of machinery and equipment were made.

## 9.2. Factors affecting Cleaner Production

- The existence of an environmental culture and awareness is a positive factor for Cleaner Production. Nevertheless, these have not been very intensely developed in Colombia. In those sectors or regions where a community environmental conscience has emerged, companies have found themselves obliged to improve their environmental performance. This is the case in the Oriente Antioqueño and Mamonal. In the case of individual entrepreneurs, efforts to promote awareness of the environmental impact of their activities must always be accompanied by a demonstration of the benefits that can be gained from improving their environmental performance, either by reducing costs and increasing productivity or by improving their competitive position in international markets.

- International markets are beginning to be perceived as a positive factor for Cleaner Production. Companies subject to pressure from external markets see Cleaner Production as a factor of international competitiveness.

- Businesses, and particularly SMEs, betrayed a total ignorance of unit costs, including the cost of energy, water and raw materials. This makes it very difficult to persuade entrepreneurs to reduce their consumption, because they are not even aware of how much they are consuming, let alone how much that consumption costs them. This lack of knowledge is an obstacle to introducing clean technologies, which in principle are supposed to rationalize the consumption of materials and inputs.

- There is a widespread opinion that current environmental legislation, particularly that referring to emission charges, works in favour of pollution control but not of Cleaner Production. Companies will often judge which is more expensive, to pay charges for water pollution or to undertake the technical changes needed to reduce their emissions. Normally, the second approach is more costly, and businesses are likely to prefer to pay the fine rather than adopt clean technologies. In Colombia today it is more expensive to be environmentally responsible.

- While there are incentives to Cleaner Production (VAT exemption for equipment certified as clean technology and income tax deductions for environmental investments), they are not very widely known or sufficiently attractive, since most companies insist on incentives for Cleaner Production. Businesspeople are aware of the penalties for "dirty" production and they know that the environmental authorities punish polluters, but they do not see those authorities as sources of support and assistance for Cleaner Production.

- Uncertainty over the permanence and incidence of environmental rules means that there is a lack of legal clarity, and this is an obstacle to promoting Cleaner Production in the country.

- With a few exceptions, business people's lack of confidence in national R&D and engineering capacities is an obstacle to developing indigenous clean technologies. As well, the lack of

funding for R&D and technology transfer (from the domestic creator to the user) also limits the development of clean technologies.

In the agriculture sector, there are certain specific factors that discourage Cleaner Production:

- The Ministry of Agriculture has no policy to limit the use of agro-chemicals or to promote clean technologies and sustainability.
- The pressures brought by companies producing chemical pesticides and herbicides discourage the introduction of organic products and biological control systems.
- The need to provide technical assistance for making proper use of biological pesticides and fertilizers is an obstacle to their wider application.
- Soil erosion is considered the principal environmental problem for Colombian agriculture, yet there are few programmes or initiatives to address this issue. A broad national programme is needed to promote restoration and conservation of our soils. The incentives for water conservation may be greater, but in fact without conserving the soil it is impossible to conserve water.

## 9.3. Conclusions regarding the outlook for Cleaner Production in Colombia

- The outlook for Cleaner Production and for an awareness of its importance in Colombia is optimistic.
- This optimistic outlook relates more to the prospects for entrenching Cleaner Production techniques and practices in Colombia than to those for producing and exporting clean technologies to the region, over the time horizon considered.
- The prospective analysis pointed clearly to progress in the various factors regarded as important for developing Cleaner Production, with a broad move towards medium and high levels of development and a consequent reduction in factors at the nil or low levels.
- The responsibility for promoting Cleaner Production in Colombia falls essentially to the MMA as the leader and coordinator of a technical and political process of joint efforts with productive sectors. Nevertheless, the interviews revealed that much of the progress achieved to date has come about at the initiative of individual businesses and institutions.
- There is a shortage of funding dedicated to research and development, and this is a serious obstacle to initiatives that might eventually lead to the export of clean technologies.
- There is a relatively strong trend to improvement in the capacity of human resources devoted to Cleaner Production over time, particularly at the R&D phase, but although this is a positive development it is not clear how these new human resources will be utilized unless sufficient funding is made available for R&D.
- With regard to the prospects for industrial-scale development, intellectual property protection and other conditions for effective participation in regional markets, such as the provision of adequate after-sales service, the prospects for progress over the period considered are modest.

- In terms of identifying which of the priority factors are likely to show progress over the period under consideration, the Outlook Workshop pointed to the following. These factors may also be regarded as priority fields of action in terms of policy development and concrete activities.

| **Factors from the first group**<br>(essentially dependent on government) | **Factors from the second group**<br>(dependent on many players for execution) |
|---|---|
| 1. Adoption of stronger legislation in favour of Cleaner Production. | 1. Technical assistance, information and training on Cleaner Production. |
| 2. Development of a Cleaner Production Policy. | 2. The availability of trained and upgraded human resources. |
| 3. Signature of new Cleaner Production agreements. | 3. Progress with Environmental Management Systems and certification. |
| 4. Stronger control mechanisms and institutions. | 4. Pricing of natural resources and public services. |
| 5. Pursuit and evaluation of existing Cleaner Production agreements and articulation of government sector policies for Cleaner Production. | 5. Comparative quality of Colombian products. |

## 9.4. Recommendations

- The MMA should move ahead decisively with a concerted and participatory process to develop a National Cleaner Production Policy. This policy should deal with specific issues and should create the means for addressing them successfully in areas and sectors defined as priorities.

- The status of existing Cleaner Production agreements should be assessed to determine their progress and identify obstacles to more effective implementation.

- The programme for negotiating new agreements for Cleaner Production should be pursued, drawing upon experience and the evaluation proposed in the previous point, with careful selection of the priority sectors and issues to be addressed.

- Further effort should be made to formulate the government's sectoral policies and agendas, relating explicitly to environmental variables and in particular to Cleaner Production. These agendas and policies must be properly articulated among themselves. The agendas already agreed should also be pursued further.

- There is need for an assessment of the environmental authorities' capacity to carry forward the development of policy and legislation, to stimulate Cleaner Production, and to supervise and monitor the process.

- The environmental authorities need to exert greater control, which means that their technical capacity for supervision and monitoring must be strengthened.

- The "command and control" approach should be supplemented by a clear policy of incentives and encouragement to Cleaner Production.

- The use of economic instruments for Cleaner Production should be improved to make them more effective both as controls and as incentives. Controls (e.g. pollution charges) should be made more rigorous and incentives (e.g. the VAT exemption) should be made more attractive and publicized more widely. It is clear that if controls are to be more effective the institutions enforcing them (the environmental authorities) must be strengthened.

- It is important to speed up the process of placing values on resources and environmental impacts and to incorporate the results in the design and application of economic instruments that will induce behavioural changes on the part of producers and consumers in favour of Cleaner Production.

- A programme should be established to educate and train human resources in Cleaner Production issues, relating to research and development, industrial-scale production and commercialization of clean technologies.

- The analysis performed points to a logical sequence starting with the consolidation of Cleaner Production in Colombia as a prerequisite for participation in the regional market.

- In the first instance, it is important to develop the national market for clean technologies, given the many problems and needs that must be addressed, before attempting to commercialize them internationally. The domestic market for technology development offers immense opportunities.

- In terms of commercialization, greater attention should be paid to marketing R&D and consulting services rather than clean technologies themselves, since the latter are so specific to local conditions that it may be difficult to adapt them in other countries where environmental conditions are different. Moreover, most of the clean technologies now being developed in Colombia are intended primarily to meet specific problems of a given business. It is unlikely that many of these technological innovations can be converted into saleable products.

- It is very important to encourage environmental management systems, since they can be used to detect pollution problems that can often be resolved without the need for heavy investment: small changes to optimize productive processes and manufacturing practices are often all that is needed.

- The approach taken by the National Centre for Cleaner Production and Environmental Technologies is appropriate for the country, because it calls for sound practices and changes in processes and products, and not only the introduction of clean technologies, as part of a Cleaner Production strategy. There is much to be done in terms of adapting practices to Cleaner Production in Colombian businesses, large, medium-size and small alike, without the need for radical technological changes that would demand heavy investment in machinery and equipment.

- There is a need for technical assistance programmes in production management to help companies determine their unit production costs: these can be a very important tool for encouraging savings in raw materials and other inputs (energy, water, etc.).

- As part of a Cleaner Production policy, forms of international cooperation should be identified to promote the transfer of technology and to open up new sources of financing for specific projects.

- With respect to the Alliance for the Environment with the United States, the existing framework should be used for undertaking cooperative projects in support of Cleaner Production.

## 9.5. Recommendations from the Workshop of Governmental Experts

During the Second Regional Conference of the Americas on Cleaner Production, a workshop of governmental experts was organized to consider four issues, listed below, relating to the development of Cleaner Production in Latin America and the Caribbean.

The methodology followed was to consult the experts' opinion on the four issues and group the responses on cards, assigning them priority in accordance with the number of responses that could be grouped under the same concept. This is a variation of the ZOPP approach (Objectives-Oriented Project Planning).

The workshop results are presented below, in the order of priority of the issues discussed:

- Policy suggestions.
- Greatest obstacle to progress with cleaner technology.
- New programmes and policies (desirable).
- Regional cooperation activities suggested.

### POLICY SUGGESTIONS:

1. Develop and utilize economic instruments to encourage Cleaner Production.
2. Negotiate voluntary agreements for Cleaner Production with regulated industries.
3. Stress pollution control and fines for polluters.
4. Disseminate information on new clean technologies and, in general, on the issue of Cleaner Production among regulated industries.

### GREATEST OBSTACLE TO CLEANER PRODUCTION:

1. Lack of knowledge, information and awareness about Cleaner Production.
2. Lack of financial mechanisms and funding to promote Cleaner Production.
3. Combination of the preceding two factors.
4. Resistance to change on the part of regulated industries.
5. Resistance to innovation.
6. Low cost of natural resources for regulated industries.

7. Lack of endogenous technologies.

## NEW PROGRAMMES AND POLICIES (DESIRABLE):

1. Organizational and institutional strategies, with emphasis on coordination and communication.
2. Use of economic incentives for Cleaner Production.
3. Market liberalization.
4. Regulation and enforcement in support of Cleaner Production.
5. Financing sources and lines of credit.
6. Education and training on cleaner technologies.

## REGIONAL COOPERATION ACTIVITIES:

1. Publication and dissemination of information on Cleaner Production.
2. Conferences, courses and workshops on Cleaner Production.
3. Common regional positions in international agreements.
4. Horizontal cooperation.

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