**A Case Study of Cleaner Production Opportunities in Small and Medium Enterprises on the Island of Mauritius**

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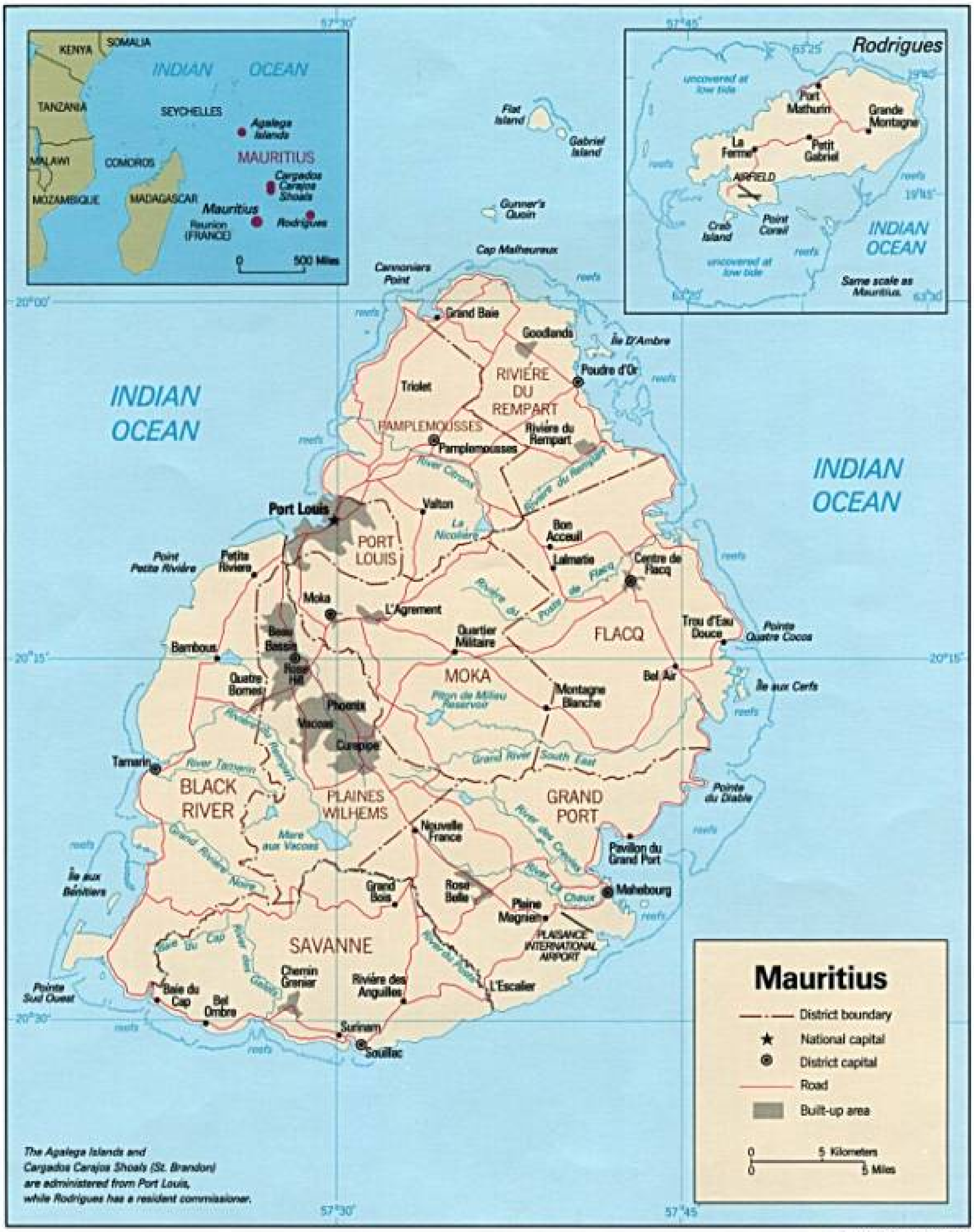
Small Islands Developing States provide a special case in development, largely due to special characteristics of their natural, economic and social environment. Understanding and implementing strategies for sustainable development become critical issues for islanders. The island of Mauritius has evolved from an agricultural to a semi-industrialized country over the past three decades. Small- and Medium-scale Enterprises (SMEs) play a vital role in the economic development of the island but they also contribute significantly towards overall industrial pollution. Large-scale industries produce more pollution than SMEs but because of their preferential access to capital investment and to new technologies, it is comparatively easier and more economical for them to control their pollution. In the case of SMEs a number of factors hinder them from the planning and implementation of pollution control actions. These factors include: lack of access to resources allowing for investments in pollution control, low level of technology, lack of space, non-availability of trained personnel, and the unwillingness of management to invest in environmental protection. The environmental management approach adopted by large-scale industries and SMEs differ considerably. The aim of this research was to highlight these differences through case studies of a large-scale industry (brewery) and a small-scale industry (tannery). The author carried out waste audits to identify cleaner production opportunities. Emissions could be effectively controlled by a combination of Cleaner Production (CP) and pollution control options. Most of the opportunities are not pursued by the factories because of a lack of skills on how to build cleaner production projects, lack of top management commitment, lack of time, and lack of allocation of responsibilities for project conception and engineering. This article concludes with recommendations for a national strategy for the implementation of the Cleaner Production concept in SMEs.

The island of Mauritius lies in the Indian Ocean at about 800 km to the east of Madagascar (see Map 1). It is 1865 $km^2$ in area and volcanic in origin. As of December 2001, the population was estimated at 1.2 million. Mauritius is the sixth most densely populated country in the world, and it has one of the lowest cropland per capita ratios. In less than three decades, Mauritius has changed from a poor developing country with uncontrolled population growth, high infant mortality, and declining or stagnant growth per capita income, to a rapidly industrializing country.




*Map 1*. Map of Mauritius and its location in the Indian Ocean (reprint with permission from Mauritius Ministry of Environment, 2/17/04)

Small islands like Mauritius provide a special case in development, largely due to the special characteristics of their natural, economic, and social environment. Understanding and implementing strategies for sustainable development become critical issues for islanders.

Over the past 15 years, Mauritius has achieved an 5-6% annual growth in the economy and steady growth in per capita income. During this time the economy has diversified from being dominated by sugarcane to a mixture of industry, agriculture, tourism, and financial services. This change is associated with a greater demand for resources, greater consumption of products, and increased volume of wastes. It is estimated that there are approximately 5,000 industrial enterprises in Mauritius (*National Environmental Strategies*, 1999). Of these, some 900 employ 10 or more persons and are referred to as large-scale, employing a total of over 100,000 people. The small and medium scale manufacturing establishments employ somewhere between 14,000-15,000 people.

Most of the large industries in Mauritius are well organised and structured and are sometimes backed up by internationally reputable mother companies. On the other hand, SMEs in Mauritius are mostly family owned or owned by a small group of shareholders. The environmental management approaches adopted by these two types of industries differ considerably. Cleaner Production (CP) should be an essential part of any comprehensive pollution management system. This paper examines a brewery and a small tannery on the island of Mauritius, looking at the environmental management approach in each factory and at how CP can create savings without significant financial investments. Targeted intervention needed for firms is then discussed.

## SMEs and Cleaner Production

Small- and medium-scale enterprises (SMEs) not only contribute to productivity growth and employment but are also significant non-point sources of pollution. It is true to say that large-scale industries produce more pollution than SMEs (Visvanathan, 1996), but because of their preferential access to capital investment and to new technologies, it is comparatively easier and more economical for them to control their pollution. In the case of SMEs, a number of factors hinder them from the planning and implementation of pollution control actions. Visvanathan has listed these factors as being:

- SMEs are generally started without the benefit of long-range project planning and feasibility studies. Entrepreneurs eager to cash in on an attractive business venture normally want to start immediately in the most expeditious manner. In addition, the limited capital cannot sustain prolonged and exhaustive pre-operation project planning and projections.

- SMEs often operate in highly competitive markets and are only marginally profitable. They maximize profit by minimizing their external and other unnecessary expenditures.
- SMEs have limited capital to invest in pollution control activities.
- SMEs are unable to attract people with comparatively high levels of technical know-how in a non-manufacturing process such as pollution control, and SMEs normally require mobile technical assistance for their pollution control.
- Most SMEs use low level technology and lack space to install pollution control devices.

Even when policy measures are in place their enforcement and monitoring is a real problem on account of the large numbers and diversity of SMEs. A large number of these firms are not recorded in official surveys. The following barriers to the introduction of CP in SMEs can be identified:

- Organizational (non-involvement or high turnover of technical and production staff)
- Systematic (poor record keeping, weak management, lack of training)
- Technical (lack of monitoring or analytical facilities, limited number of trained personnel, lack of access to technical information)
- Economic (counteractive resource pricing, lack of finance)
- Attitudinal (poor housekeeping, resistance to change, job insecurity)
- Governmental (emphasis on end-of-pipe approach, lack of incentives)
- Other (lack of institutional support, lack of public pressure)

**Case Study of Tannery and Brewery**

Methodology: The waste audits and synthesis phases were carried out as per the methodology recommended by UNEP/UNIDO (1991), UNEP/IE (1991), and UNEP/IE (1996). Three phases can be distinguished: a *pre-assessment phase* for audit preparation; a *data collection phase* to derive material balances; and a *synthesis phase* whereby the findings from the material balances were translated into a waste minimization action plan. Data were collected from the industries' record book and through monitoring programs over a period of four months.

**Tannery**

Description of Site/Activities

The tannery is situated in a residential urban area and has been in operation since 1958. It is a family-owned business employing about 20 persons and is headed by a managing director who is also the major shareholder of the company. The tannery produces for the local market only and it processes 6400 kg of raw hides collected from a local abattoir. There are no watercourses passing nearby. Water consumption is from the potable water supply line. The tannery possesses a waste permit and collects its wastewater in a tank with a 70 $m^3$ capacity located at the backyard of the tannery. It hires a wastewater tanker with a 7$m^3$ capacity every Monday to pump out the sludge from the storage tank. The tannery also holds a waste permit for disposal of its solid waste at a landfill.

*Emissions and Material Balance*

Table 1 gives a material balance for the overall tannery operations.

Table 1

*Material balance for the tannery*

| **Inputs** | **kg/day** |
|---|---|
| Raw Hide | 1,600 |
| Chemicals | 308 |
| Water | 5,500 |
| TOTAL | 7,408 |
| **Outputs** | **kg/day** |
| Trimmings and Shavings | 535 |
| Fleshing | 500 |
| Finished Leather | 500 |
| Wastewater | 5,346 |
| Gaseous Emissions | Not quantified |
| TOTAL | 6,881 |

The average daily water consumption was low at about 5.5 $m^3$/day and the average wastewater produced daily amounted to about 5.3 $m^3$/day. Analysis of the wastewater samples showed the following characteristics:

| | |
|---|---|
| $BOD_5$ (5-day Biochemical Oxygen Demand) | 5490 mg/l |
| TSS (Total Suspended Solids) | 2144 mg/l |
| Chromium, $Cr^{3+}$ | 450 mg/l |
| Sulphide, $S^{2-}$ | 3600 mg/l |

Furthermore, the tannery was disposing a total 4,140 kg of solid wastes weekly-2,000 kg of fleshings and 2,140 kg of chromed splits and shavings. The disposal costs amount to about US$600 per week.  Gaseous emissions were not significant except for solvent evaporation in the finishing section.

*Cleaner Production Opportunities*

During the synthesis, simple and readily achievable cleaner techniques were highlighted, such as the elimination of curing which would result in the reduction of 3.2 $m^3$ from the weekly wastewater flow. Solid wastes would decrease by 2,000 kg weekly if the green fleshing are sold as animal feed. The option of process change for de-liming using $CO_2$ instead of ammonium salts is expected to reduce the ammonia contents of the wastewater and also to make considerable savings as $CO_2$ is less expensive than ammonium sulphate.

In order to reduce the high concentration of chromium in the wastewater, several options were proposed. An aluminium pre-tan was suggested which would yield a further 2,000 kg of solid waste that can be recycled as animal feed and would lower the chromium concentration to 240 mg/l. This tanning process has a first stage which uses a liquor based on titanium, aluminum, and magnesium, and is known as the TAL process. In the second stage, a chromium tan is used with 9% chromium instead of the 21% presently used. The metals used in the pre-tan stage are non-toxic and can even be assimilated by animals. The product quality is not affected and the new technology requires no additional equipment.

Adopting the hair save method can eliminate the sulphide contents in the effluent, but this is an extreme option as it is associated with huge capital investment. However, the sulphide-containing wastewater stream can be segregated, stored in a separate tank, and then pre-treated for elimination of sulphide by oxidation with air using manganese sulphate as a catalyst.

Using roller application instead of spraying techniques can reduce emissions of solvent to the atmosphere in the finishing section.

Environmental Management Approach

The following important points emerged during the waste audit concerning the environmental management approach in the tannery:

- The tannery has restricted capital and has not invested in any equipment for the past 15 years.

- The tannery's personnel are mostly laymen who have learned the various operations on the job. Most of the operations are done manually and do not require highly trained people. However everything is done under the close supervision of a qualified leather technologist who keeps himself informed of the latest technologies involved in the tanning sector. Monitoring of the industry is done only in terms of input chemicals where the quantities used for each process are entered into a record book. No wastes monitoring is carried out.
- The main reason behind the low commitment to pollution prevention is due to the fact that solid and liquid wastes generated are transferred to other sites. The absence of physical degradation of the immediate surroundings of the industry is a sufficient reason to understand the passive attitude of the management towards pollution control and waste management.
- The tannery has limited management and technical resources and little experience of how to upgrade the quality and efficiency of their production.

**Brewery**

*Description of site/activities*

The brewery was established in 1963. It employs about 500 persons and the annual production is now just over 35 million litres of beer. Most of the production is meant for the local market but the export share is increasing. The company is expecting to double its annual production in the coming years, and to succeed in achieving this target the management is investing a lot in modern production techniques and training for its personnel. The factory discharges its effluents directly into the sewerage network without any pre-treatment. The solid wastes generated are collected by lorries and disposed in a landfill. Broken glasses are recycled and spent grains, dried yeast, and trub are sold to other companies to be used as animal fodder.

*Emissions and Material Balance*

The water consumption is of the order of 1200 $m^3$/day. The main outputs from the manufacturing process are mainly:

| | |
|---|---|
| Beer | 120 $m^3$ |
| Wastewater | 900 $m^3$ |
| Solid wastes | 10,000 kg/day |
| Broken Glass | 2,000 kg/day |
| Spent grains and trub | 32,400 kg/day |

The total wastewater is about 900 $m^3$/day and the pollution load is about 5,500 kgCOD(Chemical Oxygen Demand) /day and 490 kg TSS(Total Suspended Solids)/day. The brewing and processing operations generate the higher-strength effluents. Wastewater streams from the brew house and the fermentation areas were found to contain the highest organic and suspended solids loads. The overall pollution load was 5,500 kgCOD/day and 4,920 kg SS/day.

The spent grains and trub are sold to local companies as animal feed material whereas the broken glass is recycled in a sister company. Local farmers for land preparation collect the 4,000 kg of ash from the boiler blow-down.

All the $CO_2$ produced during fermentation is recovered, stored, and reused. Some is sold to external companies when required. Stack emissions from the boiler house contain particulate matter and sulphur oxides. The boilers use heavy fuel oil with a sulphur content of about 3%. The stack heights are low and the particulate emissions are above the permissible maximum limits. Residents close to the brewery complain mainly about noise and particulate matter.

Cleaner Production Opportunities

The brewery consumes about $6.0*10^6$ MJ of energy monthly (100000 litres of heavy fuel oil and 140 tonnes of Coal). The brewery is already adopting a few clean technologies such as:

- recovery of $CO_2$
- partial recovery and drying of yeast
- counter-current use of water in washings
- heat recovery and hot water storage tank
- reuse of caustic soda.

Analysis of various CP options showed that it was technically and economically feasible to reduce the water to beer ratio by one third. Furthermore, by recirculating the trub, spent grains and residual beer, into the process, about 8% of additional beer can be produced, leading to a reduction in the pollution load.

Environmental Management Approach

The brewery operates in a highly differential market where the quality dimension of the product is important. It has a focus on quality, product improvement, and on brand and company image. The brewery possesses ample management and technical skills. The awareness of pollution control is high at the management level. The brewery, though not having a certified environmental management system, does assign the responsibility of environmental management to a technical manager. There is a special planning cell for the training of its personnel and occasionally some training is done on environmental awareness. Monitoring of effluents is done on a monthly basis and the results sent to the Ministry of Environment. Some environmental research work is done in collaboration with the University, such as an on-going feasibility study of high-rate anaerobic technologies for the pre-treatment of its wastewater before discharge into the sewer system.

## Recommendations

The Ministry of Environment (MOE) is presently the principal regulatory body that looks after environmental issues. The regulatory process is operated through various instruments such as Environmental Impact Assessment (EIA) and ambient emission/effluent standards. The enforcement of these instruments and various provisions at MOE is unfortunately weak. The MOE does not have a strong enforcement division that is ably supported by a network of field monitoring laboratories and equipment.

Many of the CP opportunities do not need major investments but are not pursued by factories because of a lack of skills on how to build cleaner production projects, lack of top management commitment, lack of time and lack of allocation of responsibilities for project conception and engineering. There are two major issues to be addressed in developing an effective CP program in a country:

- **External incentives-**An appropriate government policy and regulatory formula must be in place to provide effective incentives for the firms to adopt cleaner production.
- **Response of the firms-**In many cases, firms are incapable of responding to the incentives and in such cases it may be appropriate to assist the firms to adjust. The approaches adopted for this purpose will vary considerably depending on the characteristics of the sector and of the firms involved. (*Pollution prevention and abatement handbook,* 1999)

Firms respond in different ways to the incentives provided by the government and by the market. We can distinguish two extreme types of firms which have different characteristics and which require different approaches. At one end of the spectrum are enterprises that are operating in a highly differentiated market where the quality dimension of the product is important. Such firms have a focus on quality and product improvement, and on broad company image. They typically have high-quality management and are responsive to extreme changes. The firms can be characterized as *dynamic*. The beer factory is an example of such a dynamic firm. At the other end of spectrum are firms that can be characterized as *static* because their processes and market change very slowly. Included in this group are small firms. They use traditional and relatively simple production methods, focus on cost minimization, and are often under-capitalized and lack depth in management. The tannery is an example of such a static firm.

This distinction means that approaches required to introduce and disseminate new processes will be very different. The first group will respond to opportunities for technology transfer and for management upgrading. The requirement on the government's side is to provide information, incentives, and demonstration projects. The small firms will require a more direct approach, as the management is typically much less responsive to incentives. A focused intervention is required and the following actions are needed for the tannery sector:

- The tannery sector will be economically important in terms of future development and will present environmental problems. Thus political will as well as public concern must be at a sufficient level so as to make changes.
- It is crucial to have the top management of the tannery sector involved in the process in the early stages.
- The focus must be on a small number of specific technical objectives that are relevant, feasible and measurable.
- Appropriate external incentives must be established. It may be necessary to raise resource prices and to ensure that there is a credible threat of enforcement of disposal requirements.
- Research, analyze, and publish cleaner production options in the tannery sector.
- Provide technical assistance to assist enterprises in evaluating their situation.
- Establish appropriate training opportunities for management, workers, and regulators.
- Improve access to financing-provide start-up funds to overcome the reluctance of traditional sources to finance CP.

A strong partnership between government, industry, and the scientific community is the foundation on which CP will need to be built. Table 2 summarizes the more relevant problems regarding these three actors that play an important role in CP promotion. Government has a strategic role to play in providing the necessary framework and stimulating industry demand for CP. Appropriate legislation, effective enforcement, economic incentives, voluntary agreements, demonstration projects, and information and promotion programs provide a variety of policy instruments which government can implement.

Education and training activities are crucial for the promotion of CP and different strategies can be used to integrate this concept in university curricula-from single lectures in existing environmental course modules to development of new post-graduate programs. Students and university staff can gain practical experience by assisting industry in CP activities. Training should produce innovators and to make this link involves integrating personnel from both the company and research institutions into relevant research and development activities. During the synthesis phase of an environmental auditing exercise the ideas for CP options may come from a literature search, from personal knowledge, from examples in other companies, from specialized databases, or from some further R & D. A creative, intellectual environment based on the widest possible experience is thus needed in order to think of all possibilities. Demonstration projects are an important vehicle for education and training involving participation at all levels within a company and of academics from research and educational institutions. Industry would benefit from better interaction with the academic community through objective advice, low research costs, and few, if any, personnel costs.

Table 2

*Problems of University, Industry and Government in the promotion of Cleaner Production (CP)*

| **Industry** | **Government** | **University/Research Institutions** |
|---|---|---|
| Lack of a "Waste Management Culture," leading to the mix of wastes at the source<br><br>Lack of trust in government authorities and ignorance of existing environmental regulations | Lack of clear and continuous policies to support CP<br><br>Incomplete regulatory framework and uneven enforcement<br><br>Inappropriate standards copied from industrialized | Slowly updated and rigid educational technological programs that do not reflect the actual needs of the industries and countries in the region<br><br>Poor mechanisms to facilitate the |

| | | |
|---|---|---|
| Lack of support by industry managers for the implementation of environmental management policies because the cost of pollution control has not been included in their production costs<br><br>Great differences in the capacity to deal with pollution prevention and control between large industries and SMEs<br><br>Poor environmental awareness among workers and managers<br><br>Consultant firms use a "technology colonization" approach based on the import of foreign technologies | countries<br><br>Inefficient coordination among different agencies at different levels<br><br>Lack of economic incentives by government to foster technological change<br><br>Inadequate mechanisms of communication with the industrial sector<br><br>Government-state owned industries have generally a poor environmental performance<br><br>Lack of trust in industries<br><br>Lack of human resources and infrastructure to support CP programmes and to enforce regulations<br><br>Lack of an education policy concerning environmental education throughout the educational programmes | establishment of links with industries to support technology innovation<br><br>Lack of a "language" to communicate with both industry and government<br><br>Slow response to the demands of the industries and in the delivery of results of their studies and projects<br><br>Promotion criteria and research funding are less based on the practical applicability of the research and in the bridging efforts between disciplines and between university and society |

While it is industry that ultimately must implement CP, the role of government and universities is to provide an environment that will accelerate the process and encourage industry to initiate its own CP program. Attention should be directed at the following three issues:

Providing information about the technology involved and the environmental tools industry needs to make CP assessment of its activities and products

Organizing training on CP

Helping to change educational curricula, in order to integrate the environmental dimension in all engineering and business management courses. CP promotion requires the reinforcement of CP curriculum in university engineering education. Most curricula at the university level include the study of environmental engineering topics as part of the civil engineering course. However, the principal developers of CP in industry are chemical and mechanical engineers, and these people should therefore be well prepared for this task through university programs that include CP curriculums.

## Conclusions

The Cleaner Production concept and culture need to be introduced in small-scale factories. Cleaner Production is up-side options to motivate factories toward seeking a joint solution to pollution control and increasing profitability. Many of the Cleaner Production projects do not need major investments, but what is required is a commitment and training support on how to identify and implement projects. A short-term goal in the promotion of CP is to set up one effective cleaner production demonstration project that will launch a snowball effect throughout the industrial sector, and which will eventually spread to other industries. These demonstration projects are useful in revealing obstacles to progress both within the companies and in the relationship of companies to the outside world.  The aim of such demonstration projects is also to enhance the institutional and research capacities for Cleaner Production within industry, government, and academia.

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