Heavy industries have a major impact on the environment. Environmentally sound technologies are the key to improving their performance, and mitigating the pollution they cause.

Cleaner production and eco-efficiency

7

Cleaner production is referenced throughout Agenda 21 as an important strategy for supporting sustainable development. It focuses on preventing pollution rather than merely controlling it or cleaning it up after the event. In short, the goal of cleaner production is to avoid generating pollution in the first place. This in turn can cut costs, reduce risks and help identify new opportunities. The concept was introduced by UNEP's Industry and Environment Centre (UNEP IE) in 1989, and since then it has gained considerable ground worldwide, as companies increasingly recognize the performance and financial benefits of switching from end-of-pipe solutions. There is a growing understanding that cleaner production – like eco-efficiency – is a win-win approach, and that it does not always require major changes to processes and products. Often quite minor changes result in increased financial and environmental returns.

According to UNEP, cleaner production is "the continuous application of an integrated preventative environmental strategy to processes, products and services to increase eco-efficiency, and reduce risks for humans and the environment". This means:

- for production processes – conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes;
- for products – reducing negative impacts along the life cycle of a product, from raw materials extraction to the product's final disposal;
- for services – incorporating environmental concerns into designing and delivering services.

Cleaner production also requires "changing attitudes, responsible environmental management, creating conducive national policy environments, and evaluating technology options". Indeed, UNEP emphasizes that cleaner production is a strategy going beyond technologies to encompass broader issues such as management and government policy, and extending both upstream and downstream of the production process. Upstream, it covers product design and the impacts of providing materials and energy inputs; downstream, it looks into the impacts of using products and their disposal as waste.

However, while cleaner production is not a technological 'fix', environmentally sound technologies (ESTs) are clearly an integral part of the strategy, and vital if industries and companies are to introduce cleaner production practices into their operations. As UNEP states: "If sustainable development is to be achieved, processes, products and services have to be reoriented towards new patterns, to both alleviate environmental stress and bring better industrial productivity. This requires the development and use of new policy and management tools in both government and industry *as well as the development and use of environmentally sound technologies that prevent pollution, and make efficient use of raw materials*" (emphasis added).

Cleaner production options are better than end-of-pipe solutions because the latter frequently require more materials in their manufacture and more energy in their operation,

BRITTA STEILMANN SUSTAINABLE DEVELOPMENT
GmbH & CO KG

Britta Steilmann

Cotton is clothing the world. But it can be at a cost – to the environment and to the health of people wearing shirts, jeans and other cotton garments.

In the fields, cotton is treated with more pesticides than any other comparable agricultural crop. Often, they are the cheapest pesticides – eroding the soil, polluting groundwater, contaminating the land and those working on it.

As the picked cotton passes through the production and manufacturing stages, it is exposed to more chemicals. In fact, the textile industry uses more than 8,000 chemicals – including considerable amounts of heavy metals, dyes and other substances, even formaldehyde.

And those chemicals can harm us – especially formaldehyde. As the temperature of the body is raised, the genetic composition of formaldehyde changes causing adverse effects. Children are particularly vulnerable and assailable.

Moreover, the production stage creates excessive waste whilst the washing process can be environmentally devastating.

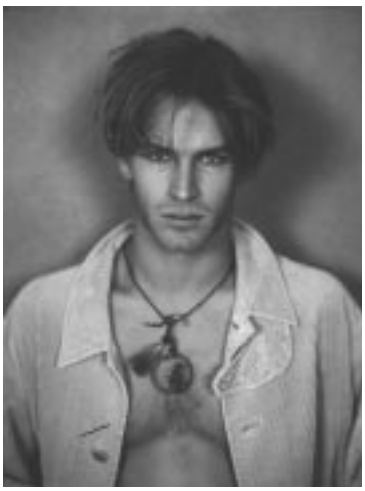
Too often, consumers only enquire about the price of the clothes they buy. Even a tag that reads ‘100% cotton’ does not disclose the way in which the cotton was cultivated or how the clothes were produced. What matters is the whole life cycle of the product.

And the challenge today for every progressively-managed company in the international textile market is to put the environment at the heart of its operations.

Klaus Steilmann GmbH and Co. KG, the parent company of Britta Steilmann Sustainable Development GmbH and Co. KG, believes that “textiles make better textiles if they are good for people and good for the environment”.

Of course the wearing qualities of our products are important for both comfort and health. But how we produce them is crucial to the concept of environmental sustainability. Clothing which is manufactured without the need for pesticides to produce the natural fibres, without the production of waste material and without the release of poisonous, persistent and even carcinogenic substances into the atmosphere is unquestionably superior clothing.

We have an ambitious, ongoing development programme that gives priority to environmental considerations in our processes and products.



Our collection *Britta Steilmann – It's One World* introduced a 'product passport' bringing together a number of environmentally relevant manufacturing techniques. Three years ago we developed a companywide ecological profile which all items must satisfy. This has been steadily extended and updated with products being redesigned to take life cycle aspects into account. Products based on natural raw materials are rigorously optimized to make them biodegradable, whilst materials based on artificial fibres are designed to be recycled or disposed of without the use of expensive technology.

Our policy on chemicals is "no more than necessary – as environmentally sustainable as possible". If chemicals are needed (for colour), only the most environmentally acceptable products are selected. Our suppliers are chosen because of their commitment to environmentally sound management.

As a result, the company now has a system in place which is in line with the model proposed by the Enquete German Parliamentary Commission for the 'Protection of People and the Environment' and detailed in its *Shaping an Industrial Society* report. The Environmental Protection Encouragement Agency states that our products "represent the highest standard for environmentally benign textiles".

At Steilmann, we are proud to have introduced a new environmental quality factor into the clothing sector. For customers, it means that the items they purchase are good not only for comfort and health, but also for the environment and for the future of our children.

Postfach 600 207, D - 44842 Bochum, Germany
Tel: 49 2327 940 461 Fax: 49 2327 320 052

BOX 7.1

Clear environmental and financial benefits

Case studies of cleaner production initiatives in developing countries and countries in transition have underlined the potential for considerable environmental and financial benefits.

- In India, a pulp and paper mill which implemented preventive measures reduced its capital investment cost for end-of-pipe equipment by 25 per cent, and its annual operating and maintenance costs by 35 per cent. It cut pollutant discharges by 40 per cent, increased annual output by 22 per cent, and reduced off-site secondary pollution by using less sodium hydroxide and energy. The company implemented 28 measures at a capital cost of US$100,000 and an operating cost of US$40,000. Total savings were US$400,000, giving a return period of less than four months.

- In the Czech Republic, a carpet producer, with a yearly production of 1.5 million square metres, disposed of 660 tonnes of solid or hazardous waste at a communal waste incinerator every year. It implemented 15 preventive measures and eliminated its expenditure for solid waste disposal of US$1.3 million; reduced the amount of solid waste by 100 per cent, water use by 30 per cent and steam use by 10 per cent; improved the quality of the output and made new by-products from recycled materials; and reduced off-site air pollution from solid waste incineration. The measures cost the company US$2.275 million to introduce. The total annual savings were US$1.3 million, giving a return period of about two years.

as well as having a disaggregated approach – frequently only arresting a pollutant in one medium for disposal in another. In other words, end-of-pipe is usually less effective as well as more costly than cleaner production.

ESTs for cleaner production

Pollution prevention is at the heart of the cleaner production concept – moving away from end-of-pipe pollution control technologies, beyond even waste minimization, to adopting strategies to prevent pollution occurring and using technologies to achieve this. "The key difference between pollution control and cleaner production is one of timing", UNEP explains. "Pollution control was an after-the-event, 'react and treat' approach. Cleaner production is a forward-looking, 'anticipate and prevent' philosophy."

What are cleaner production technologies? UNEP itself says they include:

- processes that use less toxic or non-toxic materials;
- systems to increase process efficiencies, and reduce raw materials use and losses;
- systems to collect wastes and pollutants, and recycle them back into the production process.

"While some cleaner production approaches involve modifications to existing systems and processes, others involve entirely new and innovative methods of producing products or services that leap-frog over existing technologies in terms of their environmental performance."

A UNEP study, conducted by the Toxic Use Reduction Institute of Lowell, Massachusetts, United States (and presented at UNEP's third High-Level Seminar on Cleaner Production in Warsaw, Poland, in October 1994) used several criteria to classify cleaner production approaches:

- reduction or elimination of hazardous waste and other environmental pollutants;
- efficiency in the use of raw materials;
- efficiency in the use of energy;
- reduction or elimination of the use of toxic chemicals;
- reduction of exposure to occupational hazards;
- products that are safe and compatible with the environment.

The study then identified and evaluated four types of cleaner production technologies, as summarized below.

- Business-driven technologies – fairly sophisticated production technologies adopted mainly to improve production quality or efficiency, improve competitiveness or

The Zero Emissions Research Institute aims to redesign industrial processes so that industries use their wastes as raw materials.

BOX 7.2

Tunisian initiative leads to cleaner technologies

The two-year Environmental Pollution Prevention Project (EP3) in Tunisia involved a number of initiatives aimed at introducing pollution prevention and clean technology into key industrial sectors – car batteries, edible oils and soaps, tanneries, textile dyeing and electro-plating. Providing technical assistance to industry to identify and apply no-cost and low-cost pollution prevention techniques and clean production technologies was a major feature of the project.

Assessments were conducted in 12 facilities and identified 161 improvements ranging from materials substitution, process modifications, and energy and water conservation to in-process recycling. In total, the project recommended 27 energy conservation, 36 materials conservation and 50 waste minimization innovations. Together, the various pollution prevention measures called for an initial investment of just over US$1 million with a total financial benefit of over US$3.75 million.

The EP3 project was helped by two factors. One was new legislation requiring environmental impact assessments before starting new projects. The second was the setting up of a special depollution fund providing grants of up to 20 per cent of the investment cost for depollution projects and the introduction of cleaner technologies.

The EP3 project was supported initially by the United States aid agency, USAID (October 1993 to March 1995). It is now supported by UNEP and the United Nations Industrial Development Organization (UNIDO) as part of the network of national cleaner production centres, with the new name of Centre de Production Plus Propre (CP3).

lower production costs. These technologies improve environmental performance only as a secondary or unintended benefit (for example, silver recovery systems in photo-processing).

- Clean technologies – fairly sophisticated production technologies used for the primary purpose of improving environmental performance (for example, waterless printing).
- Appropriate technologies – fairly simple technologies that improve environmental performance, but are adopted mainly for economic development, or other non-environmental purposes.
- 'Low-fruit' technologies – fairly simple technologies that add to, or modify, existing production technologies to improve environmental performance, for example, drip tanks for drag-out recovery in electro-plating operations.

The study concluded that a large volume of cleaner production technologies adopted by industry will fall into the business-driven category, while the small-scale, low-capital requirements of the appropriate and 'low-fruit' technologies – which "may be environmentally superior to more advanced technologies" – mean it is possible for developing countries to build their own cleaner production technologies, rather than import them.

Improving technologies

The UNEP study identifies four ways of improving technology and these are given below, with some examples.

- Change the process or manufacturing technology:
  - for filtration and washing, use counter-current washing and recycle used solvent;
  - for parts cleaning, use mechanical cleaning devices, improve draining, use plastic-bead blasting;
  - for surface coating, use electrostatic spray coating systems, powder coating systems, airless air-assisted spray guns.
- Change the input materials:
  - in printing, substitute water-based ink for chemical solvent-based ink;
  - in textiles, reduce the use of phosphate-containing chemicals, use ultraviolet lights instead of biocides in the cooling tower;
  - in electronic components, replace water-based film-developing with dry systems.
- Change the final product:
  - replace heavy metals in batteries with less toxic materials;
  - replace volatile chemicals with water-soluble formulations in spray cans;

- replace chlorofluorocarbons (CFCs) with ammonia or other environmentally safe materials in refrigerators.

- Re-use materials on site, preferably within the process:
  - in printing, use a vapour-recovery system to recover organic solvents;
  - in textiles, use ultrafiltration systems to recover dye-stuffs from waste water;
  - in metal rules, recover nickel-plating solution using an ion-exchange unit.

UNEP stresses the importance of "using the cleaner production approach first, and making decisions about technology later … This is not to claim that end-of-pipe technologies will never be required. The new approach is to tackle problems using a cleaner production philosophy, which will lead to a better selection and planning on technology. This will lead to a reduced need for end-of-pipe technologies, and may in some cases, even eliminate the need for them altogether."

UNEP also makes the point that cleaner production is an extremely cost-effective approach to environmental protection. Whereas end-of-pipe ESTs usually produce no return on investment nor add value to the products produced, cleaner production leads to product and process improvements, saves raw materials and energy, and reduces waste and waste disposal costs. "Cleaner production is a very important approach to environmental protection in developing countries that cannot afford end-of-pipe waste treatment."

Barriers to cleaner production

The cleaner production concept is clearly catching on. There are now hundreds of case studies demonstrating the benefits to companies of all sizes, in the form of fast returns as a result of savings in the use of raw materials, and lower waste treatment costs. Often these results can be achieved with small investments of as little as US$20,000-100,000. Yet there remain a number of demand- and supply-side barriers to cleaner production technologies and, as a result, despite the benefits of those technologies, firms still opt for end-of-pipe pollution control solutions.

BOX 7.3

Economic return in the Philippines

Some 110 companies participating in a USAID-funded industrial environmental management project in the Philippines have invested US$20 million and are reaping an annual benefit of US$30 million as a result of the reduced cost of pollution abatement. In addition, this investment has resulted in a 30 per cent reduction in pollution.

The sectors covered by the project are: sugar mills and refining; pulp and paper; vegetable and animal oils; tanneries; food and beverages; fish canning; industrial chemicals; electro-plating; piggeries; meat processing; cement; wood products; and metals and mining.

A key component of the programme is working with small and medium-sized enterprises to conduct pollution management appraisals – a tool which identifies financially sound opportunities for waste reduction at the source of pollution, rather than end-of-pipe treatment.

BOX 7.4

Gas phase heat treatment of metals

Hardening, carburizing and nitrocarburizing of steel are heat treatment processes usually carried out in baths of molten salts. The combination of chemicals and high temperatures presents risks of explosion, burns and poisoning, while environmental problems arise from the resulting vapours and the removal, transport and disposal of the toxic salts.

A metal processing company in Singapore introduced a new process which avoided these problems by applying gas phase treatment using a fluidized bed of alumina particles. A mixture of air, ammonia, nitrogen, natural gas, liquified petroleum gas and other gases is used as the fluidizing gas to carry out the heat treatment. The bed is heated by electricity or gas. Quenching is also carried out in a fluidized bed.

The new process has reduced effluents, improved safety in the factory and, in many cases, improved the quality of the final product. The company invested about US$180,000 in replacing its existing salt bath lines with four fluid beds. Savings on energy, salt and maintenance are US$87,000 a year, allowing the investment to be paid back in approximately two years.

Bishara Textile Manufacturing Company (BTM)

Bishara Textile Manufacturing Company (BTM) was established in 1962 for textile hand printing. Today, it is one of the leading companies in Egypt's textile and garment industry producing a full range of woven and knitted fabrics and outerwear garments, using long-staple Egyptian cotton blended with other natural fibres, including linen, wool and silk, and synthetics. The company – situated in the 10th of Ramadan City, one of the largest industrial zones in Egypt – employs some 1,300 people.

BTM's support of environmental issues is demonstrated within its own factory:

- Cotton fibres are collected automatically and reused in the spinning mills process through the A.C. and Humidification unit.
- The processing mill (bleaching, de-sizing, dyeing, printing and finishing) uses energy conservation, effluent water treatment and recycling technologies to reduce pollution and save resources. Within the next year, the boiler's fuel will be changed from heavy oil to gas and effluent water from the dye house will be completely recycled.
- The fabric intercuts from the cutting and sewing operations are sent to environmental charitable organizations for use in hand-loom carpet manufacturing.
- Paper bags and boxes are recycled at a nearby paper recycling factory.

The company is also playing a major role in the Environmental Pollution Prevention Project within the 10th of Ramadan City – a project which aims to assist the 800 mills situated within the area to meet the requirements of the new Environmental Law due to be implemented in March 1998.

The project – under the Chairmanship of Mr. L. Bishara, founder of BTM – is strongly supported by Egypt's largest banks and involves research centres and academic establishments evaluating the environmental effects of industrial activities, non-governmental organizations spreading the concept of 'environmental awareness' amongst individuals, and business leaders promoting the importance of environmentally responsible processes for the future development of industry.

Our commitment to encouraging environmental excellence within our own organization is matched by our intention to be amongst Egypt's industrial leaders in the field of environmental issues.

Industrial effluent (waste) water treatment from dye house plant

Bishara Worsted Wool Manufacturing Co.
10th of Ramadan City, Egypt – PO Box 47
Tel. 20 15 362 750. Fax. 20 15 362 753

On the demand side:

- traditional pollution control approaches remain dominant among many managers;
- supplies of pollution control ESTs are well organized and widely dispersed;
- government approaches favour pollution control as the accepted standard for regulatory compliance;
- pollution control technologies are typically easy to understand, and easy to install in existing production processes, and do not require rethinking processes.

On the supply side:

- the cleaner production industry is small and operates on a limited scale;
- the pollution control industry is dominant;
- government does not focus on, nor support, integrated pollution prevention approaches;
- some technologies have high initial costs;
- there is a lack of adequate capital and financing to stimulate the market;
- there are limited research and development initiatives for new technologies.

The UNEP study said: "Industry is clearly making progress in implementing and promoting cleaner production. Efforts are being made, not only in leading large companies but also in some small and medium-sized enterprises (SMEs). However, industry programmes are often not fully implemented or integrated in all company activities and cannot be said to represent industry as a whole. Industry needs to take more responsibility in moving beyond awareness-raising to actual behaviour modification, putting cleaner production tools (life cycle assessment, environmental technology audits, etc.) into real use and 'mass-spreading' the cleaner production concept and tools, particularly to SMEs."

According to the European Commission, the spread of cleaner technologies to SMEs in the member states is slow because:

- small companies have extremely limited financial resources;
- environmental issues have a low priority;
- the concept of cleaner technology is unfamiliar;
- companies are waiting for compulsory legislation, instead of anticipating future requirements;
- there is a lack of know-how on environmental policy and technological developments.

BOX 7.5

Saving costs and improving product quality

A printed circuit board manufacturer in the United States introduced new cleaner production technology into its process and made significant cost savings as well as improving the quality of the final products.

In the manufacture of printed circuit boards, the unwanted copper is etched away by acid solutions of cupric chloride. As the copper dissolves, the effectiveness of the solution falls and it has to be regenerated – traditionally by oxidizing the cuprous ion produced with acidified hydrogen peroxide. Copper in the surplus liquid is eventually precipitated as copper oxide, and usually landfilled.

Using an electrolytic technique involving a divided cell, simultaneous regeneration of the etching solution and recovery of the unwanted copper is possible. A special membrane allows hydrogen and chloride ions through, but not the copper. This is transferred via bleed valves and recovered as pure flakes.

The company invested US$220,000 and was able to recover this within 18 months thanks to cost savings on disposal, copper and other materials. The copper is recovered in high-value form and there are no hazardous chemicals to be handled.

Funding constraints and needs

The Warsaw seminar also received a report on the constraints on funding cleaner production in developing countries – some of which apply equally to accelerating the introduction and use of ESTs generally. The main difficulties were cited as:

- cleaner production is still unknown – or not seen as a proven, viable approach;
- environmental legislation and enforcement are weak;

BOX 7.6

Reducing heat loss in lead oxide units

A lead oxide unit, using a pot-type electrical furnace, manufactures a tonne of lead oxide a day. A waste minimization audit at a company in India found that the radiation heat loss from the side walls in the furnace was about 6.7 million joules per square metre every hour, and from the top some 10 million joules. These losses meant the temperature inside the furnace was not adequate for obtaining the required yield and quality of lead oxide.

The cleaner production application centred mainly around process changes. The furnace design was modified and better insulating material was used to reduce heat loss. A ceramic fibre module was added to the top of the furnace, and ceramic fibre blankets and insulating bricks were added to both side walls.

These modifications reduced fuel and power consumption, decreased the cycle time, increased the furnace temperature, and increased the percentage of lead oxide in the product. Capital investment was US$10,000 and annual operating costs are US$5,000. Savings amount to US$39,600 a year.

BOX 7.7

Conserving water, energy and chemicals

A cleaner production assessment carried out at a textile dyeing plant in Chile led to changes that produced savings in water, energy and chemical use, and also reduced emissions of particulates and solids in effluent.

Water efficiency was achieved by recycling water used in the cooling process and from the air conditioning system, as well as improving softener regeneration and service. A maintenance plan for steam traps cut heat transfer losses through leakages, while installing a digital monitoring system improved the combustion efficiency of the oil-fired boiler, saving on fuel use and reducing emissions of particulate matter. Screens fitted to dye room drains reduced suspended solids in effluents.

- competing demands for scarce resources make it difficult for developing countries to consider long-term investments – even when the benefits are known;
- banks in developing countries find it difficult to evaluate the economic soundness of cleaner production projects so are reluctant to fund them even when there are proven financial benefits and sufficient collateral;
- some macroeconomic and social policies (natural resource pricing, state financing of uneconomic production facilities) obscure the benefits of, and act as a disincentive to, cleaner production;
- financial institutions are frequently not interested in funding projects requiring smaller amounts of money;
- with smaller enterprises, banks usually pay more attention to guarantees – which such companies often cannot provide – than profits.

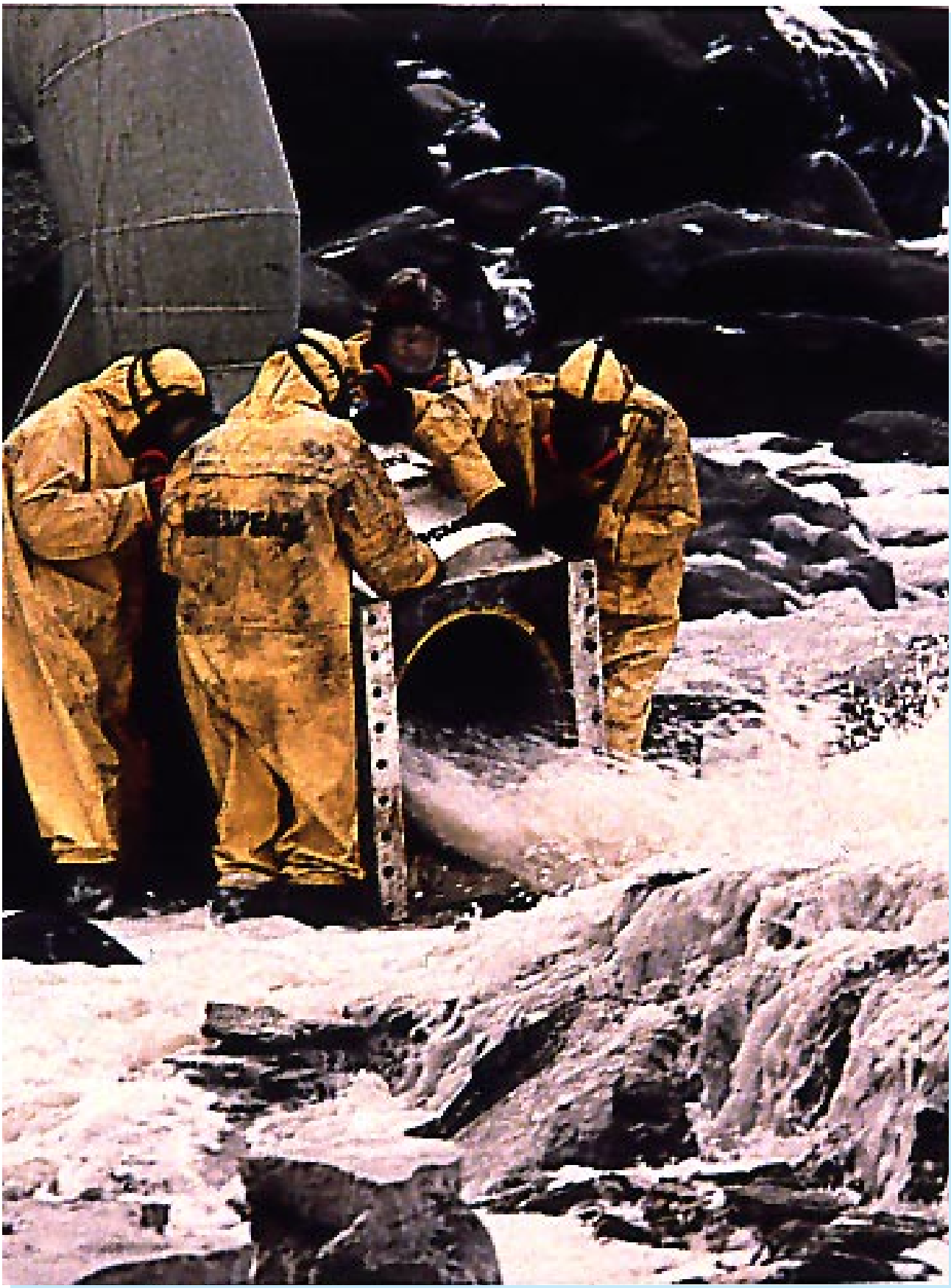
The 160 experts from governments, industry, non-governmental organizations, academia and international organizations from 45 countries attending the Warsaw seminar concluded that the specific funding and financing needs of cleaner production include:

- awareness campaigns for industry, government, funding agencies and banks, and the public;
- up-to-date, easily accessible and locally relevant information on cleaner production practices and technologies;
- training for industry managers, plant engineers, technicians, consultants, policy makers, regulators and other target groups;
- demonstration projects in different industry sectors and locations in each country.

Cleaner Production Programme

UNEP is leading the initiative on cleaner production through its Cleaner Production Programme, which was launched in 1990 when there was a shift from end-of-pipe treatment to pollution prevention. The programme – which has achieved some striking results in a short time – has four main objectives:

- to increase worldwide awareness of the cleaner production concept;



The costs of cleaner production are lower than the costs of remediation or dealing with environmental disasters.

BOX 7.8

The price can be acceptable

Cleaner production techniques and technologies can be implemented at an acceptable price, according to the results of demonstration projects in Egypt, Senegal and Zimbabwe.

Experts visited pulp and paper, and cement facilities in the three countries. They found many opportunities to reduce wastes, air emissions and water discharges, and to conserve energy, water and materials by installing and/or upgrading environmentally sound technologies (ESTs) to control pollution.

In Egypt, the country's biggest pulp and paper mill was discharging huge volumes of untreated effluent into the Mediterranean – the equivalent of untreated sewage from a city with 1.6 million people. The mill uses rice straw as a raw material. This has an extremely high silica content and produces black liquor emissions. There are no current ESTs able to handle this problem. However, the experts recommended that installing a desilicification system, followed by chemical and energy recovery, could provide an affordable solution. Recycling recovered chemicals would significantly reduce raw material costs and investment in the necessary equipment would have a favourable return period.

In Senegal's only cement plant, the main problem was dust emissions from the kiln stack and other areas. The experts proposed a full-scale cleaner production audit to identify opportunities for waste reduction, and materials, water and energy savings. They said some improvements could be implemented and paid for immediately. Others, like new gas conditioning and upgraded electrostatic filters, would need new investment.

In Zimbabwe, three cement plants had programmes in place to reduce dust emissions from kilns but the experts identified many opportunities to reduce fugitive dust pollutants by installing filters and cleaning existing ones. At four paper mills, they found opportunities for water and energy conservation, and fibre recovery through fitting ESTs.

- to help governments and industry develop cleaner production programmes;
- to foster the adoption of cleaner production;
- to facilitate the transfer of cleaner production technologies.

The programme is implementing a number of activities to help meet these objectives.

- UNEP has established nine working groups to build a network of cleaner production policy and technology experts around the world. The groups cover education and training; policies, strategies and instruments; metal finishing; textiles; pulp and paper; leather tanning; biotechnology for cleaner production; the food industry; and sustainable product development.
- The International Cleaner Production Information Clearinghouse produces publications, including a newsletter, and has a computerized database with examples of successful policies and strategies, listings of contacts and institutions, 350 technical case studies and 650 publications abstracts. An e-mail connection provides users with immediate access to the programme, and cleaner production information is available on the UNEP Industry and Environment Centre's server on the World Wide Web.
- A joint UNEP-UNIDO (United Nations Industrial Development Organization) project has set up national cleaner production centres in 20 developing countries and countries in transition. The first eight centres are in Brazil, China, the Czech Republic, India, Mexico, the Slovak Republic, Tanzania and Zimbabwe. Their role includes:
  - initiating demonstration projects in local industries;
  - raising awareness within industry, government, and research and development institutions;
  - creating local cleaner production networks;
  - collecting and disseminating information;
  - running short- and long-term training activities for industry, government and other institutions.
- Demonstration projects are operated in the cement and pulp and paper industries in Egypt, Senegal and Zimbabwe to determine both the opportunities for, and barriers to, cleaner production (see Box 7.8).

Other United Nations activities

Other United Nations and intergovernmental agencies are also promoting cleaner production. UNIDO, in addition to collaborating with UNEP

on setting up national cleaner production centres, is also working directly with a number of countries to get their governments to assign high priority to the concept. Additionally, it provides technical and financial support to companies interested in introducing cleaner production into their operations. Specific UNIDO projects include:

- demonstration of cleaner production techniques, for example in the cement and sugar cane industries in Egypt and Mexico respectively;
- a programme for pollution control in the tanning industry, involving the introduction of low-waste cleaner technologies in all phases of leather processing, and low-cost end-of-pipe wastewater treatment;
- direct support for selected factories in Sri Lanka to introduce techniques and technologies to reduce pollutants at source;
- assisting companies in Brazil to reduce dyestuff and chemical usage, energy inputs and processing times;
- helping with a pilot-scale operation for cleaner production of cereal pesticides in Poland.

The United Nations Development Programme (UNDP) is working with UNEP in Central and Eastern Europe to incorporate the cleaner production approach into the region's economic and environmental reconstruction activities in coal mining and energy efficiency.

BOX 7.9

Saving water and waste in food processing

A major food processing company in the United States developed a cleaner production programme emphasizing water conservation, waste minimization and solid waste recycling and has achieved major environmental and economic benefits. A feature of the programme was that it involved little technology.

- One project recycled solid waste and scrap material from canned food and the container manufacturing operation. Vegetable waste was recycled as pig feed; recyclable cardboard was taken to a recycling facility; wooden pallets and ingredient drums were returned to suppliers; 200-litre scrap stainless steel drums and other scrap metals were sold to a salvage company.
- A second project reduced the amount of enamel and thinner wastes in the can manufacturing process by detecting leaks and spills, installing scrapers to dry clean enamelling equipment, and filtering enamel for re-use.
- A third project, aimed at reducing water use, focused on dry cleaning of floors and equipment, and led to process modifications and policy changes, including turning water off when it was not needed, as well as maintenance and housekeeping on a continuous rather than once-a-day basis.

The recycling programme resulted in 70 per cent of the solid waste and scrap material produced being recycled. The can enamel waste reduction programme reduced the amount of solvents burned in the boiler by 80 per cent, while the water conservation programme cut water usage by half. Total annual savings are more than US$1.1 million.

Progress and problems

It is clear from reports given at UNEP's fourth High-Level Seminar on Cleaner Production, in Oxford, United Kingdom (1996), that clean production has now moved beyond the conceptual to the implementation stage and that there is a definite move towards it in all regions. Encouragingly, an increasing number of strategic alliances are taking shape. Industry is participating actively in cleaner production centres and workshops, and new groups – such as trade unions and consumers – have become involved as well.

However, as the reports from the different regions made clear, a number of steps need to be taken to accelerate cleaner production. Legislation and its enforcement have to be strengthened, and so does the training of people in cleaner production technologies. More information is another requirement. Latin America reported the problem of 'inappropriate' technologies being imported into the region. In addition, there is a lack of environmental management knowledge within companies,

AMERICAN TEXTILE
MANUFACTURERS INSTITUTE

ATMI is the national trade association for the US textile industry. Member companies operate in more than 30 states and process nearly 80 percent of all textile fibres used by plants in the United States. The industry employs more than 600,000 people.

US textile manufacturers share a strong commitment to the environment and workplace safety and health. ATMI's Code of Conduct, adopted in 1996, commits the industry to comply with laws guaranteeing fair and equal treatment of employees, and to preserve the environment in local communities and facilities worldwide.

ATMI has established two programmes, **Encouraging Environmental Excellence (E3)** and **Quest for the Best in Safety and Health (Quest)**, to encourage US textile companies to exceed government regulations and set standards for other industries to meet. The internationally registered E3 and Quest logos allow companies to communicate their commitment to customers and consumers.

To qualify for E3 and Quest membership, a company must be an ATMI member, comply with all national and local environmental and safety and health laws, and implement the programme guidelines. Each company is recertified annually by submitting reports describing its progress in achieving environmental and safety and health goals, and submitting new goals for the next year. If an E3 or Quest member violates environmental or safety and health regulations, it must explain to ATMI why the violation occurred and what corrective measures were taken.

E3 SUCCESS STORIES

US textile companies invest millions of dollars every year to ensure their manufacturing processes are environmentally friendly. E3 companies work with government regulators, community groups and employees to address environmental issues quickly and responsibly, concentrating on:

Recycling and waste minimization: E3 members recycle both everyday items like office paper and aluminium cans, and waste generated by their manufacturing operations – and use recycled fibres in their manufacturing processes.

Pollution prevention/water and energy conservation: Pollution prevention efforts go beyond reducing the amount of dyes and toxic chemicals used in processes. E3 companies are using less water, and switching to cleaner burning fuels and energy-efficient lighting.

Community involvement: E3 companies share experiences in many ways, including producing educational materials for schools, forming partnerships with universities to conduct textile research and working with environmental groups on preservation and restoration projects.

International Standards: E3 was active in the European Commission's development of an eco-label for T-shirts and bed linens, and is participating in the proposed expansion of the eco-label to all textiles.

QUEST SUCCESS STORIES

Quest members have made many changes and improvements to their safety and health processes, including:

Reducing injury and accident rates, as well as associated workers' compensation costs and days away from work.

Introducing management tools to foster more upper management involvement in safety and health issues, incorporate safety into TQM (total quality management) programmes and develop interactive safety and environmental software programmes.

Programme improvements such as modernizing facilities, improving indoor air quality and enhancing employee personal protection policies.

Demonstrating commitment to individuals through a variety of non-work related programmes to benefit their employees, e.g. on-site doctors to help employees with personal health issues, and wellness and nutrition awareness programmes.

More information about ATMI, the Code of Conduct, E3 and Quest can be found at www.atmi.org

Note: Environmental preservation and worker safety and health are priorities of ATMI. We believe that this publication provides useful and meaningful solutions for industries and companies to adopt to protect the environment and employees. Support of this publication does not imply endorsement of all UNEP's policies.

coupled with a lack of confidence in cleaner production relative to end-of-pipe technologies, and difficulty in raising the finance for cleaner production investments.

Eco-efficiency

In 1996, the World Business Council for Sustainable Development (WBCSD) – a coalition of 120 leading international companies – joined forces with UNEP to promote cleaner production and its 'cousin', eco-efficiency. The WBCSD's predecessor organization, the Business Council for Sustainable Development (BCSD), first coined eco-efficiency in its report, *Changing Course*, to the United Nations Conference on Environment and Development in Rio in 1992. BCSD defined eco-efficiency as "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 at least in line with the earth's estimated carrying capacity". Put in simple terms, the vision of eco-efficiency is to 'produce more from less' by cutting waste and pollution, and using less energy and fewer raw materials.

Cleaner production and eco-efficiency are clearly similar, interlinking and overlapping concepts. According to UNEP and the WBCSD, cleaner production starts from issues of environmental efficiency which have positive economic benefits, whereas eco-efficiency starts from issues of economic efficiency which have positive environmental benefits. They share the objective of preventing pollution, and certainly environmentally sound technologies are as important to implementing eco-efficiency as they are to achieving cleaner production.

Towards zero emissions

The ultimate goal for industry must be zero emissions. Not all business leaders regard this as a pipedream, as demonstrated by their backing for the Zero Emissions Research Initiative

BOX 7.10

Cleaner production initiatives in Thailand

Cleaner production initiatives in Thailand have included several projects under the Federation of Thai Industries' Industrial Environmental Management Programme. One of the key aims of the programme is to promote environmental awareness and the use of clean technology in Thai industry. It incorporates: waste reduction methods and technology; technology transfer; and demonstration projects for clean technologies. A feature of this programme is the involvement of private organizations and industries in the United States, as well as United Nations agencies such as UNEP and the United Nations Industrial Development Organization (UNIDO).

The textile, pulp and paper, chemicals and food processing industries have been the main focus for the programme. Some developments within the textile industry are highlighted below.

- UNIDO and United States experts carried out an in-plant assessment, which led to recommendations on training textile professionals in cleaner production techniques and to a direct technical assistance programme on specific pollution reduction technologies at individual plants.
- A study tour was organized to view the waste minimization activities of industries in other countries.
- Industry leaders and government officials were also taken to Brazil, the United States and Switzerland. This led them to identify appropriate cleaner production techniques for the industry and to formulate control strategies for dyes and the toxic constituents in colours.
- One of several demonstration projects focused on the environmental and cost-saving benefits of vacuum technology through reducing chemicals and saving energy, while improving product quality. The demonstration factory claimed a 25-40 per cent reduction in chemicals and energy use in the finishing stage, and 17 per cent savings in chemicals, with 43 per cent savings in the mercerizing range. Several textile mills subsequently adopted the system.

One major result of the programme was a new government environmental standard for the textile dyeing and finishing industry, which included a mix of regulation and voluntary measures, and a balance between pollution prevention, waste minimization and pollution control.

A similar approach featuring visits to mills in the United States has been adopted in the pulp and paper industry. Demonstration schemes have included a pilot-scale project to allow mills to assess the economic and environmental gains from dissolved air flotation which claims to recycle 7-10 tonnes of pulp a day in full-scale operation.

BOX 7.11

Cleaner production at the grassroots

In some countries, cleaner production activities are run at the grassroots level. The Netherlands and the United States are two examples.

- In the Netherlands, provincial governments are taking a leading role in implementing programmes. One of these is in the North Holland province, which has about 7,000 enterprises – 10 per cent of them discharging pollutants directly into water bodies, the other 90 per cent discharging their pollutants into municipal sewers. The North Holland pollution team works directly with industry to advise companies on pollution prevention potential, and also provides on-site technical assistance in carrying out waste minimization audits and implementing source reduction measures. The team also trains municipal government staff and encourages them to integrate pollution prevention factors into their local regulatory activities. The pollution prevention team targets its direct assistance to industry to companies with 20 or fewer employees and has helped firms in a diverse array of sectors, including chemicals, printing, bakeries, automotive garages, electrical installers, metal working and metal finishing.

- In the United States, there are more than 50 state and locally sponsored pollution prevention programmes, run by regulatory state agencies, universities, mixed agencies, etc. Their programmes provide various combinations of services but fall into three main categories: information; on-site technical assistance (including conducting waste minimization audits and advice on specific measures and technologies); and research and financial support. The targets vary. Some programmes are focused on specific industrial sectors in a limited geographical area. Others concentrate on specific sub-sectors, while some are targeted at larger generators of waste, or at smaller enterprises.

(ZERI), run out of the United Nations University in Tokyo, Japan. Indeed, ZERI has picked up an impressive degree of support from senior management of major United States, European and Japanese companies, as well as leading politicians and scientists, since it was launched in 1994. Perhaps more importantly, it has begun to achieve some measurable results from its pilot projects.

ZERI's premise is that "while immediate pollution reduction is important" in industry, "it remains insufficient", and overcoming this demands "achieving technological breakthroughs which will facilitate manufacturing without any form of waste, i.e. no waste in the water, no waste in the air, no solid waste".

The aim is a complete redesign of the industrial process, so that an industry can use its own wastes as a raw material or, failing that, so that the wastes can be utilized by another industry. Environmentally sound technologies have a central role to play in ZERI's approach, which embraces a five-step methodology, as detailed below.

- Total throughput models – examine industries to see how production could use all input factors.
- Output-input models – take an inventory of all types of output not used in the final product or manufacturing process. Often, this output is considered waste and not only has no economic value, but actually costs money to dispose of. Once the types of output have been established, industries are identified which could use them as inputs.
- Industrial clusters modelling – the output-input models offer a basis for clustering industries. Some could use the part output of two or three manufacturing processes, while some offer raw materials to four or five industries.
- Breakthrough technologies – present engineering know-how, product and process technologies will not lead to industrial clustering, so new, breakthrough technologies need to be found.
- Industrial policy design – policy makers need to rethink their approach to helping industrial sectors work together.

Work in progress

ZERI has looked at eight areas: six involving industrial clustering (fish farming, beer breweries, sugar, forestry, paper and pulp, and plastics, cement and construction materials), and two focused on 'technologies from nature' (colour pigments and waxes).

BOX 7.12

A fast response in Africa

It is no coincidence that several of the Zero Emissions Research Initiative (ZERI) pilot projects are in Africa. ZERI founder Gunter Pauli says he is looking specifically at projects "which offer fast responses to the pressing problems" and insists that the continent has "many ingredients readily available for rapid solutions".

Making the desert flower

Originating in Antarctica, the cold Benguela current – a flow of ice cold water – offers the potential to convert the Namib Desert into fertile land. In Hawaii, it has been proven to be technically possible, and economically feasible, to pump cold water from the ocean through pipes in the sand on the dry side of the islands. The effect is fast and simple: condensation. This system has made it possible to farm strawberries – a fruit considered unsuitable for a tropical climate. The Benguela current could be pumped by wind power. The Namib Desert is extremely rich in minerals and has all the necessary nutrients – all it lacks is water. A pilot programme is under way on a 10-hectare plot of land in Henties Bay.

Food from seaweed

The Antarctic sea water is full of nutrients, an abundance of plankton and macrophytes, making it ideal for fish culture, algae and seaweed farming. Seaweed is widely used as food and medicine in Japan, China, Korea and the Philippines. The ocean water off Namibia is pumped to capture the moisture in the air and relayed to the soil as condensation. It can then be channelled to ponds to cultivate seaweed on land. In 1994, Namibia exported 400 tonnes of dried seaweed.

All along the African coast – from South Africa to Mozambique, Angola and Tanzania – there are similar pockets of opportunity. Tanzania already has a flourishing seaweed farming industry, producing 10,000 tonnes of dried seaweed, and exporting US$3 million worth of crop a year. A seaweed farmer can earn up to US$1,000 a month, a fortune by the standards of any African farmer or labourer, and higher even than the incomes of many middle ranking civil servants.

Currently, American and Japanese buyers extract only half the seaweed – the rest is considered waste biomass and discarded. In fact, the remaining seaweed consists of highly nutritional and value-added components. Cooking technologies developed by the Las Gaviotas environmental research centre in Colombia will make it possible to use solar energy to boil the dried seaweeds and extract the valuable carrageenan – increasing the commercial value of the seaweed products fivefold.

Making full use of sisal

Sisal is a major crop in Tanzania and produces an extremely strong fibre used in twines, ropes, carpets and bags. The production process, however, is polluting, and only 2 per cent of the plant is used. The sisal plant can also be used for products such as citric acid, lactic acid and alcohols. Citric acid is in rising demand for soft drinks and food products. On the basis of the sisal waste stream, Tanzania could ferment about half a million tonnes of citric acid a year. Because of the country's climate, the acid could even be obtained through solid state fermentation, instead of liquid fermentation which requires hydrolysis and huge amounts of energy for boiling. Solid state fermentation would cut costs and would probably eliminate synthetic chemicals. Moreover, sisal's residue fibres are excellent raw materials for pulp and paper. Tests have also shown that sisal is an excellent base material for the production of bioplastics.

With colour pigments, for example, ZERI points out that industry has developed some 4,500 colours, most based on petrochemicals, and used from textiles to cars, and cosmetics to food. Yet the use of colour pigments in textiles is polluting, requires heavy water usage, and most of the pigments are wasted in the water. Metallic paints used in the car industry cause health hazards, both in production and disposal. ZERI believes that research into the refraction of light in the fibres of bird feathers could lead to a breakthrough and build on the optical fibre production technologies developed in tele-communications for application in the textile and car industries.

Synthetic waxes are polluting, both in production and disposal. ZERI says that studying the molecular structure of birds' wax – which is fully biodegradable – could lead to possible applications in industry, providing ways can be found to maintain the wax in liquid form at extremely low temperatures and solidify it at high temperatures.

ZERI's work on paper has focused on finding

A Bristol-Myers Squibb Company

COMMITTED TO OUR CHILDREN'S FUTURE

An Amerindian prophecy says, "we will first notice we cannot eat money after the last fish has been caught, and the last tree has vanished from the Earth".

I hope this prophecy will never come true. In fact, from the statements made at the climate change conference in Kyoto, we seem to have more grounds for optimism than ten years ago. But does that mean that we in industry can lie back and be satisfied? Not at all.

It is obvious that we are responsible not just for our immediate environment. Economic development in each part of the world is tightly linked to the global environmental situation. Increasing use of resources and fossil fuels is the main problem. But also, in the emerging markets, there is the issue that to improve living standards for everyone, we must achieve higher economic productivity – which means a bigger impact on the environment.

As a relatively young company, Pharmavit has, from the beginning, looked for solutions which do not cause negative changes to our environment.

- We implemented a biological wastewater treatment system to ensure that no contaminated water will flow back into the ground.
- In 1997, we started a programme to reduce hazardous waste emissions.
- Since obtaining ISO 9001 in 1996, we have been striving for ISO 14001 – and hope to achieve this in 1999, making us one of the first pharmaceutical and food supplement companies to reach this standard.
- Through our 'Fit for life' programme for Hungarian schoolchildren aged 10-12, we are teaching thousands of tomorrow's citizens how to protect their own environment, so that one day they will be model citizens. We plan to introduce the programme in Viet Nam.

Our acquisition by Bristol-Myers Squibb in 1996 was a big step towards sustainable development. A good example is Taxol, an anti-cancer drug. Its initial source was the bark of a rare species of yew tree – but removing the bark killed the tree. After a massive research and development effort, Bristol-Myers Squibb won approval for a semi-synthetic form of Taxol made from yew tree twigs and needles. Eventually, we expect to produce Taxol's active ingredient from cell cultures in fermentation tanks, in much the same way that penicillin is produced.

Our goal is to double sales and earnings by 2000. A major challenge during this period of accelerated growth will be to reduce the size of our environment 'footprint'. In May 1997, Bristol-Myers Squibb became the first major multinational corporation to declare that its entire environmental, health and safety management system conforms to ISO 14001.

We strive to conduct our business in a way that supports the goal of sustainable development – economic activity that meets the needs of the present generation without compromising the ability of future generations to meet their needs. In short, we are committed to our children's future.

Dr. Imre Somody
General Manager

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> We are firmly convinced that developed countries should take the lead in developing environmentally sound technologies and environmental policies, implementing the necessary changes in their own countries
>
> Romano Prodi, Prime Minister of Italy

> The global environment remains gripped by many problems. If the situation remains as it is, it may be difficult to pass on this irreplaceable Earth to the 21st century
>
> Ryutaro Hashimoto, Prime Minister of Japan

> Many states with economies in transition might turn into main polluters of the environment. That is why the United Nations should play a more active role in an intensive exchange of clean technologies and their transfer to the economies in transition
>
> N. A. Nazarbaev, President of Kazakhstan

a new technology to separate ink from fibre. Paper recycling has the drawback that only 65 per cent of the ink is removed effectively. According to ZERI, there are several technology options:

- magnetic resonance for heavy-metal-based inks – unlike fibres, heavy metals conduct electricity and can be magnetically recharged;
- using an enzymatic or microbiological approach for non-heavy-metal-based ink – since enzymes and bacteria can be made to react to specific types of products, it may be possible to manipulate them to devour a certain type of ink and leave the fibres intact;
- creating a new ink based on metalo-caloric substances.

Technology also has a key potential role in the search for a new way of distilling essential oils, preservatives and colour pigments from the leaves of felled trees. Existing distillation processes are often highly energy intensive. Designing a mobile distillation unit would open up new opportunities. The unit could also convert the second form of waste, small wood debris, for energy generation.

ZERI says the sugar industry offers an opportunity for industrial clustering. The need is to find new uses for sugar (in massive over-supply on the world's markets) and detergents,

plastics, paper and water softeners are all possible alternative uses for sugar as a sustainable raw material for products currently based on non-renewable resources. The missing link is sugar application technologies.

Off the drawing board

Three pilot plants have been built in Fiji, Namibia and Tanzania, to focus on recovering all the biomass from industrial fermentation processes, in particular brewery waste, and they have shown that it is possible to generate seven times more food, fuel and fertilizers with the same amount of input.

A five-year research programme is under way into materials separation technologies. It includes steam explosion, vacuum evaporation and membrane filtration. Brazil, Indonesia, India and Malaysia are among countries actively supporting this programme, while China, Costa Rica, Fiji, Mauritius and Turkey are involved in other ZERI activities. Gunter Pauli, who founded ZERI, says the results to date confirm that it has a tested methodology to apply the zero emissions concept to any industry. In January 1997, a new brewery which simultaneously produces beer without generating any waste, acts as a protein and fish factory, and produces local energy, was inaugurated in Namibia, marking the first commercialization worldwide of the zero emissions concept.

ZERI is attracting growing support. A number of top industrialists have committed their companies to the goal of zero emissions. It also has the backing of several government ministries in Japan, the European Commission, the United States Department of Energy, and other governments – as well as the Swedish Royal Academy of Sciences and Oak Ridge National Laboratory in the United States. ZERI research institutes are now being set up in Japan, North America, Europe, Latin America and the Baltic region.

One United States floor covering company, which supports ZERI, is investing in the development of new technology to convert post-consumer and post-industrial waste into usable, value-added products. For example, old carpet from offices is not landfilled, but taken to the factory as a raw material for producing industrial block for use on factory floors. The company is also making a recycled-content floor product made from post-consumer and post-industrial waste.

The eco-factory

The eco-factory concept – promoted in Japan and described by the Japanese External Trade Organization as the "ultimate 21st century technology" – is in line with the ZERI approach. It calls for technologies:

- "designed to lessen, beyond existing levels, the adverse influences aggravating the ecological system;
- which do not impair the productivity and economy of production processes;
- for the realization of production processes for high value-added products".

The eco-factory essentially consists of production-system and restoration-system technologies. Products shipped out of the factory are used by consumers, then discarded as wastes which are collected and fed to the restoration system for recycling as material resources for the production process. On the production side, the aim is first to design products that have a minimum impact on the environment, both during the production phase in terms of raw materials and energy use as well as pollution, and at the post-consumer disposal stage of their lives. But the concept recognizes that there will still be some waste which can be re-used via the restoration process. The eco-factory approach calls for five basic technologies: product design; production; disassembly; materials recycling; and control and assessment. Its promoters acknowledge that breakthroughs are needed in most of these areas before it can become a reality.

Industrial ecology

Both the Zero Emissions Research Initiative and the eco-factory fit firmly into the concept of industrial ecology which is attracting growing interest from business. A no- or low-waste approach is central to this concept. In-stream recovery and the re-use of materials are crucial tenets. Here, environmental considerations are incorporated into all aspects of product and process design, and technology plays a more active and positive role in achieving sustainable development.

An experiment in industrial ecology has been going on in the Danish city of Kalundborg for over 30 years. It involves the re-use of energy and materials by a number of partners in a carefully planned chain. A refinery provides gas to a power plant and plasterboard company for their energy needs, and the steam from the power plant is passed to a biotechnology company and into a district heating system. Lower temperature energy goes into an experimental fish farm. This industrial 'ecosystem' is saving 19,000 tonnes of oil, 30,000 tonnes of coal and 600,000 cubic metres of water a year. Financial savings are estimated at US$12-15 million every year.

Valid and viable

Zero emissions and the eco-factory are still emerging concepts, and therefore will only be applicable on a larger scale in the longer term. On the other hand, cleaner production and eco-efficiency are valid and viable approaches and are being implemented now at a growing pace.

Much more remains to be done to accelerate and expand their acceptance and adoption: enlarging the frontiers of cleaner production; identifying innovative approaches in new and untried sectors; and exploring new ways of financing and building capacity. UNEP itself sees the main challenge for the next two years as being on the demand side – permits, procurement, supply chain management, environmental management and the involvement of multilateral as well as private banks.

However, thanks largely to UNEP Industry and Environment Centre's Cleaner Production Programme (which has played a lead role in demonstrating that pollution and waste do not have to be generated because they can be eliminated at source), there is now enough experience of both cleaner production and eco-efficiency available to prove that they work, and produce significant benefits to business and to the environment.

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