CLEANER PRODUCTION IN THE ASIA PACIFIC ECONOMIC COOPERATION REGION
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ECONOMIC COOPERATION
REGION
PREFACE

I am very pleased that the U.S. Environmental Protection Agency (EPA) is able to contribute to this booklet, the latest in UNEP’s excellent efforts to bring Cleaner Production approaches to a wider audience. In nearly twenty-five years of trying different approaches to environmental protection, we at EPA have come to realize that Cleaner Production strategies are a cornerstone of successful sustainable development. We have made it our policy to seek pollution prevention solutions before adopting other approaches. The cases in this book provide a strong endorsement of the notion that Cleaner Production approaches result in benefits for the environment and for the firms that adopt them.

Carol M. Browner
Administrator
United States Environmental Protection Agency

Since 1990, UNEP has been providing leadership and encouraging partnerships to promote Cleaner Production, a preventive approach leading to enhanced materials productivity and pollution prevention. Cleaner Production, woven throughout Agenda 21, has been identified as one of the main paths toward the reconciliation of environmental protection and economic development.

One of the main components of the Cleaner Production Programme is information exchange, a crucial element of technology transfer. I am thus pleased to present the following collection of Cleaner Production case studies from the Asia Pacific Economic Cooperation region, demonstrating how industry in rapidly advancing economies can achieve both environmental protection and economic benefits. I wish to thank the United States Environmental Protection Agency for its partnership in producing this booklet.

Elizabeth Dowdeswell
Executive Director
United Nations Environment Programme
Cleaner Production
in the Asia Pacific Economic
Cooperation Region

APEC Members

Australia          Malaysia
Brunei            Mexico
Canada            New Zealand
Chile             Papua New Guinea
China             Philippines
Hong Kong         Singapore
Indonesia         Taiwan
Japan             Thailand
Korea, Republic of United States

The Editorial Board for this booklet was Ms Jacqueline Aloisi de Larderel, Director, Industry and Environment, United Nations Environment Programme (UNEP/IE). Sybren de Hoo and John Kryger, Senior Consultants UNEP/IE, and Garrette Clark, Research Assistant UNEP/IE. Mary Crass was responsible for commissioning and organizing the contributions. Robin Clarke edited the case studies and prepared the page lay-out and diagrams.

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INTRODUCTION

Cleaner Production is the way to achieve both environmental protection and economic benefits. It is important for high-growth economies such as those included in the Asia Pacific Economic Cooperation. With this publication, a sequel to *Cleaner Production Worldwide*, UNEP wishes to show the progress of Cleaner Production in the region and encourage its further development.

**Cleaner Production**

Industries today must maximize their productivity, while minimizing the pollution and waste that harm the environment and human health. Faced with this challenge, many large and small industries around the world are now recognizing the advantages of an approach to environmental protection that combines positive effects on the environment with significant economic savings: cleaner production.

Whereas pollution control technologies provide an 'after-the-fact' fix for emissions, effluents and waste, cleaner production focuses on the causes of problems. As its definition suggests, it entails the 'continuous use of industrial processes and products to prevent pollution and reduce wastes at their source'. Steps towards this goal include: better management and housekeeping, substitutions for toxic and hazardous materials, process and product modifications, and internal reuse of waste products. Cleaner production options increase efficiency by reducing costs for raw material, energy, pollution control, waste treatment and clean-up.

Industries in developing economies have much to gain from cleaner production, because it allows them to 'leap frog' over more established industries that are burdened with costly pollution control technologies. The Asia Pacific region includes the Asian economies that have grown at an average rate of nearly 7 per cent per year over the past decade and now produce more than half of the world's output of goods and services. However, this rapid growth has placed significant stress on regional ecosystems and human health.

The Asia Pacific Economic Cooperation (APEC) is an inter-governmental organization that provides a forum for exchange among its 18 member economies to facilitate regional economic cooperation and consensus-building on political and social priorities—notably the environment. At the November 1993 meeting of APEC economic leaders in Seattle, Washington, the leaders expressed the desirability of coordinating plans for energy conservation, improving the environment and sustaining economic growth.

The following case studies are a sample of cleaner production initiatives being taken by large and small industries in the APEC region. They are by no means exhaustive. Cleaner production is an evolving approach to environmental management, and the exchange of ideas and experiences is vital. We therefore welcome comments on this publication, suggestions for future endeavours of this kind and news of experience with cleaner production applications that we can share with others.
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WHAT IS CLEANER PRODUCTION?

Over the past 30 years, the industrialized nations have responded to environmental degradation in four successive steps: ignore, dilute, control and prevent. In this sequence, each step can be seen as the "solution" to the problems that could not be solved with the strategy of the former stage. Cleaner Production, which promotes the preventive approach, is a response to the additional financial burden brought by costs of pollution control and end-of-pipe treatment. Cleaner Production brings a powerful combination of economic savings and environmental improvements; this is why it has been recognized in Agenda 21 as a means of reconciling development and environmental protection.

- For production processes: Cleaner Production includes conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes before they leave a process.

- For products: Cleaner Production means reducing impacts along the entire life cycle of the product, from raw material extraction to disposal.

- Cleaner Production requires applying know-how, improving technology, and changing attitudes.

This marks an important departure from the traditional way of dealing with environmental impacts which, in essence, has been to collect waste by-products, and try to control them in various ways - through dilution, detoxification or solidification - or simply by trying to contain them in barrels or landfills.

Implementing Cleaner Production is not just a question of finding the right or new technology. It includes better management and housekeeping, substitutions for toxic and hazardous materials, process and product modifications, and internal reuse of waste products. It requires basic attitudinal changes at all levels within a firm, from top management to the shop floor.

Essential elements of a cleaner production strategy

![Diagram of Essential elements of a cleaner production strategy](SOURCE: Government Policies and Strategies for Cleaner Production, UNEP, 1996)
Background
Beijing Chemical Factory No. 3 (BCF 3) participated in the preparation phase of the Cleaner Production Project in China, funded by the World Bank. During 1993, representatives from BCF 3, six other companies and institutions such as the National Environmental Protection Authority (NEPA), the Chinese Research Academy for Environmental Sciences (CRAES) and the Beijing Environmental Protection Bureau (BEPB) were trained in cleaner production by consultants from UNEP/IE and IVAM Environmental Research (Amsterdam University). Part of the training included carrying out cleaner production assessments in the participating companies.

Cleaner production
In 1993, a cleaner production assessment took place at BCF 3’s penta-erythritol (PE) plant which accounted for more than 40 per cent of the chemical oxygen demand (COD) in the wastewater discharged by the entire factory. The PE plant operations include: synthesis, first evaporation, second evaporation, crystallization, washing and drying.

A total of 20 cleaner production options were identified and evaluated during the project. Nine were implemented within six months. The feasibility of a further six was also established within the first six months.
Enabling technology

Four options required substantial investments:

- installing a microcomputer to control the quantity and the speed of addition of one of the raw materials;
- improvement and expansion of the refrigeration system;
- replacement of the centrifuges by new ones with better separation characteristics; and
- installation of vacuum pumps to allow the recovery of product previously lost with wastewater during the crystallization process.

It was also decided that BCF3 should install an end-of-pipe wastewater treatment facility to meet the new wastewater discharge standards. The investment for the treatment plant was originally estimated at 8 million RMB; the annual operating cost was projected to be about 600 000 RMB. The implementation of the cleaner production options will allow the capital and operating costs of this treatment plant to be significantly reduced.

Advantages

- increased production
- reduced operating costs for treatment
- savings in raw materials and energy use.

Country

China

Industry

Chemicals

Company

Beijing Chemical Factory No 3 (BCF 3) is one of the key enterprises of the Beijing Chemical Industries Corporation. Since its foundation in 1965, BCF 3 has developed into one of the main manufacturers of chemicals in China. BCF 3 specializes in the production of additives for the processing of high polymer materials.

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Background
The Campbell Soup Company developed a corporate-wide cleaner production programme emphasizing water conservation, waste minimization and solid waste recycling.

Cleaner production
Three main projects have been established as part of the programme.
- Recycling of solid waste and scrap material from canned food and the container manufacturing operation. Recycled items include:
  - vegetable waste from soup manufacturing which is recycled as pig feed—the vegetable waste is transferred from a collection hopper to the pig farmer's truck, which is equipped with steam spargers to sterilize and cook the material on-site;
  - recyclable cardboard which is baled and taken to a recycling facility;
  - wooden pallets and ingredient drums, which are returned to suppliers; and
  - scrap stainless steel, 200-litre drums,
and other scrap metals which are sold to a salvage company. In addition, copper and tin plate scrap from can manufacturing are recycled.

- Reduction of the amount of enamel and thinner waste in the can manufacturing process:
  - an inspection programme was instituted to detect leaks and spills;
  - scrapers were installed to dry clean enamelling equipment, thereby eliminating the need for solvent baths;
  - enamel was filtered and reused wherever possible—bulk delivery of enamels and thinners in returnable containers was arranged with vendors.

- Reduction in water use, focusing on dry cleaning floors and equipment:
  - process modifications included installation of a flow meter and elimination of scrap fluming;
  - policy changes to reduce water use included a common sense programme of turning water off when it was not needed as well as continuous maintenance and housekeeping instead of once a day.

Enabling technology
All these solutions are common sense solutions which are cost saving and involve little technology or additional labour.

<table>
<thead>
<tr>
<th>Programme</th>
<th>Waste reduction</th>
<th>Annual savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycling</td>
<td>70%</td>
<td>$1 million</td>
</tr>
<tr>
<td>Enamel waste</td>
<td>80%</td>
<td>$50 000</td>
</tr>
<tr>
<td>Water reduction</td>
<td>&gt;50%</td>
<td>$125 000</td>
</tr>
</tbody>
</table>

Advantages
The recycling programme resulted in recycling 70 per cent of the solid waste and scrap material produced. For the period 1989–92, the can enamel waste reduction programme reduced the amount of solvents burned in the boiler by 80 per cent. Of particular note, the water conservation programme resulted in a 50 per cent reduction in water use per production unit between 1985 and 1992, a period in which plant production more than doubled.

The Maxton facility's solid waste recycling effort saves the plant more than $600 000 a year in landfiling costs. The sale of scrap stainless steel 200-litre drums and various other scrap metals generates approximately $18 000 annually. Reuse of the copper and tin plate scrap from the can manufacturing operation saves approximately $375 000 annually. The reduction of enamel and the bulk delivery of thinner and enamel have resulted in an annual saving of approximately $50 000. The water conservation programme has saved $125 000 annually in operating costs.

Country
United States

Industry
Food processing

Company
The Campbell Soup Company's Maxton plant manufactures heat-processed canned soups and other canned food products. The company currently produces about 33 million cases of product a year.

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Background
The manufacture of printed circuit boards (PCB) traditionally involved the electrodeposition of a tin/lead alloy onto the copper circuit of the PCB. This alloy coating protected the copper circuit during the etching process. The tin/lead electroplating bath contained 30 per cent toxic lead metal and fluoroborate-based waste which were difficult to treat.

Enabling technology
A new process was introduced, in which pure tin was used as the coating with sulphate-based plating. This eliminated lead and fluoroborate from the wastewater which was therefore easier to treat. The new technology was developed by the manufacturers of electroplating chemicals.

Advantages
The new process has been in operation for two years, and there are no adverse effects on the product quality. The advantages are as follows:

- Lead and fluoroborate are eliminated from the wastewater
- Wastewater treatment is simplified
- The costs of wastewater treatment are reduced
- Initial investment is low
- Since the new process involves only the direct substitution of tin/lead plating with pure tin plating, it does not affect other manufacturing processes.
Economic benefits

While the raw material cost for pure tin plating is slightly higher than that for tin/lead plating, the increased material cost is offset by the cost reduction in waste treatment.

The initial investment was about US$1730, which was the cost of replacing the tin/lead plating bath by a pure tin plating bath.

The recurrent raw material cost for pure tin plating, including the cost of regular replenishment of the pre-dip chemical and plating bath, is about US$5350/year more than that for tin/lead plating.

However, the increase in the recurrent raw material cost can be approximately offset by the reduction in the cost of wastewater treatment.

Example of Multi-layer PC Board Manufacturing Process Flowchart

Country
Hong Kong

Industry
Electronics

Company
The company was established in Hong Kong in 1989 and now employs more than 200 people. The factory is engaged in the production of double-sided and multi-layer printed circuit boards for telecommunications products. The company’s major manufacturing processes include circuit imaging, circuit etching and metal plating. Its products are mainly exported to the United States and Europe.

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Recycling coolant and treating oily wastewater from machining

Background
Industrias Fronterizas CMI SA de CV uses a water-soluble coolant in machining operations during the manufacture of engine manifolds. The coolant is normally recycled; however, the recycling system was having difficulty in removing tramp oil from the coolant. In addition, the coolant was developing high conductivity. Both these problems lead to failure of the coolant, machine downtime and large volumes of waste coolant. CMI also generated large quantities of oily wastewater from its floor cleaning operations.

Enabling technology
The surfactant cleaner now used is HazClean-BT, available from Delta-Omega Technologies Ltd. The cleaner works by lifting oils from surfaces without emulsifying them. Since the tramp oil is no longer emulsified it can be separated from the generated large quantities of oily wastewater from its floor cleaning operations.

Advantages
Since implementing the new cleaning procedures, CMI has had no major coolant failures, saving the company significant downtime losses, and reducing coolant use and wastewater production. Separating the oil from the water has eliminated nearly 4 million litres of oily wastewater a year that was previously injected into deep wells in Texas.

In addition, the surfactant is being used to clean the oil from the aluminium chips left after machining. This improved cleaning method has reduced air emissions from the foundry where the chips are remelted and significantly lightened the load on the scrubber used to control these emissions. As a result, the volume of liquid waste from the scrubber has dropped.

The oily wastewater is then sent to an ultrafiltration unit that separates the oil from the water, leaving water clean enough to discharge and oil waste that can be used in a fuel-blending operation.
Economic benefits

Savings due to reduced coolant use amount to nearly $26,000 a year. In addition, CMI estimates that the reduction in downtime losses from coolant failure will save them $280,000 a year.

Initially, the new ultrafiltration unit saved the company more than $3,100 a day in disposal costs of oily wastewater. This paid for the unit in four months. Now, with reduced wastewater generation due to the new cleaner, the company is still saving $62,000 a month from the unit.

Country
Mexico

Industry
Automobile component manufacture

Company
Industrias Fronterizas CMI SA de CV manufactures cast iron, cast aluminium and plastic engine manifolds for large automobile makers. CMI employs more than 800 people in a 37,000 square metre facility that includes several machining lines and an aluminium foundry.

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Reducing waste in the dessicated coconut industry

Background
Before Peter Paul Philippines Corporation entered a joint venture with Taiwan's Chia Meei company, it was generating 80,000 litres a day of wasted coconut water. The large volume of highly organic wastewater generated is a major pollution problem in any dessicated coconut (DCN) processing plant. The by-products of DCN processing at Peter Paul before implementing coconut water recovery were crude coconut oil and copra meal.

Cleaner production
As part of the Industrial Environmental Management Project (IEMP), a pollution management appraisal (PMA) was conducted at Peter Paul Philippines Corporation. A PMA aims to identify opportunities for reducing pollution using a waste management hierarchy in which waste minimization is the dominant component. One of the PMA recommendations was segregation, recovery and recycling of coconut water. This was realized when Peter Paul entered into a joint venture with the Chia Meei company of Taiwan, which established a plant next to Peter Paul.

Collected coconut water is channeled to the Chia Meei plant for concentrating, freezing and final processing as a commercial drink. Peter Paul improved its handling of shelled and pared coconuts and installed a breaker to facilitate collection of coconut water. The Chia Meei plant which started operations in November 1993 requires 40,000 litres a day of coconut water from Peter Paul. After processing, the coconut water is shipped to Taiwan where it is produced as a commercial juice.
Enabling technology
The Peter Paul and Chia Meei venture involves exporting concentrated and frozen coconut water for final processing in Taiwan. Coconut processing into a commercial juice drink involves pasteurization and centrifugation to produce a clear, non-oily solution for packing in sterile containers.

Advantages
- The estimated biochemical oxygen demand (BOD) level of wastewater from the Peter Paul facility was reduced by about 50 percent.
- The annual avoided treatment cost is approximately $3,700, assuming a 10 percent reduction in the $37,000 annual operating cost of the wastewater treatment plant.
- Peter Paul and Chia Meei company now profit from a raw material once considered as waste.
- Since workers are now paid per whole pared coconut, they pare the coconut more carefully, resulting in a better controlled paring thickness, less coconut wastage and increased DCN production; an increase of 13.6 kg of DCN per tonne of coconuts processed resulted in an estimated annual savings of $370,000, based on 10,000 tonnes of DCN production per year.

Economic benefits

<table>
<thead>
<tr>
<th>Savings</th>
<th>US$/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>treatment costs</td>
<td>3,700</td>
</tr>
<tr>
<td>increased output</td>
<td>370,000</td>
</tr>
</tbody>
</table>

The Chia Meei company was able to begin a new business processing 40,000 litres a day of coconut water into a commercial drink.

Country
The Philippines

Industry
Food processing

Company
Peter Paul Philippines Corporation is one of the largest firms producing dessicated coconut (DCN). It has a 13-hectare facility located at Barrio Pahinga, Candelaria, Quezon. It has a rated capacity of 22,000 tonnes of DCN per year, mainly for export, and it employs more than 1700 people.

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Background
It is well known in China that alcohol production causes serious pollution and consumes considerable energy and water. In the Fuyang General Distillery, distiller’s grain is used to produce alcohol, methane and hypha albumen. The methane is used as a fuel in the production process and the hypha albumen is sold as fodder.

Several initiatives have been taken at the distillery to reduce pollution. For example, some of the cooling water has been recycled; all the coal slag has been used to produce bricks; waste gases have been purified before emission; and some of the CO₂ produced from fermentation has been recycled to produce liquid CO₂. Despite these initiatives, a number of environmental problems remained, and a cleaner production audit was therefore undertaken.

Cleaner production
The cleaner production audit produced 102 options for improving production and management. Most have now been put into effect, and within the first four months 566 400 yuan RMB were saved. The options included:

- special training
- improving management to avoid leakages
- periodic maintenance of equipment
- strict control of washing water to reduce wastewater
- reuse of cooling water where possible
- obtaining guarantees of raw material quality
- improving raw material storage.

Concentrated ingredient fermentation was the next option implemented. The remaining options will be implemented gradually.

Enabling technology
Alcohol is increasingly produced using concentrated ingredient fermentation. Compared with conventional fermentation, concentrated ingredient fermentation increases sugar concentration and alcohol level. This reduces the amounts of water, energy and distiller’s grain needed; it also results in less wastewater and lower levels of spoiled raw materials.

Advantages
- wastes (of distiller’s grain and water) are greatly reduced
- water and energy consumption are greatly reduced
- raw material spoiling is virtually eliminated
- production is simpler and its management easier.
Fuyang General Distillery is a medium-sized state-owned enterprise founded in 1949 and located in Fuyang, Anhui province. Its products include 20,000 tonnes of alcohol and 12,000 tonnes of wine per year. The total product value in 1993 was 93.5 million RMB.

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**Economic benefits**

- **For 20,000 tonnes of alcohol a year**
  - **RMB/year**:
    - Treatment and disposal: +360,000
    - Raw materials: +30,000
    - Public equipment: +420,000
    - Maintenance: +42,000
    - Increased product: +482,000
    - Extra bacteria for seeding: +360,000
    - Total: +874,000

- **Capital investment**: 1,097,000
- **Payback period**: <1.5 years

**Fuyang Distillery for reference**

- Grain store (near left)
- Fermentation vessel (above)
- Production process (below)
Recovering waste materials in pineapple processing

Cleaner production
A Pollution Management Appraisal (PMA) was conducted for Del Monte Philippines, Inc., to minimize wastes, conserve resources, reduce environmental risks and improve process efficiency. One of the waste minimization options implemented was the installation of collection pans in the fruit preparation and trimming tables. At the time of the appraisal, these pans were installed in only two pilot tables. However, because of the success of the pans, they have now been installed in all the fruit preparation and trimming tables.

In addition, Del Monte introduced improved monitoring and supervision which recovered more than 60 kg an hour of lost pineapples, worth $24 000 a year.

Enabling technology
Collection pans or dripping pans were installed in the fruit preparation and trimming tables to collect fruit drops and juice drips. The pans are located underneath the tables to catch the fugitive juice drops and drips from the handling of the decored fruit.

Advantages
- juice savings amounting to more than 55 litres an hour
- the installation of these pans has addressed the employees’ concern that the drops are acidic and may have affected the employees’ skin and clothes.

Economic benefits

<table>
<thead>
<tr>
<th>Economic benefits</th>
<th>US$/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net savings from increased juice</td>
<td>24 000</td>
</tr>
<tr>
<td>Capital investment</td>
<td>17 800</td>
</tr>
<tr>
<td>Payback period</td>
<td>9 months</td>
</tr>
</tbody>
</table>

Improved monitoring and supervision saved a further $24 000 a year.
Country
The Philippines

Industry
Food processing

Company background
Del Monte Philippines, Inc., is one of the largest producers of processed pineapples in the Philippines. The company currently produces an average of 1459 tonnes of canned pineapple per day. Del Monte has more than 3800 employees.

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Recycling water and waste in the photographic industry

Background
The photofinishing industry traditionally uses large volumes of water in photographic processing. In the past, this has led to a waste of processing chemicals and pollution problems associated with the discharge of wastewaters.

Cleaner production
To solve these problems, Altech Technology Systems Inc. formulated and designed System Crystal (trade name), a closed-loop system that cleans and recycles water, regenerates and reuses some of the photographic wastes for Canada's largest photofinisher, Black Photo Corporation. The photofinishing plant, which used to discharge 265,000 litres of wastewater daily, now has a final closed-loop system by-product of only 750 litres of mixed photochemistry concentrate per day.

Enabling technology
System Crystal consists of three interrelated processes:

- Aqua-Flo is the closed-loop water treatment system which uses water sterilization and membrane separation technologies to achieve a 97% purification.

AQUA-FLOW
(purification)

- NANO FILTRATION
- REVERSE OSMOSIS
- FILTER
- HOLDING TANK
- PROCESSOR
reduction in process water usage;

❖ Chemcharge is the process chemical analysis and treatment step which allows more than 90 per cent of the chemicals used in photofinishing to be regenerated and reused; and

❖ Chemnet uses a vacuum distillation unit to recover the water from the mixed photochemistry concentrate, leaving a small residual which is disposed of as a hazardous waste.

Advantages

❖ Eliminates sewer discharge
❖ Reduces water consumption
❖ Reduces chemical use through regeneration and reuse
❖ Sets new standards for waste management in the photofinishing industry.

<table>
<thead>
<tr>
<th>Year</th>
<th>Litres</th>
<th>Cost (C$)</th>
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</thead>
<tbody>
<tr>
<td>1990</td>
<td>77 million</td>
<td>55 000</td>
</tr>
<tr>
<td>1991</td>
<td>42 million</td>
<td>33 000</td>
</tr>
<tr>
<td>1992</td>
<td>30 million</td>
<td>27 000</td>
</tr>
<tr>
<td>1993</td>
<td>24 million</td>
<td>25 000</td>
</tr>
</tbody>
</table>

Country
Canada

Industry
Photofinishing

Company
The Black Photo Corporation, located in Markham, Ontario, is Canada's largest vertically integrated photo retailer and photofinisher.

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Treating wastewater in the rubber industry

Background
Wastewater produced from the processing of latex concentrate and the production of Standard Malaysian Rubber (SMR) is traditionally treated in biological oxidation ponds. In an increasingly environment-conscious country such as Malaysia, where the permitted standards for discharge of effluents into waterways have become very stringent, it is difficult or impossible for the ponding system to meet requirements. Furthermore, the traditional system uses a great deal of costly process water.

Designing a system to treat the effluent to a standard suitable for reuse or recycling has become an important and challenging goal. Malaysia has about 80 latex concentrate and 100 SMR factories, plus numerous rubber product factories, that produce contaminated wastewater. The implications of improved treatment techniques for the preservation of the environment are therefore considerable.

Cleaner production
The effluent from an existing oxidation ponding system is further treated using a new system that produces water of a quality that not only complies with statutory discharge criteria but is also suitable for reuse. No water is discharged into the waterways.

Photos show, top to bottom:
1. latex being discharged from tanker;
2. removing solids from washings;
3. effluent pond;
4. two-stage treatment plant; and
5. influent arriving at treatment plant.
Enabling technology

The new wastewater treatment system is essentially an upward-flow clarification system with integrated filtration and aeration features that makes use of both physicochemical and biochemical processes to reduce the chemical oxygen demand (COD), the biological oxygen demand (BOD) and the solids content (SS) of the effluent.

The unique features of the system are:
- instant coagulant ‘penetration’ of the ‘solids barrier’, resulting in ultrashort chemical reaction time, optimum precipitation efficiency and minimum chemical requirements;
- dual-stage clarification that maximizes the rate of clarification and produces highly clarified water;
- closed-loop hydraulic agitation that improves oxygenation of the flocculating mass;
- cascade aeration following filtration which gives sparkle to the final effluent and improves the level of dissolved oxygen in the water; and
- reduction of BOD and COD by as much as 90–95 per cent, yielding single-digit values—sludge is soaked away in an earth pit or filter bed.

Advantages
- zero discharge to the waterways
- water reuse conserves an important resource
- the system is relatively inexpensive and easy to operate.

Economic benefits

<table>
<thead>
<tr>
<th></th>
<th>ringgit/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings in treatment costs</td>
<td>25 920</td>
</tr>
<tr>
<td>Savings in process water</td>
<td>38 880</td>
</tr>
<tr>
<td>Net savings</td>
<td>64 800</td>
</tr>
<tr>
<td>Capital investment</td>
<td>355 600</td>
</tr>
<tr>
<td>Payback period</td>
<td>5.5 years</td>
</tr>
</tbody>
</table>

Where expensive public water supply is used for processing, recycling offers a net saving of some 60 per cent. A medium-sized latex concentrate factory can save 180 cubic metres of water a day.

US$1 = about 2.54 Malaysian ringgits

Country
Malaysia

Industry
Latex and rubber

Company
Golden Hope Plantations Berhad is a leading Malaysian corporation involved in four business sectors: plantations, resource-based manufacturing, property development and overseas operations. Golden Hope has a strong commitment to the environment and was admitted to the United Nations Environment Programme Global 500 Roll of Honour in 1992.

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Fax: +60 3 263 1905
Telex: MA 30844/5

COD 6000
BOD 2500
SS 700

COD 1700
BOD 900
SS 250

COD 280
BOD 80
SS 150

discharge to waterways
200 000 litres/day

COD 25, BOD 5, SS 40

recycled water 180 000 litres/day

* conventional system
* clean technology system

COD 60, BOD 25, SS 40

Cleaner Technology

21
Recovering water and chemicals in textile dyeing

Background
The textile dyeing process starts with the treatment of the raw materials with hot alkaline hydrogen peroxide and additives, followed by dilute formic acid washing. The fabric is then dyed, washed and dried. The finishing operations include grease cleaning, drying, curing, plaiting down and rolling up, in which resin (PVAC) and softener are used. For dark colours, fixing is performed after dyeing. The Chieng Sang plant consumes 775 m$^3$ of water daily for process and boiler use.

Cleaner production
To achieve cleaner production, an EVAC vacuum suction system was installed to recover and re-use finishing chemicals. The system also facilitates the even distribution of chemicals on the fabric, thus improving the finish quality. The recovered solution is mixed with the fresh solution. This suction system has led to a 25 per cent saving in chemicals.

The company also installed a computerized spectrophotometer to match colours more accurately. This apparatus has improved the efficiency of the dyeing process and reduced re-dyeing operations by 70 per cent; as a result, chemical consumption has been cut by about 20 per cent and waste generation reduced.

Wet steam from the process is sent to the steam trap where the condensate is collected. This condensate (140 m$^3$/day), maintained at elevated temperature, is supplemented with fresh softened water and sent to the boiler. Cooling water used to reduce the process water temperature is piped and stored in a separate underground container. The 30 m$^3$/day of recovered cooling water is used to wash the fabrics in the dyeing process.

Insulation of steam pipes has reduced heat loss to approximately one-fifth of what it was, which has resulted in energy conservation and improved worker safety.

Waste segregation, improved washing, improved housekeeping, more water reuse, and improved waste treatment are now being planned and will be implemented soon.

Enabling technology
EVAC is the trade name of a vacuum system which has been recently introduced in Thailand from the United States. This equipment is installed at the finishing stage to suck excess chemical solution from the fabric, and then transfer it to the storage tank for recovery and recycling.

For accurate colour checking, a computerized spectrophotometer is used. This equipment measures light reflectance from the samples. Colours of both standard and on-site prepared samples are measured and compared so as to correct the dye solution before dyeing, hence avoiding re-dyeing operations.

A network of steam trap, storage tanks and pipes is employed to recover and prevent contamination of cooling water and steam.
condensate. The system is locally manufactured and can be ordered through a local dealer, and installed according to the factory's specifications.

**Advantages**
- increased productivity
- savings in chemicals, water and fuel

**Economic benefits**

<table>
<thead>
<tr>
<th>Description</th>
<th>Baht/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>raw water re-use</td>
<td>91 800</td>
</tr>
<tr>
<td>fuel savings</td>
<td>162 000</td>
</tr>
<tr>
<td>reduction in wastewater treatment</td>
<td>30 600</td>
</tr>
<tr>
<td>Net savings</td>
<td>284 400</td>
</tr>
<tr>
<td>Capital investment</td>
<td>1 000 000</td>
</tr>
<tr>
<td>Payback period</td>
<td>3.5 years</td>
</tr>
</tbody>
</table>

Country
Thailand

Industry
Textile dyeing

Company
Chieng Sang Industry Co. Ltd. is a medium-scale dyeing plant in Samuthsakhorn Province, Thailand. The company mainly processes 'TC' fabric, which is a cotton-polyester blend.

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Fax: +66 431 1996

Mr Günter Tharun, CDG-South East Asia Program Office; Dr C. Visvanathan, Associate Professor, Environmental Engineering Program (Email: visu@emailhost.ait.ac.th); Ms Mendeluz Bautista, IPCA Project Coordinator, CDG-SEAPO; and Mrs Nguyen Thi Lien Ha, Research Associate, CDG-SEAPO all at Asian Institute of Technology
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Conversion of pig effluent into energy and fertilizer

Background
For many years the owners of Charles I. F. E. had problems with disposal of the waste from their 1200-head pig farm. The piggery produces a daily average of 210 000 litres of slurry with an organic solids content of 1.7 per cent. This is comparable to the sewage output of a town with a population of 30 000–40 000 people.

Liquid manure, composed of a suspension of faecal and urinary waste including spilled feed, hair and bedding, was size segregated by screening. The retained solids were spread over the farm land and the liquids were held in a large reservoir for summer irrigation.

The company received many complaints about this disposal method which was far from odour-free and which wasted a potentially valuable resource.

Cleaner Production
To resolve the problem, the company decided to introduce the process of anaerobic digestion in which organic waste, in this case pig effluent, is broken down by bacteria in the absence of oxygen and at an optimum temperature of 35 °C. The bacteria produce biogas and their dead bodies provide an excellent odourless organic soil conditioner that has resulted in dramatic improvements to the farm’s cropping programme. Charles I. F. E. was assisted financially by an interest-free loan from the Victorian Government’s Cleaner Production Grant Scheme.

Enabling technology
The new technology involved:
- an automatic flushing system to clean the effluent from the pig sheds;
- a grit removal machine;
- a high-rate dissolved air flotation unit to concentrate the solids and produce biogas;
- a cogeneration plant to produce electricity and hot water; and
- the development of an organic soil conditioner called Perma Fert.

The technology base was of Italian origin but Charles I.F.E. developed some significant and unique modifications to the system during construction and commissioning stages, especially in the digestion phase which is two stage but also continuous, enabling it to cope with all wastes, including excess non-digested feed.
Advantages
No longer does the farm have to dispose of 210 000 litres per day of noxious high strength pig waste. The farm sells 'grit', which it separates from the effluent, to a local worm farmer. The farm now uses 70 per cent less water because it recycles water that is separated by the high rate dissolved air flotation unit. The plant produces 1700 m³ of biogas per day which is converted to:
- 3840 kWh of electricity per day;
- 28 800 megajoules per day of energy in the form of hot water.

The plant produces approximately four tonnes of humus solids per day which it uses to increase crop yields or to produce a fertilizer called Perma Fert. The plant produces 100 000 litres/day of nutrient rich liquor for irrigation or fertilization. The Environment Protection Authority buffered zoning, requiring the owners of the farm not to spread effluent in certain areas, has been removed. There are far fewer flies and rodents around the farm. The neighbours are much happier as the odour has almost totally disappeared.

Economic benefits

<table>
<thead>
<tr>
<th>Economic benefits</th>
<th>$Aus/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings and electricity</td>
<td>100 000</td>
</tr>
<tr>
<td>Improvements to cropping, sales of Perma Fert</td>
<td>300 000</td>
</tr>
<tr>
<td>Running costs</td>
<td>2500</td>
</tr>
<tr>
<td>Net savings</td>
<td>397 500</td>
</tr>
<tr>
<td>Capital investment</td>
<td>1 800 000</td>
</tr>
<tr>
<td>Payback period</td>
<td>5 years</td>
</tr>
</tbody>
</table>

Country
Australia (Victoria)

Industry
Agriculture

Company
Charles I.F.E. is a family company involved in the agricultural industry. The major enterprise run by Charles is a 1200-head intensive piggery.

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Reducing water use and hazardous waste in the wood finishing industry

Background
Crown Wood is one of a growing number of US firms which are applying the principles of Total Quality Management to encourage its employees to identify opportunities to achieve environmental benefits and cost savings. In 1987 Crown Wood implemented the Quality Leadership Process to promote greater 'people involvement' in solving company problems. This has resulted in major reductions in water use and hazardous waste generation.

Cleaner production
A 16-week course, Quality Problem Solving and Statistical Process Control, is taught to five-member teams. All personnel, including administrative officers, are required to sign up for the course. After completing the course, each team selects an in-house operational problem it believes is detrimental to personal safety, quality or cost.

One team, nicknamed the Hazardous Five, identified significant opportunities to reduce hazardous waste. The team recognized that approximately 54 000 kg of water-based hazardous waste was generated in one year. Costs for storage, transportation and disposal of the waste were $93 299, or $367 per 200-litre drum.

Enabling technology
After analysis of the water-based hazardous and non-hazardous waste streams, the Hazardous Five recommended a chemical addition to separate the solids and liquid portions of the waste. This treatment converted the waste streams into two phases: water suitable for recycling within the plant and non-hazardous solids suitable for disposal. The team redesigned the print line process to incorporate the chemical treatment unit and the system for water recycling into the spray booth area.

The team then addressed Crown Wood's solid waste output. The team set up a recycling programme for aluminium cans, all types of papers, and corrugated boards in the plant. To date, more than 400 tonnes of corrugated board and more than eight tractor trailer loads of aluminium cans have been recycled.

Advantages
Crown Wood reduced its annual water usage by 473 000 litres for the print room area and by 5 820 450 litres for the whole plant. Its costs for transportation and disposal of its hazardous waste were reduced to $549 per year.

Crown Wood has also moved from being the largest industrial depositor in Davie County's landfill to its fourth largest. The effort has also saved thousands of dollars which go to the company's Employee Catastrophe Fund.
The Hazardous Five team is not the only Crown Wood team to come up with significant cleaner production solutions. The company has dramatically reduced waste in its processes and saved more than $500,000 a year.

The Millroom Madness Team implemented a process change that turns a small piece of fibreboard cut from the speaker panel into a shelf for the same television cabinet, reusing materials and saving $15,000 per year.

The OOC/Finelines Team addressed the problem of glue rejects which was causing the loss of 21 finished ends and panels per day to the landfill. The team implemented a process change which eliminated glue rejects, resulting in savings of $250,000 in two years.

The Mix-Ups Team received a 1991 Pollution Prevention Program Challenge grant of $10,000 to research and implement the use of high-volume, low-pressure spray guns along its coating lines. Thomson evaluated four guns and identified one which met specifications and resulted in reduced waste. Annual cost savings are more than $130,000.

Thomson also altered its print room process to laying down or rolling-on of finishes for all top and end panels of cabinets. It successfully diverted 60% of its spraying operations from the finish room to this roll-on process in the print room and reduced materials use by 50% per cent. The process also saves the company $200,000 per year.

### Economic benefits

<table>
<thead>
<tr>
<th>Team</th>
<th>waste reduction</th>
<th>savings</th>
<th>cost</th>
<th>payback period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous Five</td>
<td>54,000kg of hazardous waste and 5.7 million litres of water</td>
<td>$100,000</td>
<td>$26,000</td>
<td>3 months</td>
</tr>
<tr>
<td>Millroom Madness</td>
<td>34 tonnes fibreboard</td>
<td>$15,000</td>
<td>–</td>
<td>immediate</td>
</tr>
<tr>
<td>OOC/Finelines</td>
<td>8000 panels diverted from landfill in two years</td>
<td>$250,000</td>
<td>–</td>
<td>immediate</td>
</tr>
<tr>
<td>Mix-Ups</td>
<td>51,000 litres/year of coatings</td>
<td>$137,448</td>
<td>$21,350</td>
<td>2 months</td>
</tr>
<tr>
<td>Lay-down/Roll-on Printing</td>
<td>reduced emissions from coating</td>
<td>$200,000</td>
<td>–</td>
<td>immediate</td>
</tr>
</tbody>
</table>

### Country
United States

### Industry
Wood finishing

### Company

### Contact
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Quality Leadership Process Coordinator  
Thomson Crown Wood Products  
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**Background**

Synthetic fibre (polyester) plays an important role in the textile industry in Indonesia. The first step in polyester production is the production of chips through a polymerization process in which raw materials—including ethylene glycol, terephthalic acid, additives and a catalyst—are combined. This process produces two types of wastes: liquid waste that is treated in the wastewater treatment plant; and solid waste, known as RG-Residue. Before
the implementation of cleaner production technologies, the RG-Residues were disposed of by incineration.

Seven boilers provide power for the process. Of these, three use heat recovered from the diesel engines, two industrial diesel oil, one natural gas and one diesel fuel.

**Cleaner production**
Cleaner production initiatives at P. T. TIFICO included the reuse of RG-Residue, substitution of industrial diesel oil with natural gas, industrial water recirculation and heat recovery. These cleaner production initiatives have increased process efficiency.

**Reuse of RG-Residue**
The RG-Residue was previously disposed of in an incinerator with a 1.5 tonne/day capacity. This process was costly and produced substantial air pollution. It was therefore decided to evaluate the reuse of RG-Residue as an additive in the production of carpet sheet for roofing. The additive was found to improve the characteristics of the carpet sheet, and incineration was stopped. This reduced air pollution substantially and produced economies in savings on incinerator fuel which decreased production costs. The plant produces about 35 tonnes a month of RG-Residue but since demand exceeds production there are no storage problems.

**Natural gas utilization**
One boiler running off industrial diesel fuel oil was converted to run off natural gas, reducing air pollution and energy costs as shown in the table on the right.

### Economic benefits

<table>
<thead>
<tr>
<th></th>
<th>US$/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas utilization</td>
<td></td>
</tr>
<tr>
<td>Net savings</td>
<td>387 000</td>
</tr>
<tr>
<td>Capital investment</td>
<td>673 700</td>
</tr>
<tr>
<td>Payback period</td>
<td>1.7 years</td>
</tr>
<tr>
<td>Industrial water recycling</td>
<td></td>
</tr>
<tr>
<td>Net savings</td>
<td>53 408</td>
</tr>
<tr>
<td>Capital investment</td>
<td>12 074</td>
</tr>
<tr>
<td>Payback period</td>
<td>3 months</td>
</tr>
<tr>
<td>Exhaust gas boiler</td>
<td></td>
</tr>
<tr>
<td>Net savings</td>
<td>601 843</td>
</tr>
<tr>
<td>Capital investment</td>
<td>1105 990</td>
</tr>
<tr>
<td>Payback period</td>
<td>1.84 years</td>
</tr>
<tr>
<td>Reuse of RG-Residue</td>
<td></td>
</tr>
<tr>
<td>energy savings</td>
<td>390</td>
</tr>
<tr>
<td>labour savings</td>
<td>1100</td>
</tr>
<tr>
<td>sales of wastes</td>
<td>5530</td>
</tr>
<tr>
<td>Total</td>
<td>7020</td>
</tr>
</tbody>
</table>

**Industrial water recycling**
In the wastewater treatment plant, liquid wastes are treated by activated sludge. Before treatment, chemical oxygen demand (COD) levels were 10 000–12 000 parts per million (ppm). Following treatment, COD levels were reduced to 20–40 ppm, a level which easily meets the government standard for wastewater of 200 ppm (Class II). Approximately 32 per cent of the wastewater is now reused in the process, reducing the need for fresh water by about 2450 litres/minute.

**Exhaust gas recovery**
Waste heat from the diesel engine is used to produce 12 tonnes/hour of steam.

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**Country**
Indonesia

**Industry**
Fibre production

**Company**
P. T. TIFICO was founded in 1973 with two shareholders, Teijin Ltd and Toyo Menka Kaisha (Japan); the company went public in 1980. P. T. TIFICO consists of 14 departments, including one dedicated to safety and environmental concerns. P. T. TIFICO produces staple fibre and filament yarn polyester.

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Fax: +62 21 553 1646

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**BOILER PERFORMANCE**

<table>
<thead>
<tr>
<th></th>
<th>diesel</th>
<th>natural gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>220 ppm</td>
<td>150 ppm</td>
</tr>
<tr>
<td>SOx</td>
<td>1242 ppm</td>
<td>0 ppm</td>
</tr>
<tr>
<td>particulates</td>
<td>0.2–0.5 g/Nm³</td>
<td>0.01 g/Nm³</td>
</tr>
</tbody>
</table>
Cold pad batch dyeing of cellulosic fabrics with fibre reactive dyes

Background
Most Australian textile mills still use traditional dyeing methods. To enable the dye to take to the fabric, undyed rolls undergo many hours of rough treatment, including the use of a variety of chemicals; wear and tear by machines; enormous amounts of hot and cold water; and treatment with up to 0.5 kilogrammes of salt per kilogramme of fabric.

A 100 per cent cotton fabric with a pre-bleach requires at least eight hours in the dye machine. It is then detwisted, overspread and dried. The fabric is then returned to the spreading unit and resin is applied. After this, the fabric is steamed, calendered, spread to width, rolled and packaged for shipping.

Cleaner production
In late 1992, the Australian Dyeing Company—which treats 200 000 kg of fabric a week in its two mills—began a restructuring strategy to reduce costs and increase efficiency and productivity. The programme was made necessary by the Australian economy and the influx of clothing imports. The programme investigated alternative dyeing methods, and ways of reducing environmental impact.

Enabling technology
Two new processes were introduced: cold pad batch dyeing and the use of Cibacron C dyes.

Cold pad batch dyeing is a more environmentally-sound and high quality dyeing method. The process removes salt from the effluent, reduces the use of water and energy, reduces the volumes of effluent and takes up less room on the production floor. It also uses less chemical, and the switch to Cibacron C dyes further reduces the colour carried in the effluent.

The new dyeing system, specifically designed for dyeing circular knits containing cotton, was developed by Beautech Ltd of
Rock Hill, South Carolina, United States. It is simple and compact, and the dyeing machine is driven at running speeds of up to 55 metres a minute while reducing water consumption by 88 per cent.

**Costs**
The process involved the purchase of two pieces of special equipment—a padding machine which dies the fabric and a trickle or rinsing machine—which marginally increased the company's costs. This was overcome by the company promoting the environmental benefits of the process which enabled it to charge marginally more for the product to cover the extra costs. After about six months the company began to notice an improvement in the environment and in consumer awareness.

**Advantages**
- The fabric undergoes less turbulence and so retains a smooth, uniformly coloured appearance with added lustre and a soft drape and handle.
- Larger runs of fabric of the same colour can be made.
- Cost is comparable with traditional dyeing but the quality is improved.
- The company's image has improved as a result of the superior product.

**Economic benefits**

<table>
<thead>
<tr>
<th>Economic benefits</th>
<th>A$/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net savings</td>
<td>619 200</td>
</tr>
<tr>
<td>Capital investment</td>
<td>400 000</td>
</tr>
<tr>
<td>Payback period</td>
<td>8 months</td>
</tr>
</tbody>
</table>

**Country**
Australia (Victoria)

**Industry**
Textile dyeing and finishing

**Company**
In 1958 the Australian Dyeing Company began operations at Clifton Hill, Victoria; 21 years later a second plant opened at Seymour. The company is Australia's largest commission fabric dyehouse, processing both knitted and woven fabrics. The company's speciality is dyeing large quantities of knitted fabric, particularly 100 per cent cotton and cotton blends.

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Mr Ian Fyman, Managing Director
Mr John Knight, Managing Director

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Reducing wastes in a panelbeater’s repair shop

Background
Major expenses in the repair shop of any panelbeater are the cost of paint, the cost of cleaning materials and the disposal of solid wastes. Spray guns used for applying paint to cars are often inefficient, allowing paint to get into the air. The fumes produced often cause complaints and are potentially dangerous for workers.

Cleaning costs consist mainly of the cost of the cloth used for cleaning and the gloves worn by workers. Damaged car parts are a major waste from this business.

Cleaner production
Barry Mansfield Smash Repairs Ltd in New Zealand needed to reduce pollution caused by emission of fumes. A secondary aim was to reduce material use and waste. Efforts were successfully made to reduce waste in the respraying process, to reduce the cost of materials used in cleaning down vehicles several times during repairs, and to reduce the volumes of solid waste taken to landfill sites.

Enabling technology
Paint spraying
The business replaced four existing spray guns with more efficient high-volume, low-pressure spray guns. This increased the amount of paint that actually reached the cars from 30 to 65 per cent.

Thinner are used for washing the guns. Instead of new thinners being purchased, used thinners are now being recycled by Refined Solvents Ltd.

The exhaust system from the spray booth was equipped with filters preventing solvents and excess paint from being emitted into the air. Renewing these filters
was a major cost, which has now been reduced since less paint is wasted.

Cleaning materials
Cars need to be wiped down at several stages during repair. Workers used to use cheesecloth off a roll, taking a new piece for every job. Now washed rags of terry towelling are used for most jobs. Rags are kept in two boxes, so that slightly soiled rags can be reused if possible. Cheesecloth is still used for the final wipedown. The cost of the gloves used by the workers has also been reduced by reusing the gloves.

Solid waste
Plastic bumpers are now being collected by another business which can recycle them. Materials previously wasted are being reused, saving on disposal costs as well as reducing the impact of these materials on the landfill. Overall, the volume of solid waste being sent to landfills was reduced by 45 per cent—from 19.3 to 10.5 cubic metres a month—over a six-month period.

Advantages
- Reduced levels of air pollution
- Savings on the purchase of materials
- Reduced wastes going to landfill sites
- Improved working conditions and a healthier work place
- Increased business from large car owners as a result of a tidier, cleaner workshop.

<table>
<thead>
<tr>
<th>Economic benefits</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PAINT SPRAYING</strong></td>
<td><strong>NZ$</strong></td>
</tr>
<tr>
<td>Cost of new spray guns</td>
<td>2400</td>
</tr>
<tr>
<td>annual saving in paint</td>
<td>6000</td>
</tr>
<tr>
<td>annual saving in filters</td>
<td>1500</td>
</tr>
<tr>
<td>Net saving</td>
<td>7500</td>
</tr>
<tr>
<td>Payback period</td>
<td>4 months</td>
</tr>
</tbody>
</table>

The business also saves $40 per month by recycling used thinners instead of buying new thinners. Using washed rags instead of cheesecloth for cleaning has produced savings of $180 a month, and reusing gloves has reduced their cost from $11 to $7 a month. This has resulted in additional savings of about $3000 a year, or nearly 50 per cent of net savings.

Waste collection costs have also been reduced, from $91 to $68 per month.

Country
New Zealand

Industry
Automobiles

Company
Barry Mansfield Smash Repairs Ltd, in Wellington, New Zealand, employs six people repairing and repainting cars. The business is now part of the Workplace Pride Wellington cleaner production programme.

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Automating a bicycle wheel plating operation

Background
Shaoxing General Bicycle Plant consists of 11 branches, of which the bicycle wheel electroplating branch causes the most serious pollution. The plant has end-of pipe wastewater treatment facilities which cost more than 0.2 million RMB a year to run. Even so, the quality of effluent does not meet National Environmental Standards. As production increases, environmental damage is likely to mount.

Cleaner production
A cleaner production audit was carried out to reduce environmental pollution, improve working conditions and raise efficiency. The audit revealed 38 cleaner production options; 24 of them were no-cost options and have already been implemented, producing savings of about 57,500 yuan (RMB) monthly in raw materials and environmental protection. A further 11 options are low-cost and will be implemented when the installation work is completed. The other three are high-cost and lengthy options. After an analysis of their technical and economic feasibility, and their environmental benefits, the option of automating the plating line—was implemented first.

Enabling technology
The automatic system will include:
- rearranging and resiting the plating baths
- automating the control of temperature, the addition of materials and the
maintenance of correct process parameters
❖ doubling output and productive efficiency
❖ lowering the cost of waste treatment and reducing effluent.

Advantages
The benefits are savings in raw materials, increased productivity and a reduction in the costs of waste treatment. Technical engineering works for a new production line for 0.3 million medium- to high-grade bicycles will be completed soon. The new automated electroplating line will be able to supply the high quality plated wheels needed for this development, and will provide a sound basis for raising the quality and the price of the bicycles produced.

The new development will also enable the factory to meet national environmental standards, notably those in the ISO 9000 Series Quality Identification.

<table>
<thead>
<tr>
<th>Economic benefits</th>
<th>RMB/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net savings</td>
<td>978 180</td>
</tr>
<tr>
<td>Capital investment</td>
<td>5 000 000</td>
</tr>
<tr>
<td>Payback period</td>
<td>4.6 years</td>
</tr>
</tbody>
</table>

These figures are based on electroplating 300 000 pairs of wheels a year.

The reduction of wastewater and effluents is as follows:
❖ acid and alkaline wastewater, 38 per cent
❖ nickel rinsing wastewater, 35 per cent
❖ nickel contained in rinsing water, 23 per cent
❖ chrome rinsing wastewater, 33 per cent
❖ chrome contained in rinsing water, 90 per cent.

Country
The People's Republic of China

Industry
Bicycle industry

Company
The Shaoxing General Bicycle Plant is a large state-owned enterprise, which has a total output of one million bicycles annually. In 1992, the total value of production reached 280 million yuan (RMB).

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Recycling, substitution and fibre recovery in pulp and paper production

Background
The pulping process starts with storing wood for about 30 days to allow for natural drying and oxidation of the sap which facilitates the cooking process. From the storage areas, logs are moved through a series of steps which include:
- Raw material preparation—debarking, chipping, screening and storing
- Pulp making—cooking, screening, washing and bleaching
- Chemical recovery
- The production of pulp sheet in a pulp drying machine.

The paper manufacturing process includes the following steps:
- In mills which do not have a pulping operation, raw material preparation involves screening and refining, dissolution of chemicals and mixing of all ingredients
- Sheet forming in paper machines.

Cleaner production
PT Indah Kiat Pulp and Paper (PT IKPP) has tried to minimize the environmental impact of its activities through the use of cleaner production technology. For example, at the Perawang mill efforts to minimize waste and reduce effluents include:
- Using a heat recovery system to recover heat from the digesters before the pulp is discharged now provides more than 11 m$^3$ of wash water at a temperature of 70 °C per tonne of pulp.
- Using oxygen rather than bleaching chemicals to reduce the lignin in the pulp has lowered the chemical and biological oxygen demand of the effluent.
- Recycling the cooking chemical provides power for cooking, pulp drying and paper making, and has reduced the chemical oxygen demand of the effluent from 14 000 to 1 400 parts per million
- Recycling the water from the pulp drying machine using a cascade system has
The total investment cost of the environmental protection system in PT Indah Kiat Pulp and Paper Corporation at Perawang was about US$42 million. The system includes the treatment of solid, liquid and gaseous wastes. A further US$1.8 million was invested in a fibre recovery system.

- Reduced water consumption by 23 percent per tonne of pulp
- A fibre recovery system is used to recover good fibre from reject pulp, and is saving 40 tonnes of pulp per day, worth $7000 a day
- All spills in the mill are now collected and used again.

**Economic benefits**

**Country**
Indonesia

**Industry**
Pulp and paper manufacture

**Company**
Established in the mid-1970s, PT Indah Kiat Pulp and Paper produces pulp and paper in three factories in Indonesia. The mill at Perawang, Riau, employs nearly 8000 people, and produces 790,000 tonnes a year of short fibre pulp, and 254,000 tonnes a year of writing and printing paper. Other plants, at Tangerang and Serang, West Java, produce paper and cardboard.

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Reducing waste and energy use in textile dyeing

Background
Cotton and polyester dyeing involves filling tanks containing fabrics with water and then heating, adding dyes, bleaches and other chemicals, rinsing, cooling and then combing or ironing the fabric (see flow chart below). The process used in dyeing wool and acrylic products is similar. The processes use large quantities of water and chemicals, produce wastewater containing high concentrations of suspended solids, and often waste energy.

Cleaner production
As part of the Environmental Pollution Prevention Project (EP3) sponsored by the US Agency for International Development, a Pollution Prevention Assessment was carried out at the Quimica y Textiles Proquindus SAC1 factory in Chile, which dyes a variety of materials for fabric manufacturers. The assessment identified 37 pollution prevention opportunities, which were divided into those of first, second and third priority. Six of the 19 high priority options have been costed in detail. Their costs, savings and payback periods are shown in the box opposite. Further research is needed to quantify the cost savings and environmental benefits of the other opportunities. The research already carried out suggests that:

- Repairing steam traps could reduce fuel use by 36 per cent (the equivalent of 454 tonnes of oil a year)
- Modifying rinsing techniques could reduce water use by 50 per cent, to 125 000 m³ a year
- Changing to sodium chloride in one process and filtering the decarbonizing acid bath in another could reduce sulphate in the effluent by more than 70 tonnes a year
- Improving process controls, screening drains, cleaning sumps regularly, preventing boil overs, repairing steam leaks, using lower foaming detergents, and improving the vessels in which dyeing takes place would make large but so far unquantified improvements in the levels of chemicals released
- The 330 m³ of solid waste, consisting of used sulphate, shavings and combings from fabric finishing could be recycled at least once before it is discarded.

Advantages
When completed, these pollution prevention options will save on the raw materials and energy used in the mill, reduce levels of toxic waste, improve operating efficiency and product quality, and provide a demonstration of the environmental and economic value of cleaner technology in the dyeing industry.
**Economic benefits**

<table>
<thead>
<tr>
<th>Action</th>
<th>Cost</th>
<th>Savings</th>
<th>Payback Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>replace leaking steam traps</td>
<td>$700</td>
<td>$47,000/year</td>
<td>1 week</td>
</tr>
<tr>
<td>modify rinsing procedures</td>
<td>$400</td>
<td>$45,000/year</td>
<td>&lt; 1 week</td>
</tr>
<tr>
<td>replace sulphate with sodium chloride</td>
<td>none</td>
<td>$7500/year</td>
<td>immediate</td>
</tr>
<tr>
<td>repair leaks in wool laundries</td>
<td>$50</td>
<td>$3700/year</td>
<td>&lt; 1 week</td>
</tr>
<tr>
<td>repair leaks on Zonco washer</td>
<td>none</td>
<td>$2200/year</td>
<td>immediate</td>
</tr>
<tr>
<td>filter sulphuric acid continuously</td>
<td>$700</td>
<td>$300/year</td>
<td>2.5 years</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1850</strong></td>
<td><strong>At least $105,700/year</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Country**
Chile

**Industry**
Fabric dyeing

**Company**
Química y Textiles Proquindus SACI is a dye house serving a variety of fabric manufacturers. The firm employs 90 people and in 1992 processed 350 tonnes of cotton and 360 tonnes of wool fabric.

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**COTTON AND POLYESTER PROCESSING**

- Cotton and Polyester Processing
- Desizing and Bleaching
- Finishing
- Softening (optional)
- Finished Product
- Raising (optional)
- Ironing
- White Fabric
The United Nations Environment Programme

UNEP is dedicated to bridging the gap between awareness and action. Since it was created in 1972, it has worked closely with other members of the UN network and forged new relationships among scientists and decision-makers, engineers and financiers, industrialists and environmental activists on behalf of the environment. It seeks the balance between national interests and the global good, aiming to unite nations to confront common environmental problems. Unique among UN bodies, it exists as a catalyst, spurring others to act, and works through and with other organisations, including UN agencies, industrial bodies and governments.

Industry and Environment

The Industry and Environment Office was created by UNEP in 1975 to bring together industry and governments to work in cooperation towards environmentally sound development.

The Cleaner Production Programme

This programme was launched in response to a decision from the UNEP Governing Council to reduce global pollution and waste. The objectives of the programme are to:
  - increase worldwide awareness of the cleaner production concept;
  - help governments and industry develop cleaner production programmes;
  - foster the adoption of cleaner production throughout society; and
  - facilitate the transfer of cleaner production technologies.

To meet these objectives, the programme focuses on training and the collection and dissemination of information on cleaner production that:
  - explains the concept;
  - illustrates technical applications; and
  - helps people develop cleaner production programmes.

These efforts, initiated through a number of different activities, have cultivated an ever-expanding informal network of cleaner production experts, both in industry and government agencies. Further details are available from UNEP/IE in Paris or the Regional Office for Asia and the Pacific in Bangkok.

**UNEP Industry and Environment - Cleaner Production Programme**

**History:**
  - UNEP Governing Council: 1989 decision on environmentally sound technologies
  - Canterbury CP conference: October 1990 CP concepts and network launched
  - UNCED: June 1992 recommends to strengthen CP
  - Paris CP Conference: October 1992 reorientation of CP as follow up to UNCED
  - UNEP Governing Council: 1993 decision 17.17 on transfer of environmentally sound technologies
  - Warsaw CP Conference: October 1994

**Programme Highlights:**
1. Information and Publications:
   - Cleaner Production Worldwide:
   - Government Strategies and Policies for Cleaner Production
   - Audit and Reduction Manual for Industrial Emissions and Wastes
   - CP Newsletter
   - ICPIC
2. Seminars and Workshops in all parts of the world:
3. Demonstration Projects (ongoing):
   - Pulp and Paper and Cement industries in Egypt, Senegal, Zimbabwe, Ghana
   - Cleaner Production in China
4. National Cleaner Production Centers:
   - UNEP and UNIDO initiation of eight centers in Brazil, China, Czech Republic, India, Mexico, Slovak Republic, Tanzania, Zimbabwe
   - Creation of a network between National Cleaner Production Centers and similar centers funded by other organisations
What to do next?

There is a variety of information and advice available from the United Nations Environment Programme at:

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Note that all telephone numbers in this booklet have been shown in the internationally agreed format. The plus sign indicates the code for international dialing from the country you are in; these codes are generally different for each country. The next group of figures is the unique code for the country into which you are dialing. If you are telephoning from the same country the international code is not required but you may need a national code, often a zero.