Cleaner Production

Guide for Textile Industries

Beirut 2010

Lebanese Cleaner Production Center

United Nations Industrial Development Organisation

Austrian Government

Industrial Research Institute

Ministry of Industry- Lebanon

Ministry of Environment- Lebanon

Association of Lebanese Industrialists

STENUM

FOREWORDS

The Industrial Research Institute (IRI) is proud to have hosted the Lebanese Cleaner Production Centre (LCPC) for almost 6 years now. LCPC is considered an integral part of IRI, representing the environmental face of the industrial sector.

LCPC has succeeded, once again, in convincing 4 more Lebanese SME's in the Textile sector to apply CP options to their process. Thus making a total of more than 25 SME's applying and benefiting from cleaner production.

We are proud that LCPC is producing its fourth manual for the industrial sector and first of a kind for the Lebanese plastic industries.

We consider LCPC an added-value to the industry and a strong benefactor to environmental conservation in Lebanon, incarnating a successful prototype of collaboration between IRI and MoE. We therefore, at IRI, declare our commitment to engage the resources available to us to market LCPC and its methodology and make it a success story, a model replicable in the Arab world.

Dr. Bassam Frenn
Director General IRI– Hosting Institution

The LCPC has the pleasure to present the "CP Guide for Textile Industries".

LCPC takes this opportunity to congratulate the industrial establishment in the Textile Sector. We will continue to work with you for continuous improvement and development.

We highly acknowledge the cooperation, commitment and positive contributions of the Ministry of Environment, Ministry of Industry, Industrial Research Institute, and Association of Lebanese Industrialists. The financial assistance provided by the Austrian Government through UNIDO are gratefully acknowledged. Thank you all.

Dr. Ali Yaacoub
Director-Lebanese Cleaner Production Center

Table of contents

List of figures

List of Tables

List of Abbreviations

CP	**Cleaner Production**
ISO	**International Standard Organization**
VSD	**Variable Speed Drive**
PVC	**Poly Vinyl Chloride**
UV	**Ultra Violet**
NaOH	**Caustic Soda**
CO_2	**Carbon Dioxide**
SO_2	**Sulphur Dioxide**
NOx	**Nitrogen Oxides**
PAHs	**Polycyclic aromatic hydrocarbon**

1 Introduction to Textile Sector in Lebanon

The textile industry constitutes approximately 14% of the total industry sector in Lebanon. The total manufacturing units are about 800 of which more than 100 are located in the Maten area. They produce a total about 101 million US dollars worth of goods. The manufacturing units that employ more than 2 workers contribute in about 38 % of the total national production (around 35.6 million US dollars), whereas industries that employ less than 20 workers supplied the rest. In Lebanon, the process of fabrication begins with already manufactured yarns. The raw fibers pass through 3 main stages of processing: Fabric production, finishing, and fabrication.

In Lebanon there is no exhaustive assessment that has been made yet on the textile industry. However it can be stated from previous partial assessments on this sector conducted by the Industrial Research Institute that a significant pollution load can arise from many stages of the production cycle of a typical textile operation.

The textile industrial sector in Lebanon is mainly constituted by old industries using relatively obsolete technologies. These industries, some of them established during the sixties, are mostly medium and small-scale industries.

Environmental impacts and risks of textile production

1. Air emissions: The fossil fuels that industries burn contribute to the country's emissions of carbon dioxide, a primary contributor to the greenhouse effect. Textiles industries are also responsible for emissions:

- Nitrogen and sulphur oxides from boilers which create acidity in the natural environment (freshwater lakes, rivers, forests and soils) and lead to the deterioration of metal and building structures. They also contribute to smog formation in urban areas
- Solvent content peaks in the ambient air from ovens used for coating operations
- Solvents released from cleaning activities (general facility cleanup and maintenance, print screen cleaning
- Volatile emissions of hydrocarbons

2. Waste water pollutants: generally speaking, the waste water is disposed of in an environmentally unfriendly way, into the sewage networks where available or else in cesspools, with no regard to the BOD, COD and/or heavy metals content of the water. The waste water generated from textile industries in Lebanon also includes: BOD, COD, Total suspended solids, oil and grease, Phenol, Sulphide, Chromium, Copper.
3. Solid waste: It usually ends up in curb-side waste containers and are dumped along with the municipal waste stream in landfills, open dumps or valleys. However, it is generally agreed that industrial solid wastes from textile industries are managed with little or no environmental control and include the follows:

- Ashes and sludge
- Cardboard boxes, bale wrapping film or fabric
- Plastic bags containing chemical raw material
- Paper cones and tubes
- Waste fabrics, yarns, fiber from processing

Nearly all the old enterprises do not have any wastewater treatment system. Industrial wastewater is only treated superficially, and then discharged directly into the surrounding environment due to the absence of any municipal sewer system.

The industrial solid wastes are sometimes separated from domestic waste, but no legal requirements oblige the enterprises to do so. Sorting of industrial waste is made in most cases with the final aim of selling the waste to third parties for recycling purposes.

Some of the industries are equipped with industrial wastewater treatment facilities. However, this is confined only too few. Pollution control measures such as cleaner production options and environmental impact assessment are rather embryonic, and in most cases the assessment of environmental impacts arising from the production operations is still neglected.

The implementation of clean production techniques in the textile industry can help to reduce effluent characteristics and volume considerably. It will also reduce the overuse of raw materials and energy. The economic advantages gained by implementing cleaner production are twofold: it will reduce both the costs of production and the need for costly end-of-pipe pollution control facilities. At the same time health and environmental impacts on plant workers and the surrounding community are reduced. The intervention of the CPET will focus on three main issues: water and energy conservation, optimization of chemical usage and process or equipment modification. This intervention is expected to lead to significant improvements if at start minor changes in behavior are observed by the industries (i.e. Changes in routine existing practices, applying overall good house keeping, minor process modifications, regular monitoring of water effluents, reducing packaging waste, exploring new sources for product recycling, improving purchasing specifications, etc….)

2 Textile Manufacturing Processes

Broadly defined, the textile industry includes the spinning, knitting and weaving of natural and man-made fibers, the finishing of textiles and the production of ready-made garments. The most common sectors in the Egyptian textile industry are: cotton fabrics, wool fabrics, man-made fabrics, synthetic fabrics and blended fabrics.

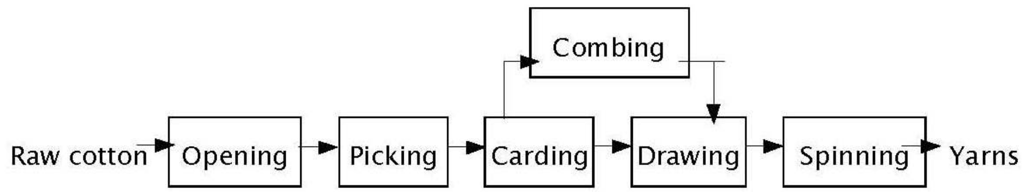
2.1 Processing of Cotton Based Textiles

Cottons and cotton-based textiles are processed through three main stages, comprising spinning, knitting or weaving and wet processing.

1. **Spinning**

Spinning is the process which converts raw fibre into yarn or thread. The fibres are prepared and then drawn out and twisted to form the yarn, which is then wound onto a bobbin or cone. The spinning process is entirely dry, although some yarns maybe dyed and finished as a final customer product. The spinning process is illustrated in the Figure 1.

Figure 1: Main Stages in the Spinning of Raw Cotton



2. **Knitting**

Knitting is carried out by interlocking a series of yarn loops, usually using sophisticated, high speed machinery. This process is almost completely dry, although some oils may be applied during the process for lubrication. These are removed by subsequent processing and enter the wastewater stream.

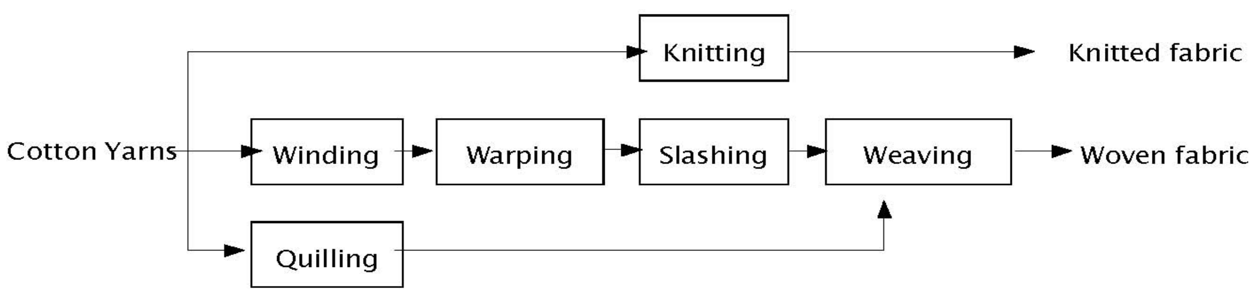
3. **Weaving**

Weaving is the most common method used for producing fabrics. The process is carried out on a loom (of which numerous varieties exist) which interlaces lengthwise yarns (warp yarns) with widthwise ones (weft or filling yarns).

Prior to weaving, the warp threads are coated with a size, to increase their tensile strength and smoothness. Natural starches are the most commonly used sizes, although compounds such as polyvinyl alcohol (PVA), resins, alkali-soluble cellulose derivatives, and gelatin glue have been used. The sizing compound is dried on the threads and remains a part of the cloth until it is removed in the subsequent processes. Other chemicals, such as lubricants, agents, and fillers, are often added to impart additional properties to a fabric. This process usually adds on about 1015% to the woven goods.

The knitting and weaving processes are illustrated in Figure 2.

Figure 2 Main Stages in the Weaving and Knitting of Cotton Yarns



4. **Wet Processing**

The stages of wet processing of cotton textiles, both woven and knitted, are shown in Figure 3.3 as follows:

Figure 3: Wet Processing of Knitted Cotton Fabrics

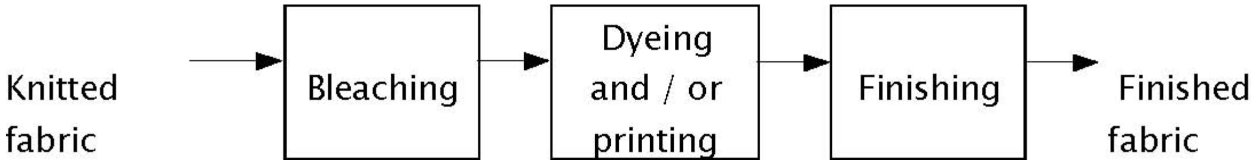
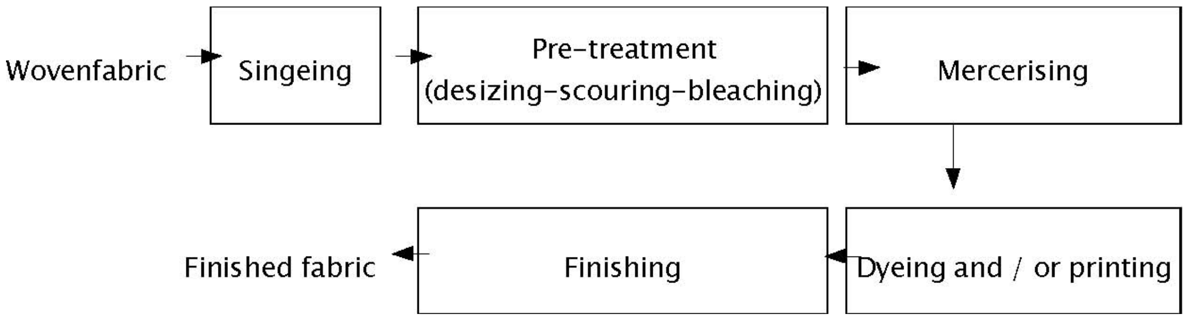


Figure 4: Wet Processing of Woven Cotton Fabrics



(i) Pretreatment Processes

Sizing and Desizing: Sizing is carried out before the weaving process to increase the strength and smoothness of the yarn, to reduce yarn breakages. Desizing, either with acid or enzymes then removes size from the fabric, so that chemical penetration of the fabric in later stages is not inhibited. Desizing effluents have very high organic concentrations, contributing 40-50% of the total organic load from the preparatory sequences. Gums and PVA may be removed by a simple hot wash but starch and its derivatives have to be made soluble by soaking with acids, enzymes or oxidants before being removed by a hot wash.

Scouring: Scouring is carried out to remove impurities that are present in cotton, both natural (e.g. waxes, fatty acids, proteins, etc.) and acquired (such as size, dirt and oil picked up during processing). This is usually done at high temperatures (above 100 °C) with sodium hydroxide and produces strongly alkaline effluents (around pH 12.5) with high organic loads. They tend to be dark in colour and have high concentrations of Total Dissolved Solids (TDS), oil and grease.

The scouring is normally done either on a Kier, a J Box, or an open width pad roll system, or on open width continuous plant. Common scouring agents include detergents, soaps, alkalis, antistatic agents, wetting agents, foamers, defoamers and lubricants.

Bleaching: Bleaching is used to whiten fabrics and yarns using sodium hypochlorite or hydrogen peroxide. Many cotton processing factories in Egypt use sodium hypochlorite as it is cheaper than hydrogen peroxide. However, this is highly toxic and is now strictly limited or banned in many countries. It can also break down to form absorbable organo-halogen compounds, which are both toxic and carcinogenic. Bleaching generates effluents with a low organic content, high TDS levels and strong alkalinity (pH 9-12).

Once bleaching is complete, the bleaching agent must be completely removed, either by a thorough washing or using enzymes.

Mercerizing: In this process, the cotton yam or fabric is treated with an alkali (sodium hydroxide, NaOH) to improve luster, strength and dye uptake. It also removes immature fibers. The process is normally carried out on dry fabric; wet mercerization reduces the steam consumption, but requires stringent control of the operational parameters, such sodium hydroxide concentration.

Excess sodium hydroxide is normally recovered for reuse in either the scouring or other mercerization stages. The rinse wastes are alkaline, high in inorganic solids and caustic alkalinity, and low in BOD. With the increasing trend toward cotton-polyester blends, much less mercerizing is being carried out.

Combined mercerizing: Where scouring is carried out simultaneously with the mercerization in hot conditions, is now becoming popular, as the mercerization increases the rate of scouring. This combined process reduces capital cost, space requirements, energy costs, labour requirement and chemical costs.

(ii) Dyeing

The major classes of dyestuffs used in the textile industry are as follows:

- Acid Dyes: Mainly used on wool, silk and polyamide fibers. They give very bright colors, whose fastness ranges from very poor (allowing colors to run) to very good.
- Basic Dyes: Usually applied to acrylics and polyesters to produce very bright colors.
- Direct Dyes: Commonly applied to rayon and cotton.
- Disperse Dyes: Applied to cellulose acetate, polyamide and polyester fibers.
- Reactive Dyes: This group produces a range of bright shades, and commonly used for cellulose textiles.
- Sulphur Dyes: Most commonly used for dyeing cotton, rayon and cotton-synthetic blends and produce strong, deep colors in the final fabric.
- Vat Dyes: These cover an almost full range of shades and are particularly important in the dyeing of cellulose fibers (such as cotton).
- Azoic Dyes: Produce deep shades of blue, violet, yellow, orange and scarlet.

(iii) Printing

Printing is a process that is used for applying colour to a fabric. Unlike dyeing, it is usually only carried on prepared fabric where it is applied to specific areas to achieve a planned design. The colour is applied to the fabric and then treated with steam, heat or chemicals to fix the colour on the fabric. The most commonly used printing techniques are:

Pigment printing, commonly used for all fabric types.

- Wet printing uses reactive dyes for cotton and generally has a softer feel than pigment-printed fabrics.
- Discharge printing creates patterns by first applying colour to the fabric and then removing selected areas.
- Final washing of the fabric is carried out to remove excess paste and leave a uniform colour.

(iv) Finishing

The finishing process imparts the final aesthetic, chemical and mechanical properties to the fabric as per the end use requirements. Common finishing processes include:

- Wrinkle Resistant/Crease Retentive - using synthetic resins.
- Water/Oil Repellent - using silicones and other synthetic materials (e.g. fluorocarbon resins).
- Flame Retardant - most commonly carried out on synthetic fabrics, by co-polymerization of the flame retardant into the fabric itself; introduction of an additive during processing; application as a textile finish. Natural fibers such as cotton can only be made flame retardant by applying a chemical finish.
- Mildew Resistance - using hazardous substances such as mercury, copper, arsenic and chlorinated phenols (e.g. PCP).

5. Commonly Used Wet Processing Equipment

The most common pre-treatment machinery and equipment used in textile mills are:

- Rodney Hunt Bleaching Range.
- Farmer Norton Bleaching Range.
- Brugman Line (Rope form).
- Croft Bleaching Range.

Commonly used wet processing equipment includes:

- Jet dyeing machine.
- Pad -thermosol/Pad-steam range.
- Continuous dyeing, washing and drying ranges (knitted fabrics).
- Roll and screen printers.

2.2 Wool Processing

Wool processing involves the following stages:

Figure 5: Conversion of raw wool into woolen and worsted yarns

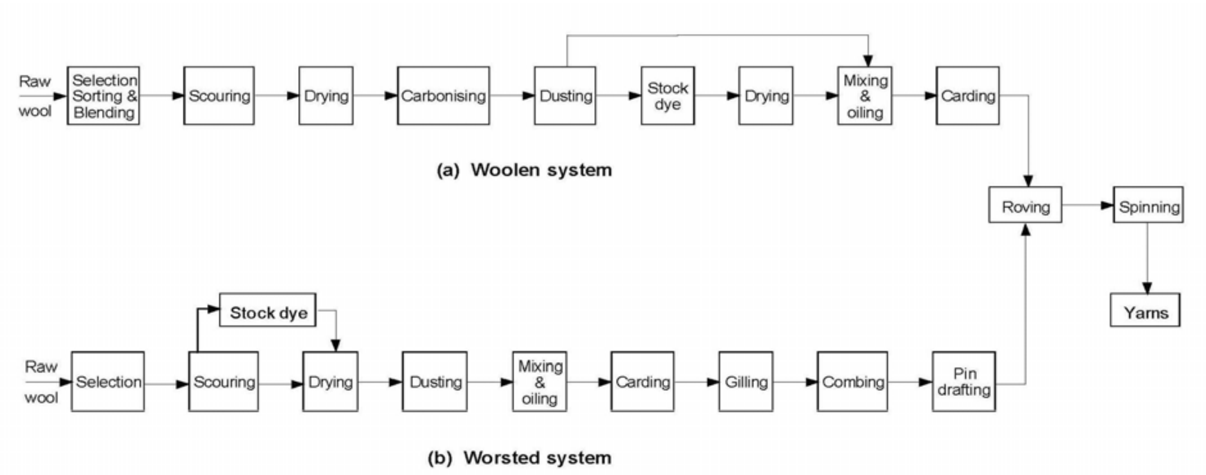


Figure 6: Weaving or knitting

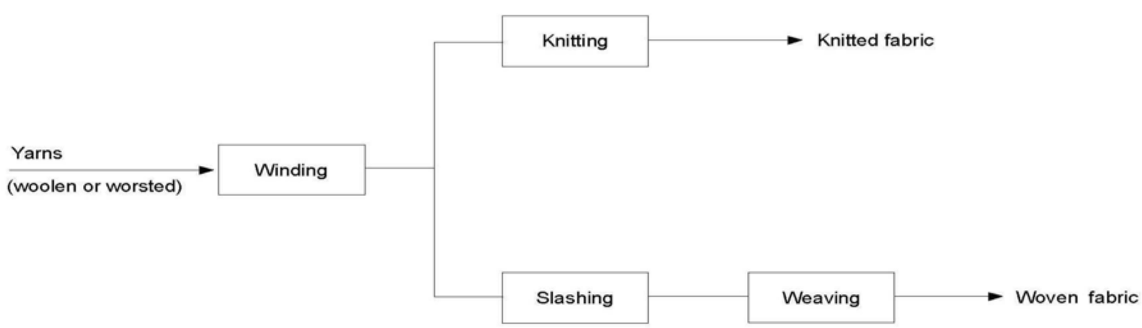


Figure 7: Finishing of woollen or worsted fabric

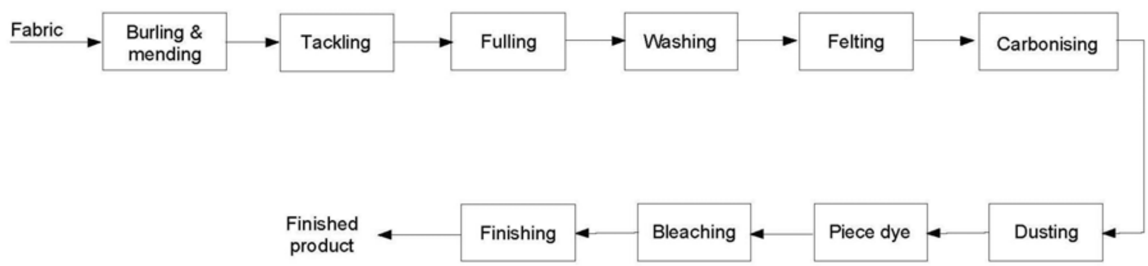


Table 1: Summary of the operating conditions follows

Process	**Conditions**
Scouring	NaOH, 1.5-2.5g/l, detergent 1-18g/l, temperature »65 degrees centigrade.
Carbonizing	100g H2SO4 (98%) per 1kg of wool, heating by indirect steam for 45 minutes.
Bleaching	Bleaching of wool can be carried out using sulphur dioxide, hydrogen peroxide followed by optical brightening.
Dyeing	The dye formulation depends on the nature of the dye (acid or metalised dye), grade of wool and the type of dyeing machine being used. Acid dyeing temperature ranges from 60-100 degrees centigrade, whilst the metalised dyeing temperature range is »85 degrees centigrade.
Finishing	• Insect repellent finishes: Mitin, Dieldrin and Boconize for permanent moth-proofing. • Water and oil repellent finishes: fluoro-chemicals.

3 Introduction to Cleaner Production

3.1 Cleaner Production Audit

A Cleaner Production Audit can be defined as:

A systematic review of a company's processes and operations designed to identify and provide information about opportunities to reduce waste, reduce pollution and improve operational efficiency.

- Present all available information on unit operations, raw materials, products, and water and energy usage.
- Define the sources, quantities and types of waste generated.
- Clearly identify where process inefficiencies and areas of poor management exist.
- Identify environmentally damaging activities and report on legislative compliance
- Identify where Cleaner Production opportunities exist, outline how much these will cost to implement and quantify the benefits.
- Prioritize the Cleaner Production opportunities identified. Priority should be given to low cost/no cost measures and those with relatively short pay-back periods.
- Incorporate an Action Plan, which will describe how the Cleaner Production measures can be best implemented at the factory.

3.2 Prevention instead of cure

Cleaner Production is defined as the continuous application of an integrated preventive environmental strategy to processes, products and services to prevent waste and emissions, increase the overall efficiency and to reduce risks to humans and environment.

- In production processes, Cleaner Production addresses the saving of raw materials and energy, the elimination of toxic raw materials and the reduction in the quantities and toxicity of wastes and emissions.

- In product development and design, Cleaner Production addresses the reduction of negative impacts throughout the life cycle of the product: from raw material extraction to ultimate disposal.
- In services, Cleaner Production addresses the incorporation of environmental considerations into the design and delivery of services.

As mentioned before Cleaner Production is the continuous application of a preventive strategy and methodology.

Cleaner Production is Help for self-help in the company.

In this context it is quite important to say that it is you who knows your own company best and that this expert know- how is essential. Therefore Cleaner Production will only be successful if you do your best to support and promote it. External knowledge can and shall only help you to find solutions. From this point of view Cleaner Production is above all a stimulation of new ideas through an external view.

Typical Cleaner production options involve good housekeeping, process optimization, raw material substitution, new technology, new product design and internal and external recycling.

Table 2: Cleaner Production options

Cleaner Production options	
Housekeeping	Improvements to work practices and proper maintenance can produce significant benefits. These options are typically low cost.
Process optimization	Resource consumption can be reduced by optimizing existing processes. These options are typically low to medium cost.
Raw material substitution	Environmental problems can be avoided by replacing hazardous materials with more environmentally benign materials. These options may require changes to process equipment.
New technology	Adopting new technologies can reduce resource consumption and minimize waste generation through improved operating efficiencies.
Internal recycling	These options are often highly capital intensive, but payback periods can be quite short.
External recycling	Sometimes recycling of materials (e. g. packaging material) or water can allow for multiple or cascaded use and thus minimize raw material consumption.
New product design	Sometimes waste of one company can become a raw material for another company. This includes bio-digestion and compostation. Changing product design can result in benefits throughout the life cycle of the product, including reduced use of hazardous substances, reduced waste disposal, reduced energy consumption and more efficient production processes. New product design is a long term strategy and may require new production equipment and marketing efforts, but paybacks can ultimately be very rewarding.

A Cleaner Production project follows a certain methodology and consists of the following elements:

6. **Data collection – mass flow, energy flow, costs and safety**

   This is one of the basic and most important and often also quite time consuming steps: the proper description of the status quo. The better the actual procedures and data are known the better the implementation of the right CP options is. In this step especially the tables in the chapter "CP report" help to collect, to organize and to crosscheck data.

7. **Reflection: Where and why do we generate waste**

   After the collection of data, the data are analyzed according to the principles of Cleaner Production.

8. **Option generation**

   Starting from the analysis CP options is generated. New, creative and/or already well-known ones will come up, aiming at a reduction at the source by good house keeping, product or process modification, organizational changes, internal or external recycling. In this process step the options checklists in the "CP report" can help.

9. **Feasibility analysis**

   For selected options a feasibility study will analyze the economical, technical and ecological feasibility.

10. **Implementation**

    In this step Cleaner Production options are implemented. Either after proceeding the steps 1 to 4, but very often options is directly implemented without the detailed feasibility analysis – when advantages and feasibility are obvious – or even without the option generation – as data collection and data reflection already makes obvious CP options visible.

11. **Controlling and continuation**

    Probably the most important and challenging aspect is the setting up of a systematic way for successful, on-going improvement. Here environmental controlling is needed, the setting up of new goals and targets and the continuous implementation.

Company analyses as used in a Cleaner Production Project / Programme may be used for five different kinds of evaluations:

Table 3: Evaluation Analyses

Evaluation of the company analyses	For use by
Regular report, ecological controlling	Management
Waste management plan	Authorities, company
Analysis of ecological/economical weak points	Personnel / management
Environmental management system (ISO 14001)	Business partners / customers
Environmental report	Public

3.3 Numbers and Indicators

To get an overview of the raw materials, energy and water used we collect numbers indicating volumes and costs. These numbers typically come from accounting.

If we compare raw materials and products and waste we get an idea of the efficiency of our processes. How big are the losses? In a procedure which we call benchmarking, we compare our numbers to sector specific average numbers and numbers characterizing the best in class. This most effectively is done using indicators. Typical indicators are production related consumptions and production related waste generation.

Environmental indicators are important for assessing Cleaner Production opportunities and for assessing the environmental performance of one dairy processing operation relative to another. They provide an indication of resource consumption and waste generation per unit of production.

4 Main Waste Flow

4.1 Solid Waste

The waste products not specifically generated by the processes respond to the most common waste flows, and may be classified as generic or repeated waste from all processes. There is a wide range of such waste products, which we identify below:

- Obsolete (out of fashion) and out of date dyes
- Wooden pallets
- Paper sacks
- Containers for bulk products
- Metal drums
- Plastic bags and drums
- Cardboard boxes
- Metal rings
- Yarn cones (broken or discarded)
- Dye trays and supports (broken or discarded)
- Used oils and lubricants
- Exhausted cleaning solvents
- Plastic and paper packaging waste
- End products that do not meet specifications
- Rejected textile raw materials
- Spilled solid/liquid products.

There are no data on the bibliography concerning the quantities of these waste products, generated, which, to a large extent, depend on the production capacity, the different processes that are carried out and the nature of the waste products.

4.2 Wastewater

In the dyeing, printing and finishing processes, there are some operations exist that are not directly linked to the production process, but that become essential for the sequential development of production.

Although attempts are usually made to perform processes in stages or grouping together the types of dyes and colour of dye in order to minimise “down times” due to stoppages for cleaning and maintenance of the machinery, cleaning operations and the fine-tuning of the facilities cannot be totally eliminated. These operations are usually carried out using water, detergents and cleaning products.

This cleaning, usually employing water and detergents, is performed on:

- The fixed machinery, that is to say, large machinery, in general.
- Normally transportable accessories, such as: moulds, trays, bobbins, roll stands, etc.

The cleaning of accessories may be done in a more automatic procedure with automatic washing systems, brushes, scrapers, etc.
Some cleaners incorporate industrial solvents and organochlorine compounds into their active ingredients in order to boost their cleaning power on remains of dyes and printing pastes.

Cleaning wastewater contains remains of dyes, pastes, fibres, lint, detergents and cleaning solvents. No reliable data are available on volumes and characterisation of such wastewater.

Water for supply purposes, used in dyeing, printing and finishing, whether it comes from supply companies, surface catchment or wells, has some conditioning factors regarding its quality and therefore, requires the appropriate treatment.
Such treatment usually includes:

- Elimination of iron and manganese
- Elimination of suspended solids
- Elimination of hardness
- Elimination of salinity

These treatments generate the following wastewater:

- Wastewater from the washing of filters in order to eliminate suspended and precipitated solids.
- Water for the regeneration of the ionic exchange resin beds, or saline rejects from inverse osmosis (if available). In both cases with high conductivity.

The cooling circuits must be purged periodically in order to eliminate concentrations of salt. These purged liquids are eliminated by being incorporated into the wastewater, which increases its conductivity.

The water circuits of the steam boilers must be purged and cleaned, including the steam drums. Apart from the concentrations of salts, basicity and silica from the purging itself, descalers are used for the cleaning of circuits. All of this maintenance operations generate wastewater, containing these products.

4.3 Atmospheric emissions

Cleaning with solvents

Operations exist that are not linked directly with the production process, but which become essential in order to develop continuous production. This is the case for some cleaning done with solvents, which constitute sources of diffuse origin emissions.
These solvents and degreasing agents are used for cleaning printing machines, specifically in the print injectors and other parts which are in contact with dyes, pigments and printing pastes also in some dyeing equipment.

Storage of end products

Textiles stored can, in some cases, emit volatile compounds due to their use in the operations to which they have been subjected and the residual presence in manufactured products, especially auxiliary materials, with which the textile products are impregnated.

4.4 Other Waste flow

Although the description of processes has been exclusively limited to direct production processes of dyeing, printing and finishing, some general facilities exist at textiles factories that are necessary for the normal functioning of those processes.

These general facilities or support facilities generate, in turn, waste flows that must also be considered.

Solid Waste

The main source of waste generation from auxiliary facilities is sludge from the wastewater treatment plants.

Lastly, all water treatment previously indicated generates:

- Sludge and sediment from chemical precipitations and mechanical separations (sedimentation, filtration)
- Sludge Remains of containers of products used in such treatment

Wastewater

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Atmospheric emissions

The main focal point of the generation of emissions into the atmosphere is the boilers that generate steam. Wastewater treatment plants (of the aerobic biological or activated sludge types) also generate emissions of volatile organic compounds contained in the wastewater from the dyeing and printing processes.

4.5 Main Pollutants in Wastewater

A generic list of the main chemical compounds that can be found in the wastewater of any dyeing, printing and finishing operation is included.

Table 4: Substances that are potenntially present in Wastewater

SUBSTANCE	DYEING OF COMBED & SPUN YARN			DYEING & FINISHING OF FABRICS		DYEING & FINISHING OF KNITWEAR		PRINTING
	Cotton	Wool	Synthetics	Cotton	Wool	Wool	Cellulosics	
Soaps	X	—	—	X	X	X	X	—
Anionic detergents	X	X	X	X	X	X	X	—
Non-ionic detergents	X	X	X	X	X	X	X	—
Sodium carbonate	—	X	—	X	X	X	—	—
Sodium chloride	X	X	X	X	X	X	X	—
Sodium sulphate	X	X	X	X	X	X	X	—
Fats and oils	X	—	X	X	—	—	X	—
Vegetable impurities	X	—	—	X	—	—	—	—
Starch	—	—	—	X	—	—	—	—
Carboxymethylcellulose	—	—	—	X	—	—	—	—
Methyl cellulose	—	—	—	X	—	—	—	—
Vinyl polyalcohol	—	—	—	X	—	—	—	—
Polyacrylamides	—	—	—	X	—	—	—	—
Polyesters	—	—	—	X	—	—	—	—
Wetting agents	X	—	—	X	—	—	X	—
Softeners	X	—	X	X	—	—	X	—
Nitrogenated compounds	X	—	—	X	X	X	X	X
AOX	X	X	X	X	X	X	X	—
Sodium hypochlorite	X	—	X	X	—	—	X	—
Sodium chlorite	X	—	X	X	—	—	X	—
Optical bleaching agents	X	X	X	X	X	X	X	—
Sulphites	X	X	X	X	X	X	X	—
Bisulphites	X	X	X	X	X	X	X	—
Dyes	X	X	X	X	X	X	X	X
Pigments	—	—	—	—	—	—	—	X
Copper	X	—	—	X	—	—	X	—
Chrome	X	X	—	X	X	X	X	X
Formaldehyde	X	—	—	X	—	—	X	—
Acetic acid	X	X	X	X	X	X	X	—
Naphthol	X	—	—	—	—	—	—	—
Aromatic amines	X	—	—	X	—	—	—	—
Formic acid	—	X	X	X	X	X	X	—
Nickel	—	X	—	—	—	—	—	—
Cobalt	—	X	—	—	—	—	—	—
Phosphates	—	—	X	X	X	—	X	—
Phenoles	X	X	X	X	X	—	—	—
Sulphurs	X	—	—	X	—	—	X	—
Trichloroethylene	—	—	—	—	X	X	—	—
Perchloroethylene	—	—	—	—	X	X	—	—
Titanium dioxide	—	—	—	—	—	—	—	X
Iron	—	—	—	—	—	—	—	X
Aluminium	—	—	—	—	—	—	—	X

5 Cleaner Production techniques and processes

Implementation of cleaner production techniques at any manufacturing plant can help to reduce effluent characteristics and volume considerably. It will also reduce the overuse of raw materials and energy. The economic advantages gained by implementing cleaner production are twofold: it will reduce both the costs of production and the need for costly end-of-pipe pollution control facilities. At the same time, health and environmental impacts on plant workers and the surrounding community are reduced. Cleaner production techniques may be classified into three groups**: water and energy conservation**, **optimization of chemical usage** and **process or equipment modifications.**

5.1 Water and Energy Conservation

In the table below, interesting statistics about water usage (per unit of production) in different sectors of the textile industry. This data clearly shows a significant variation in water usage even within each plant category, due to the differences in the washing cycles, washing equipment employed and extent of water re-use. Where a large difference exists between the median and maximum values this probably reflects instances of indiscriminate water use including bad housekeeping. Sharp differences between the median and minimum values may indicate instances of strict control over water use and better housekeeping, water re-use or the selection of improved washing equipment.

Table 5: Water usage per unit of production

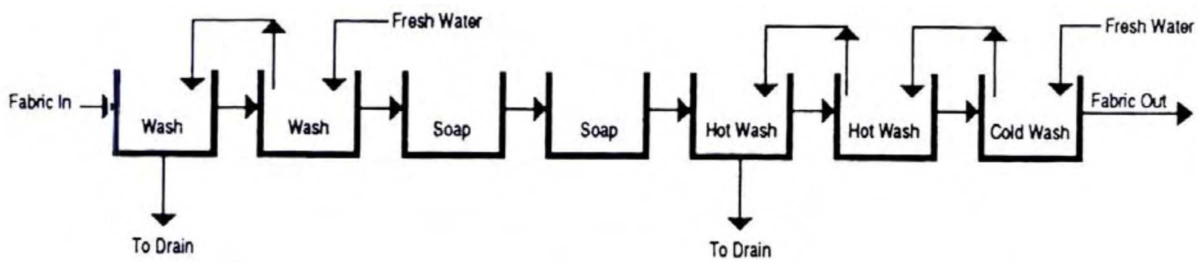
Sub-category	Amounts of Water Typically Used in l/kg of Product Produced		
	Minimum	Median	Maximum
Wool Scouring	4.2 (0.5)	11.7 (1.4)	77.6 (9.3)
Wool Finishing	110.9 (13.3)	283.6 (34.1)	657.2 (78.9)
Dry Processing	0.8 (0.1)	9.2 (1.1)	140.1 (16.8)
Woven Fabric Finishing			
Simple Processing	12.5 (1.5)	78.4 (9.4)	275.2 (33.1)
Complex Processing	10.8 (1.3)	86.7 (10.4)	276.9 (33.2)
Complex Processing plus Desizing	5.0 (0.6)	113.4 (13.6)	507.9 (66.9)
Knit Fabric Finishing			
Simple Processing	8.3 (0.9)	135.9 (16.3)	392.8 (47.2)
Complex Processing	20.0 (2.4)	83.4 (10.0)	377.8 (45.2)
Hosiery Products	5.8 (0.7)	69.2 (8.3)	289.4 (34.8)
Carpet Finishing	8.3 (1.0)	46.7 (5.6)	162.6 (19.5)
Stok & Yarn Finishing	3.3 (0.4)	100.1 (12.0)	557.1 (66.9)

Water conservation significantly reduces effluent volume. It is not unusual to find situations where a reduction of more than 25% in water usage can be achieved by following water conservation practices. Common sources of water waste are excessive water use in washing operations and poor housekeeping measure such as broken or missing valves, unattended leaks from pipes and hoses, instances when cooling waters are left running when machinery is shutdown, etc. Implementation of strict housekeeping measures such as plugging leakages, checks on running taps and the installation of water meters or level controllers on major water carrying lines are examples of simple water conservation strategies.

Other reasons for large effluent volume is the choice of inefficient washing equipment, excessively long washing cycles and use of fresh water at all points of water use. One simple idea for water conservation is to segregate water used for cooling purposes and set up an independent closed loop system for its possible direct and repeated use. One example of such a system could involve the diversion of non-contact cooling water to a clear well for direct re-use or to the influent water line of the textile mill. Such a practice can result in significant water conservation.

Most of the effluent volumes arising from a textile mill come from washing operations, primarily the preparation of fiber and dyeing operations. Since most of the washing cycles are in a series, used water in the various washing stages can be re-used. This method of the water recycling is called countercurrent washing. With this method the least contaminated water from the final wash is re-used for the next-to-last wash and so on until the water reaches the first wash stage, where it is finally discharged.

Figure 8: Counter-Current flow



Check-list for Water Re-use

1. Establish the average volume of water used in various wet processes and for miscellaneous non-process related purposes over a shift basis.
2. For the major water consuming wet processes, identify the level or levels of water quality required to maintain product quality.
3. Estimate water quality after use either by wet sampling or by setting up an approximate mass balance for all the wet processes considered in step 2.
4. Prepare a number of practical alternatives for water re-use based on information

obtained in steps 1, 2 and 3. Practical considerations would include layout of the processes and existing pipe work, technological limitations on water treatment and the sensitivity of the fabric or the process to the used water quality. (The latter consideration is important in wet processes such as dyeing).

5. Evaluate the costs of all the alternatives. Costs should include both installation, operating and maintenance, bearing in mind:
    a. Possible reduction in fresh water consumption and subsequent decrease in the costs of water billing. In some instances fresh water saved may be used for more productive purposes.
    b. Possible reduction in the effluent volume and the resulting costs of effluent treatment and perhaps in the pollution fees.
    c. Possible increase in effluent concentrations, due to reduced volume, and the probable effect of this on increased pre-treatment costs to protect the effectiveness of the effluent treatment plant. Consideration should be also given to the occasional bleeding and handling of used water required after several use cycles.
    d. Additional costs of new pipelines, used water storage equipment, pumping, additional treatment of waste water, operating costs (energy and chemicals) and miscellaneous items.

As with water conservation, attention paid to reductions in energy use can deliver cost savings and lower emissions from boilers or generating plants simultaneously. Textile plants can be prodigious energy users. Minimizing losses from unlagged pipes and cutting down excessive consumption can give good results. For large plants a formal energy audit may help to pinpoint where the most effective savings can be made. In some cases investment in energy recovery may also be justified. A heat exchanger, recover heat from liquid used in the dyeing process, is saving the about 13.2 MJ of heat per year. Fabric dyeing requires large amounts of hot water - often more than 50 times the weight of the fabric processed. The recovery of heat from used water is difficult because the water contains fabric particles that clog conventional heat exchangers. To overcome this problem, a heat exchanger was designed in which there a turbulent water flow through the machine to prevent fibers was settling on the heat exchange surfaces. This also improved heat transfer. Some 23 cubic meters of hot water per hour pass through the heat exchanger and its temperature is reduced from 95°C to

38°C. Incoming cold water is heated from about 10°C to 67°C. Energy savings arising from the new system paid for installation costs in less than two years.

5.2 Optimization of Chemical Usage

The choice of process chemicals used is a key decision for reducing impacts. Processing chemicals have a range of potentially hazardous properties, it is possible to substitute safer chemicals for those used traditionally. The higher cost of some safer substances can usually be justified through benefits such as lower worker illness and savings from the reduced cost of required safety measures.

In addition to acute toxicity, the possibility of long-term exposure effects such as carcinogenicity should also be kept in mind. This can be a concern for chemicals which have been inadequately tested and where the low acute toxicity may give managers a false sense of security.
In all cases process chemicals must be carefully handled in accordance with the safety advice of the manufacturer or any other authoritative source.

In addition to problems of possible toxicity, textile processing uses a variety of chemicals with considerable BOD and COD. It is possible to lower these pollution problems by reducing the chemical loads, since very often a large margin of safety is employed. In many cases, knowingly or unknowingly, these safety margins may be applied more tightly at a textile mill to eliminate the need for reprocessing.

For the reason a careful study of the various textile processes, with respect to the minimum requirement of different chemical recipes, can be particularly important. It is possible to reduce the amount of process chemical by 20-50% by adopting such measures which will in turn reduce the effluent load in terms of BOD by about 30-50%. Another obvious benefit is lower operating costs.
One strategy to achieve chemicals and effluent reduction, especially in the context of large textile processing mills, is to use automated chemical dispensing.

An automated chemical dosing system offers some important advantages over the manual method. Automation also offers faster delivery times, better laboratory-to-dye house correlation, a wider variety of styles and higher quality. Handling of some chemicals is hazardous so an automated system also minimizes the chances of worker injury.

The effluent load can also be reduced by effective recovery practices and the re-use of process chemicals to tie maximum possible extent. Preparation chemicals (including optical brighteners and tints) must however be selected in such a way that their re-use does not create quality problems such as spotting.

Four important areas where chemical recovery and re-use have proved most effective are:

- Re-use of dye solutions from the dye-bath
- Recovery of caustic in mercerizing
- Recovery of size in cotton processing
- Recovery of grease in wool processing.

One method for reducing the BOD load in the effluent is to substitute low BOD process chemicals for those having high BOD values. Again, by referring to the BOD list of textile chemicals, the processor can determine which chemicals can be exchanged for those with high BOD values, while maintaining product quality

The substitution of low BOD process chemicals for high BOD ones does however have two drawbacks. Firstly, the increased cost usually associated with the low BOD products and secondly, while these chemicals have low five-day BOD values, little is known about their long-term biodegradability.

Generally, the low BOD chemicals are found to be associated with low biodegradability and hence their use may demand prolonged periods of effluent aeration in biological treatment plants.

Check-List of Possible Chemical Substitutions

1. Use synthetic warp sizes (based on PVA and acrylates) in place of the conventional starch based size preparations.
2. Use mineral acids for acid-desizing in place of enzymatic desizing.
3. Use synthetic detergents in place of soaps.
4. Use sodium acetate in place of soda ash for neutralizing scoured goods so as to convert mineral acidity into volatile organic acidity.

5. Use ammonium sulphate in place of acetic acid for pH adjustment in disperses dyeing and pigment printing. Although the salt concentration of the effluent would increase in this substitution, ammonium would serve as a nutrient in the biological treatment process.
6. Substitute emulsion-thickening - fully or partially - for gum thickening in textile printing.
7. Use sodium bicarbonate (in place of acetic acid) in conjunction with peroxide or perborate for the oxidation of vat dyestuffs.
8. Use permanent adhesive on tables and screen-printing machines (Flat Bed and Rotary types) in place of conventional gumming.
9. Use durable resin finishes in place of temporary finishes based on starch materials.
10. Use single-class dyestuffs like Indigosol, pigments, etc. for dyeing blended varieties in pale shades in place of two stage dyeing using two different classes of dyes (e.g. polyester using disperse and cellulosics using vats, reactives, etc.)
11. Use all-aqueous phthalogen blue dyeing in place of solvent-based phthalogen blue dyeing which requires speciality auxiliary products.
12. Use monochlorobenzene in the place of other carriers for dyeing Dacron.
13. Substitute formic acid for acetic acid in dye baths (acetic acid 0.64 kg BOD/kg; formic acid 0.12kg BOD/kg.)
14. Replace carding oils and anti-stat lubricants with non-ionic emulsifiers.

5.3 Modification of Processes and Equipment

Often it is possible to change a textile production process in such a way that waste arisings are greatly reduced or eliminated. It also depends on which products are being produced, the product quality required and effluent standards that apply.

Partial List of Cleaner Production Process Modifications

1. Single-stage desizing-scouring- bleaching processes for the processing of cellulosics and their blends with synthetics.
2. Solvent-aided scouring and bleaching processes.

3. Activated peroxide bleaching taking chemically treated goods straight into a peroxide bath through the washing machine.
4. Dyeing-sizing of warp yarns for denim style products.
5. Hot mercerization in place of conventional cold mercerization, often enabling the elimination of separate scouring treatment.
6. Combined Disperse and Reactive/Direct colour-dying of blended fabrics containing low percentages of cellulosics.
7. Use of padding method in place of exhaust methods for dyeing, wherever possible.
8. Use of bicarbonate in a peroxide bath for vat oxidation to convert the caustic alkalinity into carbonate alkalinity for its easier removal; caustic alkalinity requires a plentiful supply of water.
9. Electrolytic process for the dyeing of vat colours and reduction-clearing of disperse colour printed synthetic fabrics.
10. Dry-heat fixation techniques for the development of Rapidogen prints in place of the conventional acid-steaming method.
11. Direct finishing of pigment printed goods and direct carbonising of disperse printed goods without intermediate washing.

1. Washing Operations

Popular avenues for exploring process/equipment modification have been found in fabric washing and drying (water extraction) operations. For example, fabric can be washed with different types of equipment, each with different unit water consumption and efficiency rates. Some of the parameters affecting washing efficiency are water application per unit weight of fabric, method of application viz. spraying, pulsing, cascading, water temperature, contact time and/or fabric speed, number of washes and duration of the washing cycle, intermediate water extraction methods such as squeezing, suction, beating.

Water Conservation Measures in Dyeing Equipment

Batch Operations

- Winch Dyeing: By dropping the dye bath and avoiding overflow rinsing, water consumption could be reduced by 25%.

- High and Low: By replacing the overflow with Pressure Jet Dyeing batchwise rinsing, water consumption can be cut by approximately 50%.
- Beam Dyeing: About 60% of water consumption may be reduced by preventing overflow during soaking and rinsing. Automatic controls proved to be quite economical with a payback period of about four months.
- Jig Dyeing: A wide range of reductions (ranging from 15% to 79070) were possible by switching from the practice of overflow to stepwise rinsing. Rinsing with spray technique, which was tried on a laboratory scale, was also effective.
- Cheese Dyeing: A reduction of around 70% was possible following intermittent rinsing.

Continuous Operations

A 20-30% saving was realised by introducing automatic water stops. Counter-current washing proved to be the most effective method. Horizontal washing equipment delivered the same performance as to vertical washing machines, using the same amount of water.

2. Optimisation of Sizing-Desizing Systems

Size represents the largest single group of chemicals used in the textile industry which, in most cases, does not become a permanent part of the product. Size recovery therefore presents one of the greatest opportunities for savings. This is most convenient in vertically integrated mills where the recovered size can be returned directly to the make-up kettles at the slashing operations.

The common types of sizes used on textile warp yarns are:

1. Starch
2. Carboxymethyl cellulose (CMC)
3. Polyvinyl alcohol (PVOH)
4. Polyacrylic acid (PAA)
5. Polyvinyl acetate (PVAc)
6. Polyester (PET)
7. Modified cellulose and starches

3. Pad-Batch Dyeing

One potential improved process for dyeing is pad-batch dyeing. This method is one of the most reliable and controllable available today and has been used quite successfully in a wide variety of applications. Benefits include the elimination of the need for salt or chemical specialties from the dye bath, with associated cost savings and waste reduction.

This method is interesting because it offers several significant advantages, primarily in waste reduction, simplicity and speed. Production case histories have shown that pad-batch dyeing for cotton, rayon and blends conserves energy, water, dyes, chemicals, labour and floor space. Salt consumption is reduced from about 100% for each weight of goods to zero. Water consumption for pad-batch dyeing with beam wash-off is typically under two gallons per pound of dyed fabric, compared to typically 20 gallons or more on atmospheric becks for the same fibre reactive dyed shades. Energy consumption is similarly reduced from about 9000 BTUs per pound of dyed fabric for becks to under 2000 BTUs per pound for pad batch with beam washing. Chemical use (including alkali as well as speciality chemicals), with associated BOD and COD loadings for waste streams, can be reduced by up to 80% compared with atmospheric beck's. In general, the quality of pad-batch eyeing is equal to or better than other dyeing systems with benefits that include:

1. Reduced effluent waste loads
2. Low capital outlay
3. Low energy requirements
4. High production speed
5. Reduced labour requirements
6. High colour yields
7. Outstanding reproducibility
8. Excellent penetration, and leveling characteristics
9. Rapid fixation
10. Substantial overall cost savings (dyes, chemicals, labour, water, etc.)

4. Solvent Processing

Solvent preparation, dyeing, finishing, and drying were closely examined by the industry. Advantages claimed for solvent technology are:

1. Elimination of a pre-scour
2. Smaller, less costly equipment
3. Flexibility of making short, continuous runs
4. Low utility requirements
5. Considerable water usage reduction
6. Better levelling and uniformity
7. Better -eproducibility between runs
8. Possibility to integrate dyeing and finishing

However, solvent technology did not meet wide acceptance due to two factors. Firstly, chemical systems, dyes, specialities, etc. appropriate to solvent use were not available at a commercially competitive cost. Secondly, environmental regulations for airborne emissions from solvent processing equipment, storage facilities, and hazardous waste regulations on recovery by-products (still bottoms, etc.) made many solvent processes uneconomic. A tight control over solvent systems is required to keep solvent losses below 5% of the fabric weight.

For a plant deciding to employ solvent processing, a reasonable approach is to buy both solvent processing and solvent recovery systems from one supplier. This is usually the most economical route from a capital cost and installation standpoint. Consideration should also be given to fixed detection units located at the entry and exit ends of the production equipment and near the recovery unit.

Assuming that the quality of goods is the same when solvent procedures are compared to conventional ones, the following list gives some key factors which should be considered in an economic evaluation:

1. Is new equipment needed or can the existing equipment be converted?
2. Would the installation of solvent equipment reduce the load on the effluent treatment plant significantly?

3. Is a comparison between water and utility costs and the costs of solvents along with their availability favourable in economic terms?

5. Transfer Printing

In normal textile processing, colour pastes are applied to a textile material. These pastes contain dyestuff, a thickening agent, water, and other chemicals. After printing and dyeing, the dyestuff fixation occurs by steaming. After steaming, an intensive washing process is necessary to remove the thickening agent, residual dyestuff, and other chemicals. This washing process produces a large amount of effluent. The after-washes of printed textiles also use considerable energy, incurring a high cost.

Transfer printing has important advantages in comparison to normal textile printing. In transfer printing, paper is first printed with volatile disperse dyes. The printed paper is heated together with a textile material in a thermopress at up to 200°C for thirty seconds. Under these conditions, the dyestuff is transferred from paper to textile material by sublimation. The transferred dyestuff has a good washing fastness.

In contrast to normal printing, in transfer printing only the dyestuff, and no other chemical, is deposited on the textile material so no after-washing is required and no effluent is generated. For conventional printing: 250 kg of water per kg of textile is required. In transfer printing only 2 kg is needed. Disadvantages of transfer printing include low rates of production as well as the limitation to volatile dyes (and to fibres which have affinity with these dyes).Important advantages are that dyestuff consumption is considerably lower than with direct printing on textiles. A dye yield of 80% can be realised with printed paper transfer, and penetration can be better controlled. With no need for after treatment, hardly any water is consumed leading to less effluent generation. Considerably less energy is consumed during drying. Approximately one-half ounce of water per square yard is used in transfer printing compared with between seven to 32 ounces of water per square yard used in direct printing. No after treatment such as steaming, washing, or drying is required. Thus transfer printing is cheaper. It demands less production space, fewer skilled staff and creates less pollution.

In its present form, transfer printing is only suitable for some synthetic fibres and can not yet be used for natural fibres. It has been particularly successful with polyester. Some transfer printing has been done cn acrylic, nylon 66, and triacetate. Some wool has been successfully printed by means of the so-called Fastran process after a pre-treatment. Due to the nature of the present transfer process as well as the low quantity of dyestuff delivered to the paper, the penetration of the dye into the fibre is also limted.

6. Foam Processing Technology

Textile chemicals processing solutions can be diluted using air in place of part of the water by forming foams.

The basic types are stable and unstable foams. Each type requires a different chemical system and mechanical arrangement for producing, handling, and applying the foam. Use of these techniques can result in energy and cost savings, since there is less water to evaporate when drying the fabric. However, foam processing on continuous equipment (e.g. backcoating), has the disadvantage that, when the production line stops, the foam must be disposed of. This can be very difficult, especially when stable foams (e.g. backcoating) get in the wastewater, producing suspended solids which are hard to treat and will not settle. Possible ways to destroy excess foam include spraying it on to heated pla es or dry cylinders where it can be rapidly dried, scraped off and recovered as a solid waste for disposal. Prior to setting up a foam operation, it is important to plan how foam disposal will occur other than by discharge to the process effluent stream.

6 Cleaner Production options and examples from the Lebanese Industries

6.1 Preventing ineffective use of resources

Cleaner Production is an approach to environmental management that aims to improve the environmental performance of products, processes and services by focusing on the causes of environmental problems rather than the symptoms. In this way, it is different to the traditional 'pollution control' approach to environmental management. Where pollution control is an after-the-event, 'react and treat' approach, Cleaner Production reflects a proactive, 'anticipate and prevent' philosophy.

Cleaner Production is most commonly applied to production processes by bringing about the conservation of resources, the elimination of toxic raw materials, and the reduction of wastes and emissions. However it can also be applied throughout the life cycle of a product, from the initial design phase through to the consumption and disposal phase. Techniques for implementing Cleaner Production include improved housekeeping practices, process optimization, raw material substitution, new technology and new product design.

The other important feature of Cleaner Production is that by preventing inefficient use of resources and avoiding unnecessary generation of waste, an organization can benefit from reduced operating costs, reduced waste treatment and disposal costs and reduced liability. Investing in Cleaner Production, to prevent pollution and reduce resource consumption is more cost effective than continuing to rely on increasingly expensive 'end- of-pipe' solutions. There have been many examples demonstrating the financial benefits of the Cleaner Production approach as well as the environmental benefits.

6.2 Water and Energy Conservation

The use of water and energy is one of the main environmental impacts associated with the textile processing and production, and also forms a substantial proportion of production costs. Several water conservation and waste prevention techniques are available by which to decrease water volume.

These techniques include

- The use of high-pressure sprays for clean-up.
- The elimination of excessive overflow from washing.
- The substitution of mechanical conveyors for flumes,
- The use of automatic shut-off valves on water hoses.
- The separation of cooling water from composite waste flow.
- The recirculation of cooling water.
- The dry cleaning of equipment and production areas prior to washing; and

6.3 Boiler and steam distribution system optimization

Steam is produced in a boiler and distributed throughout the plant by insulated pipes. Condensate is returned to a condensate tank, from where it is re-circulated as boiler feed water, unless it is used for heating in the production process.

The amount and pressure of the steam produced depend on the size of the boiler and how the fuel is injected into the combustion chamber. Other parameters include pressure level, fuel type, and maintenance and operation of the boiler.

Inefficiencies in boiler operation of boilers and steam leaks lead to the waste of valuable fuel resources as well as additional operating costs.

Combustion of fuel oil results in emissions of carbon dioxide (CO2), sulphur dioxide (SO2), nitrogen oxides (NOx) and polycyclic aromatic hydrocarbons (PAHs). Some fuel oils contain 3–5% sulphur and result in sulphur dioxide emissions of 50 – 85 kg per 1000 litres of fuel oil.

Sulphur dioxide converts to sulfuric acid in the atmosphere, resulting in the formation of acid rain. Nitrogen oxides contribute to smog and can cause lung irritation.

If the combustion is not adjusted properly and if the air:oil ratio is too low, there are high emissions of soot from the burners. Soot regularly contains PAHs that are carcinogenic.

Table 6: Emissions produced from the combustion of various fuels to produce steam

Input	Outputs	
Fuel oil (1 % sulphur) 1 kg	Energy content	11.5 kWh
	Carbon dioxide (CO_2)	3.5 kg
	Nitrogen oxides (NO_x)	0.01 kg
	Sulphur dioxide (SO_2)	0.02 kg

1 kg of oil = 1.16 litre of oil (0.86 kg/L)

1 kW.h = 3.6 MJ

Oil is often spilt in storage and at the boiler. If the spilt oil is not collected and reused or sold, it can cause serious pollution of soil and water.

Instead of using fuel oil with high sulphur content, it is advantageous to change to a fuel oil with low sulphur content (less than 1 %). This increases the efficiency of the boiler and reduces sulphur dioxide emissions. There are no investment costs involved, but the running costs will be higher because fuel oil with lower sulphur content is more expensive.

It is essential to avoid oil spills and, if they occur, to clean them up properly and either reuse or sell the oil. A procedure for handling oil and oil spills should be instituted and followed.

If the boiler is old, installation of a new boiler should be considered. Making the change from coal to oil or from oil to natural gas should also be considered. In some burners is it possible to install an oil atomiser and thereby increase efficiency. Both options (new boiler and atomiser) will often pay back the investment within 5 years. The actual payback period depends on the efficiency of the existing boiler, the utilisation of the new boiler, the cost of fuel, and other factors.

Steam leaks should be repaired as soon as possible when identified. Even small steam leaks cause substantial losses of steam and corresponding losses of oil and money.

Insulation of hot surfaces is a cheap and very effective way of reducing energy consumption. The following equipment is often not insulated:

- valves, flanges;
- scalding vats/tanks;
- pipe connections to machinery.

Through proper insulation of this equipment, heat losses in these equipments can be reduced by 90%. Often the payback period for insulation is less than 3 years.

If steam condensate from some areas is not returned to the boiler, both energy and water are wasted. Piping systems for returning condensate to the boiler should be installed to reduce energy losses. The payback period is short, because 1 m3 of lost condensate represents 8.7 kg of oil at a condensate temperature of 100 °C.

The efficiency of boilers depends on how they are operated. If the air to fuel ratio is wrongly adjusted incineration will be poor, causing more pollution and/or poorer utilization of the fuel. Proper operation of the boiler requires proper training of employees and, if the expertise not is available within the company, frequent visits of specialists.

6.4 Waste minimization and segregation

The Textile processing and production industry also offers excellent opportunities for waste avoidance, re-use and recycling. Some simple steps to take include:

- remove solid wastes (such as soil) without using water;
- separate useful products from the waste stream at an early stage to prevent contamination and maximize potential for material recovery;

6.5 Equipment inspection and maintenance

The periodic checking of components (washing machines, pumps, valves, filters, refrigerators, ovens and switches, etc.) will avoid excessive water and energy use, filter clogging and off-quality production. Close attention should be paid to common defects such as missing guards, loose electrical cords, and leaks of water, steam and compressed air.

6.6 Purchasing and storage

Badly managed purchasing and storage can lead to over-stocking and poor storage, with material lost through aging, spillage and contamination. Proper material handling begins with procedures for ordering, purchasing, and storing:

- register dates and quantities of all purchases on receipt to minimize surplus and spoilt orders;
- use proper racks, storage bins and bulk tanks, and store goods away from heavily trafficked areas to avoid container damage; and
- obtain supplier details about proper packaging, handling, chemical constitution, and control of impurities for cleaning agents, etc.

6.7 Technological modifications

Once the first step of improving housekeeping has been taken, the eco-efficiency assessment can move on to technology modifications and material substitutions. On the whole, such changes to the process require some capital investment; however savings in energy and water use can result in attractive pay back periods, perhaps within a few months. The easiest technologies to implement in the textile processing and production industry are often those proven in other industries, and the design stage of a process (and particularly a new facility) offers the unique and optimum opportunity for making change.

Measures to reduce water usage, effluent generation and energy consumption which are commonly adopted include:

- the optimization of process lay-out, for example to separate cooling waters from process and wastewater re-circulate for re-use;
- the use of taps with automatic shut-off valves and flow restrictors;
- the installation of high pressure nozzles and automatic shut-off nozzles on hoses for equipment and workplace cleaning;

- using waste heat from refrigerators for heating (e.g. preheating water).
- Install dry vibration or air jets for cleaning to reduce water consumption and effluent production.
- If washing is necessary, install counter current washing systems.

6.8 Waste management

A cornerstone of good waste management is the segregation (the capture, separation and storage) of different waste streams to allow material recovery, recycling and re-use. Benefits include reduced waste disposal costs, savings in material and supply costs, and revenue generation through marketing saleable materials.

Literature and websites

This guidebook was compiled using:

- Ecoprofit-Materials, STENUM GmbH (www.stenum.at)

- Book: Half is enough – An introduction to Cleaner Production

- SEAM Project – Textile Sector Report Part A

- SEAM Project – Textile Sector Report Part B

- http://www.geosp.uq.edu.au/emc/cp/case%20studies.htm

Here you can find links to case studies, publications, manuals and fact sheets to different industry sectors

- https://www.unido.org/NCPC/Sector/Sectors.cfm

Technical reports and descriptions of different sectors

- UNEP Publications: Technical Report Nº16 "The Textile Industry and the Environment".

- Regional Activity Centre for Cleaner Production (RAC/CP) – Mediterranean Action Plan (MAP): Pollution Prevention in the Textile Industry within the Mediterranean Region

- Cleaner Production Enhancement in Textile Sector in Lebanon – CPET in Lebanon

Annexes

Case study of an interlining fabrics mill

The company, Kufner Textilwerke in Weißkirchen/Stmk. has 200 employees and an annual turnover of approximately US$ 40 million (1992). The Austrian plant is a subsidiary of an international group. The products include less expensive knitted interlining fabrics and fleeces, and interlining fabrics from natural goat and horse hair in a variety of about 200 articles which differ mainly in weight per unit area and finishing. Their main sales are natural hair interlining fabrics which go to the top clothing manufacturers of the world. High quality characterizes the products as well as methods of working and management. "Natural fibres deserve ecologically compatible production methods" was the statement made by the manager of the company at the start of the project.

The company mainly produces finished fabrics from natural fibres in this mill. Therefore the production process includes dry processing as well as wet processing.
The processes include cleaning of goat hair, spinning, sizing, weaving, washing the fabrics (mainly for desizing and removing natural contamination), drying, dyeing part of the fabrics and finishing.

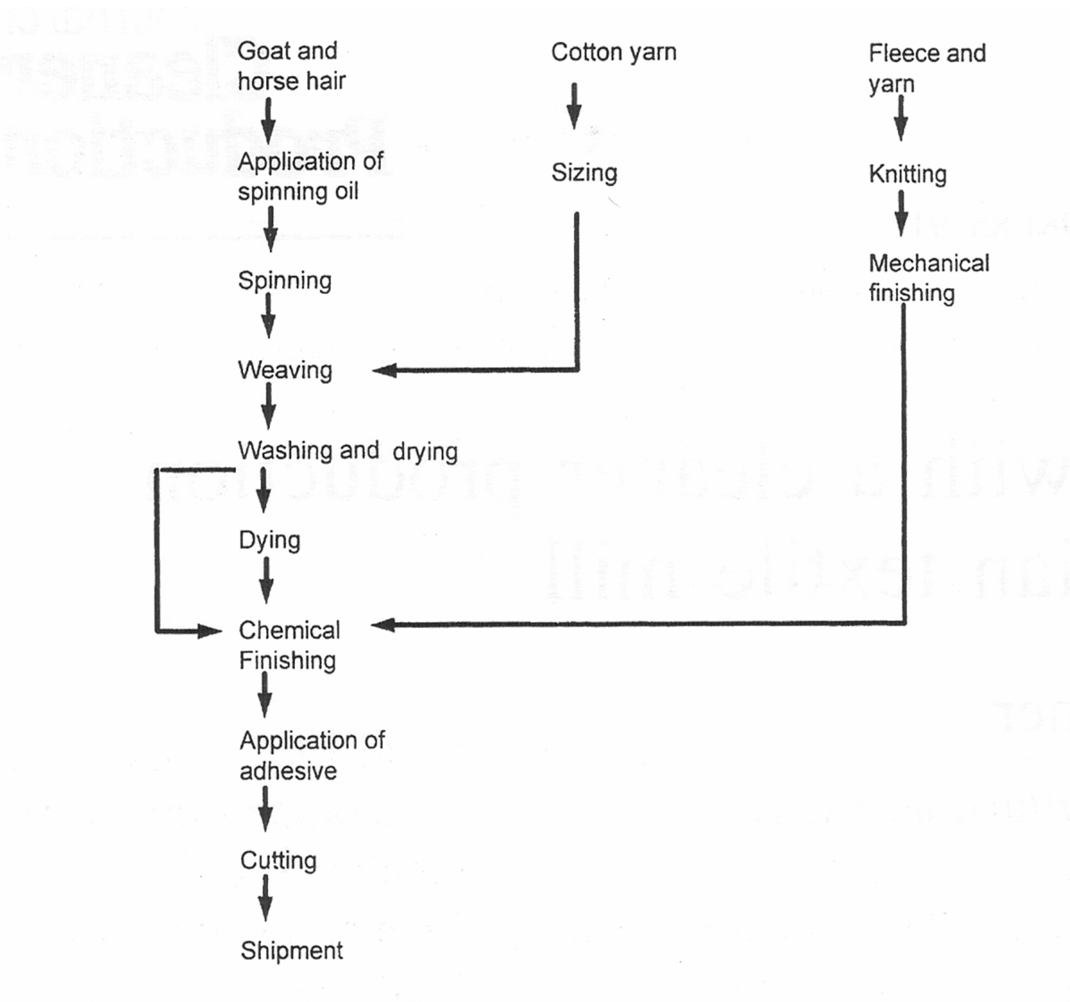


Figure 9: flowsheet of the textile mill

Table 7 gives the process steps and their main emissions. The effluents from the mill are discharged into a publicly owned water treatment plant. The company holds a permit which allows them to release 300 kg/d COD. As production has increased continually, the company exceeded this limit frequently. The waste water quantity was 200 m^3/d when the project started in' late 1992. One of the project's aims for the company was to decrease the high chemical oxygen demand of the waste water. Additional problems were: high peak loads, foaming and intense colour of the waste water. These problems had been addressed in earlier projects, mainly by trying to treat the total waste water stream physically in the plant.

Table 7: process steps of the textile mill

Process step	Waste or emission
Cleaning of hair	short fibres, dirt
Spinning	dust
Sizing	waste water from equipment cleaning
Weaving	waste from cutting edges
Washing	waste water with fibres, sizes and spinning oils
Knitting	Yarn
Dyeing	spent dyeing baths, washing water
Finishing	excess baths, dryer exhaust gas
Coating with adhesive	waste adhesive
Cutting	cutting waste

First of all, a comprehensive inventory of the materials used, energy consumed, products produced and the waste and emissions both to the public treatment works and the atmosphere was made for a business year. A one-day meeting with the management and the accountants of the company was conducted to determine the structure of the inventory, then data were collected, mostly using the accounting system of the company. The weight of the products was known from the quality system of the company.

To determine the composition of waste water and gaseous emissions, analysis of the processes had to be carried out: first, it was determined theoretically which substances went to the waste water and in what amounts by considering physical properties, operational practices and production schedules. Again, workshops with the management and the operators were conducted.

Measurements of the single emission streams were then made to verify the theoretical analysis. The process of producing the first input/output analysis lasted for more than 6 months. The result is shown in simplified form in Table .

Table 8: Input/Output analysis

The inputs included:	The outputs included:
Raw materials (goat and horse hair, cotton yarn, fleece)	Products (finished fabrics, finished fleeces)
Auxiliary materials (size, lubricants, dyes, finishing materials, paste, packaging materials, greasing materials, repair materials)	Waste (contaminated hair, yam, reject product, containers, waste paste, waste fabrics)
Water	Waste water (carrying dirt, short fibres, natural greases, the sizes and lubricants and part of the dyes)
Air, energy (natural gas, electricity)	Gaseous emissions (from exhaust air, burning gas, etc.)

This inventory of masses and costs was done manually in the first run, which was a time-consuming process. But from the figures, which cannot be reproduced here, both the company and ourselves learned a lot: for example, the amount and composition of the waste and the waste water, and we defined efficiencies (ratio of material x in the products to material x purchased). These calculations are now done on a routine basis to illustrate the development and provide a controlling tool. So far, only estimations had been done, so there was no systematic mass balance.

Figure gives an overview of the material flows in the company. Raw and auxiliary materials account only for 3 % of the total mass flows. Of the 3.100 t/a raw materials, 35 % is hair, 58 % yarns, and 7 % fleece. The 800 t/a auxiliary materials consist of 6 % sizes and spinning oils, 20 % finishing chemicals, 6 % dyes and dyeing chemicals and 68 % adhesive paste. Most of the mass flows result from air (95 % for drying and 5 % for burning fuel) and from water (mainly for cleaning the fabrics).

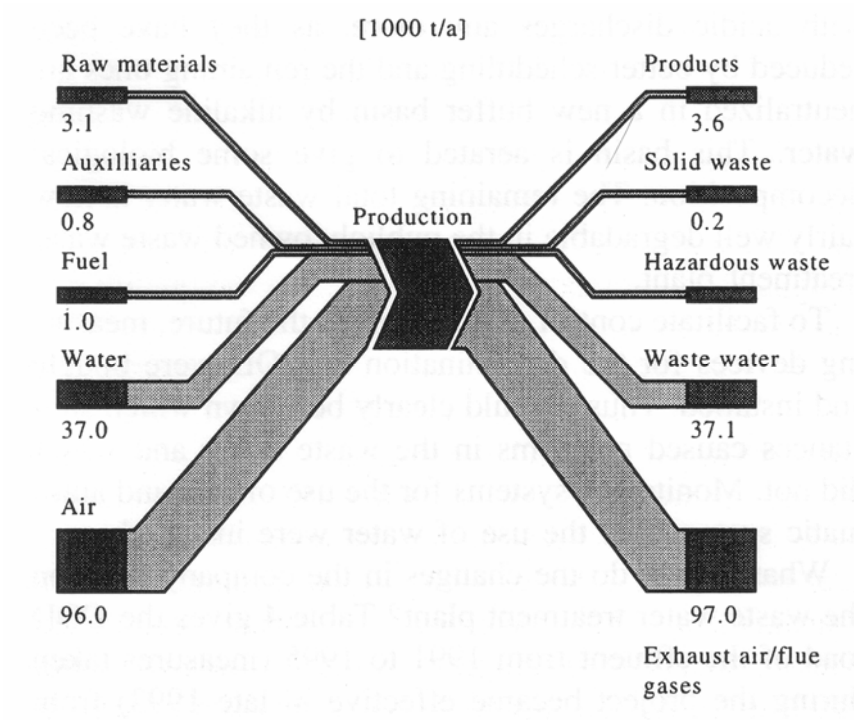


Figure 10: Overview of the materials flows in the textile mill (including raw and auxiliary materials, water and air)

To our knowledge the product and the company are quite unique. There are only a few competitors worldwide. So it is difficult to obtain indicators for direct comparison. To compare the use of water by this mill to other plants we use data from a BAT-study of the European Commission: according to this study, the water consumption for desizing in the textile industry in general can range from 2.5 to 210 l/kg fabric, for dyeing 17 to 25 (values for wool). In our mill, only a small percentage of fabric is dyed. The main water consumption therefore is for desizing. The average consumption in 1992 was 12 l/kg woven fabric. In the production of fleeces, very little water is used for cleaning.

The company has a high consumption of energy: it spent approximately US$ 1 million for energy in 1992, 30 % of this amount for natural gas. 50 % of the gas was fired in the two directly heated stenters, the rest was consumed by the steam boiler.

The solid waste consisted of 25 % reject product, 20 % waste from trimming the edges, 30 % contaminated hair, and 25 % waste paste, scrap iron, and packaging materials. Approximately 3 % of the input raw and auxiliary materials, mainly salts, sizes and spinning oils, were discharged into the waste water. We evaluated these streams for their economical and environmental impact. Regarding economical value, the chemicals lost in the processes were arranged at the top. As regards the ecological impact, waste water and the emissions in it, the flue gases got priority.

Table 9: Priorities in the project

Priority
Input/output analysis
Collection of process data: installment of meters, installment of laboratory, definition of procedures
Waste water: reduction of waste water loads
Stenter: Reduction of energy consumptions and emissions
Solid waste: improved waste logistics, composition of contaminated hair
Hazardous waste: fine filtration
Electricity

With this analysis to hand, we defined the priorities: the water supply and waste water system of the company was one area for more detailed work, the stenter and its gas consumption another, solid and hazardous waste the third and the consumption of electricity in general the last one.

During the second part of the project, we looked for options to reduce waste and emissions. As a result, water consumption was analysed in detail. The flow of water was traced through the processes, flow schemes were produced, and data collected describing the water consumption of each single machine independent of time and product. Similar work was done in respect of the other priorities. A good overview of cleaner production options in the textile industry can be taken from the UNEP technical report on the textile industry.

The results of the project were: 10 % of the process water could be saved by reusing cooling water as process water, 20 % of water usage could be avoided by optimizing the use of water through better process control, mainly in the washing process (e.g. switching off the water supply when the equipment is not used). Water is also saved by consequently applying the counterflow principle to the washing step: the fabrics are washed in two steps. The fresh water is added in the second step. The waste water from the first step is used to preclean the fabrics in the first step.

We also assessed the input materials for their ecological impact. For this, the suppliers were asked to produce data on the composition of, and ecological evaluations on, their materials. Most of them co-operated on an active basis. We also asked for the exact task of the material in the process, as well as its dosage.

The largest sources of COD in the waste water were identified: they turned out to be fibres, sizes, spinning oils, paste and finishing baths. Thirty per cent of the chemical oxygen demand in the waste water of the plant could be avoided: fibres and dust are now kept out of the water by vacuum cleaning the fabrics before washing them and removing fibres from the waste water by a sieve. The solids can be landfilled.

The company now uses sizes and spinning oils which have a higher yield, a lower consumption and a better biodegradability.

Additionally, operational sequences have been partially changed to avoid wastes by frequently changing finishing baths: if it is possible, small lot sizes are avoided and a number of small lots is collected to form one big lot. The operators were trained to calculate the exact demand of chemicals to avoid bath rests. To optimize dosage and to avoid losses of chemicals, in 1995 an automatic dosage system for finishing chemicals was installed. This investment of US$ 200,000 is estimated to pay for itself within 2 years.

Adhesive paste, used to glue the interliners to the fabrics in producing jackets, which is spilled during production or during the cleaning of equipment is recovered by filtering waste paste with a sieve and reusing it instead of disposing of it. This saves the company over US$ 1OO,OOO per year. Some components of the finishing baths are no longer used, because the quality of the fabrics is acceptable without them. Others have been substituted because of their high volubility in the subsequent drying process. A basin for buffering the waste water was also built to eliminate peak loads for the publicly owned water treatment plant.

Wasted dyeing baths are reused once now in preparing new baths: Thus the emission of dyes is reduced by 50 %. The accumulation of natural greases and of traces of spinning oils prevents a further reuse.

Peaks of COD are eliminated, the COD load of the primary effluent has been reduced by 30 % in spite of the introduction of a fourth shift in weaving and finishing, which are the waste water producing production steps. The BOD,, which used to be as low as 7-10 % of the COD, is now well above 25 %. There are no problems with acidic discharges any more, as they have been reduced by better scheduling and the remaining ones are neutralized in a new buffer basin by alkaline washing water. This basin is aerated to give some biological decomposition. The remaining total waste water is now fairly well degradable in the publicly owned waste water treatment plant.

To facilitate control of materials in the future, measuring devices for the determination of COD were bought and installed. Thus it could clearly be shown which substances caused problems in the waste water and which did not. Monitoring systems for the use of fuel and automatic systems for the use of water were installed.

What impact do the changes in the company have on the waste water treatment plant?

Table gives the COD load of the effluent from 1991 to 1995 (measures taken during the project became effective in late 1993) from an evaluation made in July 1995.

Table 10: COD load of the effluent from the waste treatment plant

Year	**COD [mg/l]**
1991	74
1992	85
1993	103
1994	16
1995	60

Data for 1995 consider data from January to May. The light transmission of the effluent of the treatment plant, which used to be lower than 30 cm, is now well above 60 cm.

Electricity was saved by frequency controlling blowers in the dryers and the air-conditioning system, and by changing the lighting system to a more energy efficient one.

Hazardous waste could be reduced by 60 % by increasing the life time of hydraulic oils from 1 to 3 years by fine filtrating them with cellulose cartridges. The supplier of the fine filtrating equipment provides analyses of the oil to document the quality of the reprocessed hydraulic oils.

All in all, the company saved in total some US$ 200,000 by taking these measures, with a payback time of approximately 1.5 years. Another important outcome was that the need for an efficient quality management system was shown to reduce the amount of solid waste. Now, the company is preparing for IS0 9000 certification.

Problems with the implementation of options arose from:

- the need for time to test changes in recipes
- the need to keep production flexible due to quick responses to customers' demands
- simultaneous time demand for quick and simple solutions
- steadily increasing production for plants that were built for much lower production, thus increasing the amount of sizes to facilitate weaving at higher velocities, and rising temperatures in the stenters to increase drying velocity

Two research projects resulted from this project (Table), which were conducted by the company after the end of the project together with the equipment suppliers.

One of these was to further minimize the use of water in the washing process by recycling the washing water. Experiments were carried out to clean it by ultrafiltration, whereby the sizes could be recovered from the washing water. Tests with different types of membranes were conducted. The results were very promising, however the suppliers did not give guarantees regarding cost and performance of equipment because of the complex composition of this waste water stream (sizes, spinning oil, natural contamination from the hair). In principle it is possible to reduce the use of washing water by more than 50 %, but at the moment investments and the risks involved are too high, regarding the unusually low local price for the sizes. As a result this option was not realized.

Size recovery could become economically interesting only if production increases by roughly 300 %, so this option was dropped.

The other project concerned the energy demand of the dryers which could be further reduced if the leakage of air through the inlet and outlet could be minimized (not the case with the present equipment (Table)). However, the drying process was improved by vacuum removal of water and by introducing muffles to improve the control of the gas flow in the chambers of the stenter.

This however cannot eliminate the formation of “blue haze”, so it was decided to install a gas washer in the near future.

Table gives an overview of the measures which resulted from the project.

The installation of a laboratory, and the teamwork in the company have changed the knowledge of the environmental effects of the company completely. The controlling tools (input/output analysis, water meters) supply the company with the necessary information. There is now continuous control of the environmental impact. The company has become a reference, both for the suppliers and within its own group.

A quality management system was established to decrease quality waste and further increase productivity.

Table 11: Research projects resulting from the case study "inlay fabrics mill"

Title	Description	Aims	Results
Optimization of washing process	Ultrafiltration and recycling of water in combination with possible substitution of sizes and optimization of existing equipment	75 % reduction of water usage, 50 % recycling of sizes	Investment too high at the moment. Recovery of water possible, at the moment not economical
Minimization of stenter emissions	Improved control in combination with substitution of chemicals and optimization of equipment	Elimination of "blue smog", further reduction of energy consumption	Further reduction in gasconsumption, limited by air leaks, which cannot be avoided with present equipment

Table 12: Selected measures resulting from the project and their results

Year	Measure	Result
1993	Control of water in washing machine	-20 % water use, no relevant cost
1993	Reuse of cooling water as process water	-10 % water use, no relevant cost
1993	Installment of vacuum cleaner and rotary sieve to keep solids out of washing water	-30 % COD
1993	Changing operational sequences in finishing	less wasted finishing bath rests, no relevant cost
1993	Filtering of spilled paste	contributes to less COD in waste water and saves several US$ 10,000 a year, no relevant cost
1993	Substitution of components of finishing bath	lower emissions of hydrocarbons to the exhaust fumes, hardly quantifiable
1993	Changing lighting system	- 30 % electricity for lighting in certain areas, payback 2 years
1993	Fine filtration of gear and hydraulic oils	- 60 % hazardous waste, payback 2 years
1993	Frequency control of blowers	less electricity, - 15 % gas consumption in dryers, payback 1 year

1993-1996	Better waste logistics, composting of dust and dirt, external recycling of textile waste	-75 % industrial waste (quality domestic waste)
1993	Installation of a waste water buffer basin	elimination of peaks
1994	Reuse of spent dye bath	-50 % colour in waste water
1994	Installation of own laboratory	
1994	Input/output analysis as controlling tool	
1995	Modification of burners in stenter First drying step by vacuum removal of water	not yet quantified
1995	Dosage system for finishing chemicals	annual savings of US$ 100,000, payback 2 years
1995	Voluntary emissions report	
1996	Introduction of quality management system	
1996	Open Day	

To cite the management at the end of the project: “Suddenly we became aware of things we used to be blind to”. Today there is regular feedback of the actual consumption of raw materials, water and energy. The installed electronic data processing is primarily working on a material balance and improves the flow of information. Their own laboratory now allows the study of new raw materials, a steady control and washing, dyeing and finishing experiments: measures that pay off economically as well as ecologically. Also the communication of the management with the authorities has changed fundamentally: the company now keeps a record of the daily water consumption, waste water and its COD and supplies the local authorities with a monthly report.

- Cleaner Production Assessment Report -

Introduction

1. Objectives and description of the CP report form:

Cleaner Production in the view of this project is a systematic approach to operational improvement of foundry companies. In this context it is quite important to state that your company know-how is the most important expertise to develop economically and environmental friendly solution for the benefit of your organisation. You know your procedures best and it is essential for the success of a CP project that this knowledge, detailed information about your company, is compiled and transferred to the external CP expert. Only with the help of this data the consultant is able to analyse strength and weaknesses of the organization as a hole and is able to generate reasonable business solution from an external point of view.

The methodology of this knowledge and data collection depends on the specific situation of your company, and may sometimes be rather exhaustive. In big companies, a lot of data may already be available and electronically retrievable by simply pressing some keys. In other companies only few data will be available and need to be generated during the assessment phase of this project. In any way the result of the first project phase will be a comprehensive collection of your company data to identify feasible CP options, to assess the development and results of the measures and to provide the management with figures for project review. The data acquisition will as well be the basis for the technology assessment report and the final Cleaner Production report.

To facilitate you an efficient and effective data acquisition in compliance with the CPC CP methodology the international expert team has developed a format for the CP report containing all necessary instructions, data form sheets and tables to develop the final CP report. This report will be completed during the project by developing and completed step by step all form sheets and tables. You will get detailed instructions to each table and additionally the international and national CP expert team will assist you in developing the database of your company.

The report will include basic information of your company, a detailed data inventory, the formulation priority areas and reasonable measures, an action plan and appropriate indicators for the implementation and monitoring of the identified CP options. The report will in the final stage also contain your environmental policy and technology recommendations.

The report will be evaluated by the CPC project managers. All company specific data will be kept confidential.

2. User instructions

Generally you are kindly asked to follow the instructions given in the report form. In case of difficulties and questions the external CP experts will assist. Please look as well in the supporting documents of the workshops were you can find details on data acquisition. The table of contents at the beginning shows the structure of the report and the eight chapters. All chapters will have specific objectives, instructions for the correct completion of the tasks and a description of the expected results.

All forms shall be filled out completely. If some information is not available or not applicable in general or at the time being, please indicate why it was not possible. If possible please keep the MS Word formats, the coversheet and structure as proposed.

UNIDO– CLEANER PRODUCTION PROGRAM

CLEANER PRODUCTION CENTRE LEBANON

Cleaner Production Assessment Report

Of

Textile Company in Lebanon

Introduction

1. Table of Content

2. Initial Environmental Assessment

Objective and description:

This chapter shows you first step in this project. It will demonstrate your initial evaluation of your company's environmental performance. This first evaluation gives the reader a first impression of how you see your company before detailed assessment.

Worksheets:

diagram (Document D1)

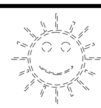
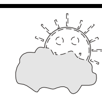
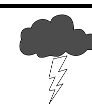
Expected result:

- first ideas about your strengths and weaknesses in your environmental performance
- awareness for the project

Analyse the current environmental performance of your company

Define the strengths and weaknesses of areas with environmental impact in order to define the goals for the work of the project team. A first assessment of the current situation is provided by the "initial diagnosis" with the "Weather diagram". An assessment of the situation with these symbols will probably give better results than grades or percentages.

Worksheet 1-6: Our environmental situation

Company Name:				
Raw material use		*		
Energy use		*		
Waste water	*			
Pollution prevention		*		
Waste separation		*		
Exhaust air		*		
Smell		*		
Noise		*		
Authorities				
Neighbours		*		
Motivation of management	*			
Motivation of employees		*		
Working place condition		*		
....				

3. Company Information

- **Objective:**

This chapter gives a brief company profile and contact information. A small site map shall demonstrate the area of assessment and the location of the departments.

- **Content:**

Company table
Site Map

- **How to use this form?**

Fill in the empty lines

3.1. Company table:

- Company Name	
- Address	
- Phone, Fax	
- e-mail	
- web	
- Trading Since (year)	
- No. of Employees	
- Industrial Process used	
Environmental Team:	
- assigned Environmental Manager and position within the organization	
- Team members and positions	
Contact Person: Name Phone Fax and e-mail Position	

3.2. Brief Company profile

Please describe your company in a paragraph. Present your products, ownership, certifications, strengths, …

The Company was established in 1987. The good reputation enabled the company to mark in the textile industry as a leading manufacturer, importer, exporter and distributor.
We carry the largest and most diversified selection of textile fabrics and clothes piece goods.
The companies offer a lot of the highest level of quality, with complete program of continual work in conducting the operator of production to offer the best satisfaction to the customers.
The company employs more than 100 persons

3.3. Process Flow Chart

- **Objective and Description:**

What are the most important inputs and outputs in the individual processes? Processes which take place as part of your company's activities can be represented using a detailed process flow chart. Flow chart production is a key step in the assessment and forms the basis for material and energy balances which occur later in the assessment. Process flow charts should pay particular attention to activities which are often neglected in traditional process flow charts, such as:

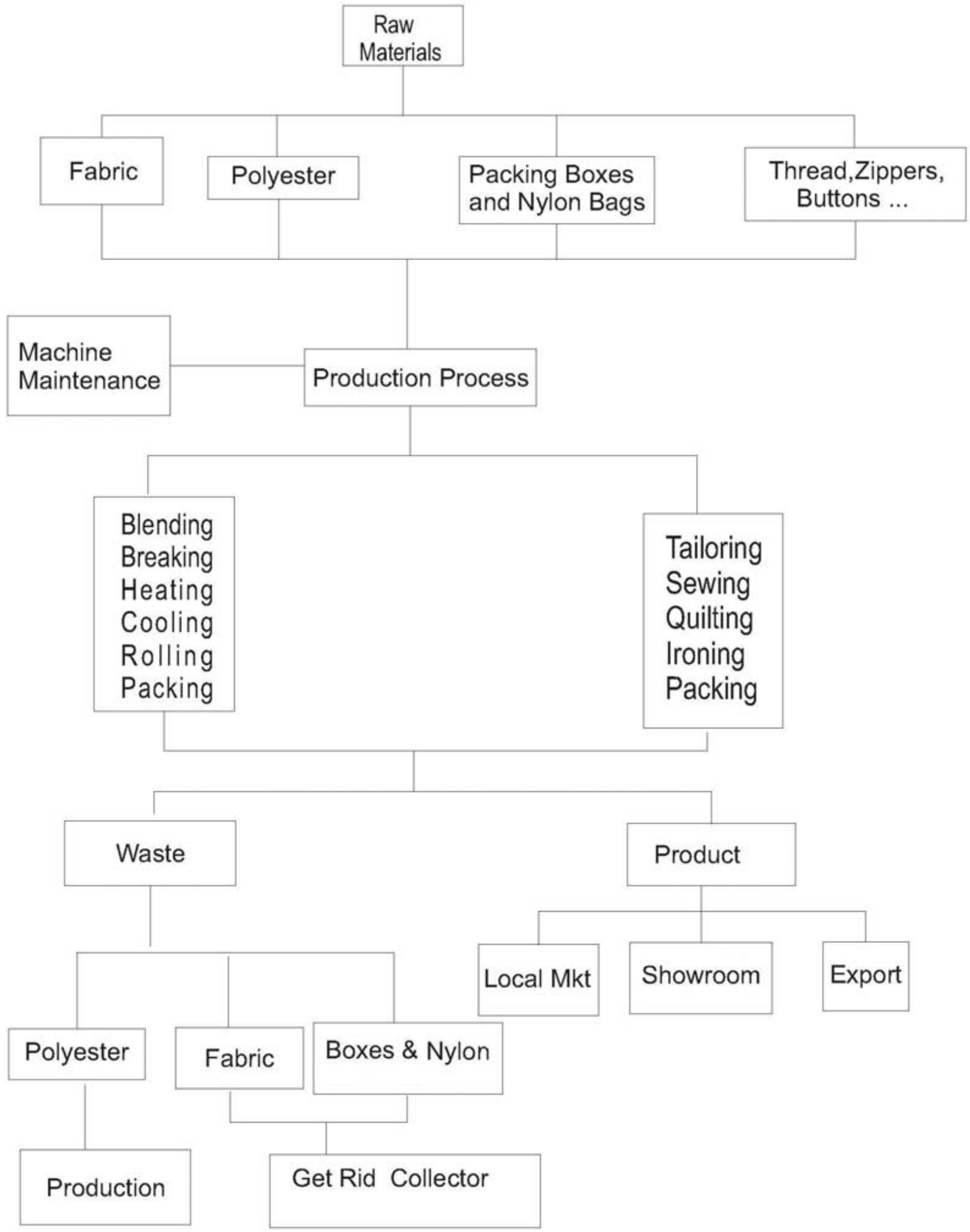
- cleaning; materials storage and handling; ancillary operations (cooling, steam and compressed air production); equipment maintenance and repair; materials that are not easily recognisable in output streams (catalysts, lubricants etc.), waste from shut down, by-products released to the environment as fugitive emissions.

The process flow chart is meant of providing an overview and should thus be accompanied by individual input/output sheets for each unit operation or department.

- **How to use this form?**

Please prepare a flow chart of all processes and find a logic way of numbering. Use boxes for the processes and arrows for the flow of materials and energy. Try to differentiate core and auxiliary processes.

Company Flow Chart



4. Environmental Policy

The Policy should be defined after assessing the environmental impacts of the organization. The policy should outline the commitment of the management to reduce its negative environmental impacts. The policy should also state how the company continuously improves their environmental performance. The policy must be signed by the management of the organization.
(If possible prepare the policy in accordance to the regulation of ISO 14001)

The environmental shall draft an environmental policy during the project period and hand it to the management for reviewing. For the ECOPROFIT award all companies have to present an environmental policy.

5. Summary of production data

- **Objective:**

This chapter gives a detailed description of the production figures on a yearly basis. These figures will help the consultants to understand the main raw material flows and the cost profile of your company. These figures are very important to develop an appropriate indicator set for the company. These indicators can then easily be compared with benchmarks from other companies. The important waste streams of you company will give information about you waste management and your resource efficiency in general. This summary is an overall compilation of the main inputs and outputs of the company independent of the different process steps.

- **How to use this form?**

Please fill in the empty lines in the form sheets (1-4) with annual data. These forms were distributed already in workshop one. Please copy, if already done in the CP report, if not please fill in with care and try to give accurate figures from you last fiscal year. Where the data are not available please indicate why – where data are not applicable leave the space free. The data you require you can usually find at different sites – i.e.

Entry:

- documents for book-keeping and cost accounting,
- waybills,
- information of suppliers concerning formulae,
- in-house data identification concerning packaging
- ...

Use:

- cost centre accounting
- measurements at plants and machines
- information from staff concerning operating hours and change intervals
- bills of materials
- formulae
- machinery specifications (manuals)
- rating plates

Exit:

- product lists and formulae,
- records of waste and emissions, waybills
- settlement of accounts with disposal companies,
- information of the waste water association
- ….

5.1.1 - Worksheets

Worksheet 1-1: The most important products/services

Company: Editor: Page:

No.	Product or service / purpose	Quantity per annum	Unit
1	Home Textile	1,000,000	sets
2	Bath & Towel Line	5,000,000	sets
3	Shirts	16,000	Pieces
4	Pants	35,000	Pieces
5	Sports Wears	30,000	Pieces

Worksheet 1-2: The main raw and auxiliary materials[1]

Company: Editor: Page:

No.	Material	Quantity per annum	Unit	Specific costs in …….	Total costs in ……	Purpose / use	% going into the product
	Fabric	2,300,000	MTS		4,600,000 $	Main Products	
	Polyester	860,000	Kg.		1,500,000 $	Main Products	
	PVC Nylon	400,000	Pc.		140,000 $	Main Products	
	Nylon Rolls	18,500	Kg.		50,000 $	Main Products	
	Pads	275,000	PC		20,000 $	Main Products	
	Packing Boxes	90,000	PC		15,000 $	Main Products	
	Towels By Meter	44,000	MTS		200,000 $	Main Products	
	Zipper	5500	Pieces		13,000	auxiliary materials	
	Bottom	350000	Bottom		1,000	auxiliary materials	
	Yarn	11000	cone		8,500	auxiliary materials	
	Ruban	300	kg		2,000	auxiliary materials	
	Inter fabrics	1500	kg		6,000	auxiliary materials	

[1] Please consider:

milk, other inputs (milk powder, sugar, flavours, marmalade, …), water, packaging materials, cleaning agents (caustic, acids, disinfectants, …), lubricants,

Worksheet 1-3: Energy data

Company: Editor: Page:

No.	Energy	Amount per year	Unit	spec. costs	Conversion into kWh	Consumption in kWh	Share in %	Total costs in	Share in %
1	Electricity Peak load	450,000/year	kWh kW	0.08		450,000kw/year		36,000 $	27.95 %
2	Dsitrict heating Peak load		GJ kW		x 277,8				
3	Oil	100	kg	3 $	x 11,4			300 $	0.25 %
4	Gas	50,000	LITRES	1.3 $	x 10,0			65,000 $	50.45 %
5	....								
6	....								
7	....								
8	....								
9	Fuels: Diesel Gasoline	55,000	Liter Liter	0.5 $	x 10,0 x 9,0			27,500 $	21.35
10	....								
	Total:						100 %	128,800 $	100 %

Worksheet 1-4: The main waste and emissions[2]

Company: Editor: Page:

No	Waste / liquid or gaseous emissions	Quantity per annum	Unit	Spec. disp. costs	Purchasing costs	Disposal costs	Total costs
1	FABRIC	30,000	KG	2	60,000 $		
2	CARTOONS	8,000	KG	1.75	14,000 $		
3	Plastic/Nylon	4,000	Kg	0.5	2000 $		
4	Different sewing Tools	500	Kg	2 $	1,000 $		
5	water	200,000	Liter				
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							

[2] please consider: waste water, waste water load (BOD, COD, …), whey, solid waste (glass, metall, plastics, paper, industrial waste), hazardous waste

Worksheet 1-5: Possibilities of minimizing waste and emissions in our company

Company: Editor: Page:

Waste / Emission / Problem zone	Which possibilities are available in our company?
Solid: Fabric + Towels + Damaged Boxes + Nylon	Recycling
Emissions: Mainly gaseous emissions from Dacron machine oven.	Subject to several filters to minimize the toxic effect of these emissions.
Fresh water extra use	Optimizing water recycling loop
Water vapor	Measuring the loss if any and optimizing the loop
High energy cost	High electricity and Fuel oil usage, possibility of cogeneration system under study

6. Mass and energy balances for option finding

Worksheet 2-1:

Benchmarks: Name if known **Process: Name and Number**							
Input		**Source of information**	**Output**			**Source of information**	
Name:	Quantity	Value		Quantity	Balance	Value	Loss
raw material 1:			product 1:				
raw material 2:			product 2:				
raw material 3:			product 3:				
water:			non-product 1:				
energy:			non-product 2:				
others 1:			non-product 3:				
others 2:			waste water:				
others 3:			energy loss:				

7. Generation and Implementation of the CP Options

- **Objective:**

Identifying Cleaner Production opportunities depends on the knowledge and creativity of the project team members and company staff, much of which comes from their experience. Many Cleaner Production solutions are arrived at by carefully analysing the cause of a problem.

Another way of identifying Cleaner Production opportunities is to hold a 'brainstorming' session, where people from different parts of the organisation meet to discuss solutions to specific problems in an open and non-threatening environment.

Some other sources of help from outside the organisation could be:

- this guide and the workshop texbooks
- external industry consultants;
- sector associations;
- equipment suppliers;
- literature and electronic databases

Once a number of Cleaner Production opportunities have been suggested and recorded, they should be sorted into those that can be implemented directly and those that require further investigation.
The objective of the evaluation and feasibility study phase is to evaluate the proposed Cleaner Production opportunities and to select those suitable for implementation.

Technical evaluation

The potential impacts on products, production processes and safety from the proposed changes need to be evaluated before complex and costly projects can be decided upon. In addition, laboratory testing or trial runs may be required when options significantly change existing practices. A technical evaluation will determine whether the opportunity requires staff changes or additional training or maintenance.

Economic evaluation

The objective of this step is to evaluate the cost effectiveness of the Cleaner Production opportunities. Economic viability is often the key parameter that determines whether or not an opportunity will be implemented.

When performing the economic evaluation, costs of the change are weighed against the savings that may result. Costs can be broken into capital investments and operating costs. A standard measures used to evaluate the economic feasibility of a project is the "payback period".

Capital investment is the sum of the fixed capital costs of design, equipment purchase, installation and commissioning, costs of working capital, licenses, training, and financing. Operating costs, if different to existing conditions will need to be calculated. It may be that operating costs reduce as a result of the change, in which case, these should be accounted for in the evaluation as an ongoing saving.

Environmental evaluation

The objective of the environmental evaluation is to determine the positive and negative environmental impacts of the option. In many cases the environmental advantages are obvious: a net reduction in toxicity and/or quantity of wastes or emissions. In other cases it may be necessary to evaluate whether, for example, an increase in electricity consumption would outweigh the environmental advantages of reducing the consumption of materials.

For a good environmental evaluation, the following information is needed:

- changes in amount and toxicity of wastes or emissions;
- changes in energy consumption;
- changes in material consumption;
- changes in degradability of the wastes or emissions;
- changes in the extent to which renewable raw materials are used;
- changes in the reusability of waste streams and emissions;
- changes in the environmental impacts of the product.

In many cases it will be impossible to collect all the data necessary for a good environmental evaluation. In such cases a qualified assessment will have to be made, on the basis of the existing information.

Given the wide range of environmental issues, it will probably be necessary to prioritise those issues of greatest concern.

- **How to use this form?**

  The **worksheet 2-2** is a compilation of the identified CP options per area of focus. Fill in the option and try to evaluate the feasibility of the option, with the help of the expert team as accurate as possible.

  The opportunities selected during the assessment phase should all be evaluated according to their technical, economic and environmental merit. However, the depth of the study depends on the type of project. Complex projects naturally require more thought than simple projects. For some options, it may be necessary to collect considerably more information. An important source of this information may be employees affected by the implementation.

Worksheet 2-2*:* CP options generated

Give the CP Options according to the table below. The number in the upper left corner of the table corresponds with the selected Process (see number flow chart)

No.	***If table is not complete for your purposes kindly add new components but keep lay out settings***	Only fill out **Pos** (= positive, yes), **Neut** (= neutral, don't know), **Neg** (= negative, no) or **n.a.** (= not applicable, not available)						
Description of CP Option[1]		**Directly Implemented[2]**	**Technical Feasibility**	**Economic Viability**	**Environmental Evaluation**	**Implementation Decision**	**Investment (€)**	**Savings (€)**
1	**Power Saving Bulbs**	**Pos**	**Pos**	**Pos**	**Pos**	**Pos**	6000 $	7800 $
2	**New Generator**	**Pos**	**Pos**	**Pos**	**Pos**	**Pos**		
3	**Re-use of 50 % Fabrics and Polyester waste**	**Pos**	**Pos**	**Pos**	**Pos**	**Pos**	0	30,000 $
4	**Sorting Cardboard and Plastics**	**Pos**	**Pos**	**Pos**	**Pos**	**Pos**	0	5,000 $
5		**Pos**	**Pos**	**Pos**	**Pos**	**Pos**		
6								
Add rows if needed - place cursor at the beginning of this line, go back one position by pressing the "←"-button and press "Enter".								

[1] Try to describe exactly, what should be changed, for example: change of raw material by using recycled material, change manual control of fuel feed for boiler to automatic control consisting of preventative maintenance etc.

[2] Without further assessment

For every focus a table can be added by copying the table above.

8. Implementation and continuation

- **Objective:**

The objective of the last phase of the assessment is to ensure that the selected options are implemented, and that the resulting reductions in resource consumption and waste generation are monitored continuously.

As for other investment projects, the implementation of Cleaner Production options involves modifications to operating procedures and/or processes and may require new equipment. The company should, therefore, follow the same procedures as it uses for implementation of any other company projects.

However, special attention should be paid to the need for training staff. The project could be a failure if not backed up by adequately trained employees. Training needs should have been identified during the technical evaluation.

- **How to use this form:**

Preparation of an action plan: To ensure implementation of the selected options, an action plan should be developed, detailing:

- activities to be carried out;
- resource requirements (finance and manpower);
- the persons responsible for undertaking those activities;
- a time frame for completion with intermediate milestones.

Worksheet 2-3 gives an example for an action plan:

It is very important to evaluate the effectiveness of the implemented Cleaner Production options. Typical indicators for improved performance are:

- reductions in wastes and emissions per unit of production;
- reductions in resource consumption (including energy) per unit of production;
- improved profitability.

There should be periodic monitoring to determine whether positive changes are occurring and whether the company is progressing toward its targets.

8.1. Worksheet 11: Action Plan

Give a detailed action plan table

No.	Task	Resources needed (if any)	Responsible person	Date due	Date accomplished
1.					
2.					
3.					
4.					
5.					
6.					

9. Sustain Cleaner Production activities

- **Objective:**

If Cleaner Production is to take root and progress in an organisation, it is imperative that the project team does not lose momentum after it has implemented a few Cleaner Production options. Sustained Cleaner Production is best achieved when it becomes part of the management culture through a formal company environmental management system or a total environmental quality management approach.

An environmental management system provides a decision-making structure and action plan to support continuous environmental improvements, such as the implementation of Cleaner Production.

If a company has already established an environmental management system, the Cleaner Production assessment can be an effective tool for focusing attention on specific environmental problems. If, on the other hand, the company establishes a Cleaner Production assessment first, this can provide the foundations of an environmental management system.
Regardless of which approach is undertaken, Cleaner Production assessment and environmental management systems are compatible. While Cleaner Production projects have a technical orientation, an environmental management system focuses on setting a management framework, but it needs a technical focus as well.

Like the Cleaner Production assessment, an environmental management system should be assessed and evaluated on an ongoing basis and improvements made as required. While the specific needs and circumstances of individual companies and countries will influence the nature of the system, every environmental management system should be consistent with and complementary to a company's business plan.

- **How to complete form:**

Write in this section how you a planning to sustain your project. Compile a report to the management for reviewing with discussions about lessons learned, savings archived and achievable, recommendations (from the CP expert to the management) and the next steps of the projects. Outline the continuous improvement process and the possibility for the future.

10. Annex

Containing all relevant additional data.