SEAM Programme

A Guide for Cleaner Production Opportunity Assessments in Small and Medium Enterprises

Ministry of State for Environmental Affairs
Egyptian Environmental Affairs Agency

Entec UK Ltd., ERM
UK Department for International Development

A Guide to Undertake Cleaner Production Opportunity Assessment for Micro, Small and Medium Enterprises

SEAM Programme
Implemented by:

Ministry of State for Environmental Affairs
Egyptian Environmental Affairs Agency
Entec UK Ltd
ERM
UK Department for International Development

GUIDANCE MANUAL PRODUCED BY THE SEAM PROGRAMME

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About the SEAM Programme

1.1 The SEAM Programme – An Introduction

Support for Environmental Assessment and Management (SEAM) is a major environmental programme implemented by the Egyptian Environmental Affairs Agency (EEAA), Entec UK Ltd and ERM with support from the UK Department for International Development (DfID).

The SEAM Programme aims at improving environmental planning and services for the poor and strengthening decentralized environmental management. It has four components focussing on environmental management issues. These include developing Governorate Environmental Action Plans (GEAP) in four Governorates in Egypt (Sohag, Dakahleya, Qena, Damietta and South Sinai), delivering community environmental projects (CEPs) that benefit the poor, improving solid waste management and implementing cleaner production (CP) projects in industry to enhance competitiveness and reduce pollution.

1.1.1 The Cleaner Production Component

The main goal of the Cleaner Production component is to show that significant financial savings and environmental improvements can be made by relatively low-cost and straight-forward interventions, such as good housekeeping, waste minimization, process modification and technology changes. This approach was recognized as having two benefits – valuable materials can be recovered and reused, rather than being wasted, and industries move towards environmental (legislative) compliance.

1994-99 - Cleaner Production initiatives were successfully undertaken in medium to large scale Egyptian industrial units in the textiles, food processing and edible oil and soap sectors. 32 factories were audited and 21 Demonstration Projects implemented at a cost of LE16 million, with an average pay back of 6 months. Examples of interventions included water and energy conservation, ecolabelling for textile exports, oil and fats recovery, HACCP, recovery of cheese whey, etc.

(2000-05) - The programme focused primarily on micro, small and medium size enterprises (MSMEs) in Egypt. It focused on 4-5 main priority sectors in five governorates which are the food, metal foundries, textile, furniture and other miscellaneous small industries. About 100 audits and 30 demonstration projects are to be undertaken in MSME priority sectors including food processing, metal foundries, furniture, textiles, and other miscellaneous projects. The aim here is to enhance efficiency, reduce pollution, yield financial savings and improve the environment for surrounding communities.

More information on various sector manuals and case studies may be procured from http://www.seamegypt.com/indust.htm.

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Introduction

1.1 About this Guidance Manual

This manual is intended to provide a practical guidance to professionals and environmental consultants in Egypt for promotion of Cleaner Production in Micro, Small and Medium Enterprises (MSMEs).

Specifically, the manual provides guidance on

1. How to promote Cleaner Production in Industries, particularly MSMEs
2. How to prepare for and conduct Rapid Cleaner Production Opportunity Assessments (CPOA),
3. How to prepare for and conduct Comprehensive CPOA,
4. How to transform the result from CPOA to one or more projects for implementation,

This manual is not sector-specific; rather, it is intended to present a generic CPOA-cum-implementation project methodology that can be used across various manufacturing sectors and service sectors. The annexes to this manual however contain resources for specific manufacturing sectors relevant to Egypt.

1.2 Why Focus on MSMEs?

MSMEs are a critical component of the Egyptian economy. Egypt was in fact one of the participants in the Bologna Charter [1] meet on Small and Medium Enterprises (SMEs) policies held in June 2000, which highlighted the need for focusing on SME growth in national economies.

MSMEs in Egypt are classified as shown in **Table 1.1** below.

Table 1.1: Definition of MSMEs in Egypt[2]

Category	*Labour*
Micro	1– 4
Small	5 – 14
Medium	15 – 49

[1] Refer to http://www.oecd.org/EN/document/0,,EN-document-0-nodirectorate-no-20-1360-0,00.html for more details.

[2] Taken from http://www.sme.gov.eg/sme_statistical_information.htm

The MSMEs represent the main bulk of the private sector companies (more than 90%) responsible for the present and future development of the economy[3]. MSMEs provide 77% of jobs in the non-agricultural private sector and generate 80% of the economic value added in Egypt. The government expects these enterprises to employ half of the annual new entrants to the labour force over the next 20 years[4].

The growth of MSMEs, while beneficial to the Egyptian economy, has led to adverse environmental impacts and degradation. MSMEs typically develop in clusters. As a result, pollution loads on a collective basis have been found to be often quite high even if the environmental impacts of individual units are negligible. Many a time, such enterprises are frequently located near human settlements. As a result, they pose considerable on-site and off-site risks to the neighbourhood as well as to the environment.

Increasingly stringent environmental legislation poses a threat to the survival of these units, which are a crucial component of the economy, and a source of employment to a large segment of the population. MSMEs are unable to meet environmental regulations, mainly because of high capital and operating costs, space constraints and lack of adequate skills for operating the facilities. Besides the environmental requirements, MSMEs in Egypt are facing severe competition, both in the domestic and export market, requiring process and product improvements, adoption of new technologies and building of newer skills.

It is therefore critical to develop practical, cost-effective and sustainable solutions that could address both environmental and productivity concerns of the MSMEs. **The concept of Cleaner Production presents such a strategy.**

1.3 What is Cleaner Production?

The United Nations Environment Programme - Division of Technology, Industry and Economics (UNEP DTIE) defines Cleaner Production as:

"The continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency, and reduce risks to humans and the environment. Cleaner Production can be applied to the processes used in any industry, to products themselves and to various services provided in society."

3 Fawzy, Samiha: The Business Environment in Egypt, ECES working paper 34, Cairo, November 1998. (taken from http://www.sme.gov.eg/sme_statistical_information.htm)

4 Handoussa, Heba: Employment, Budget Priorities and Micro enterprises, Paper prepared for a conference on Employment and Unemployment in Egypt, Cairo, January 2002. (taken from http://www.sme.gov.eg/sme_statistical_information.htm)

Box 1.1 gives us the operational definition of Cleaner Production.

Box 1.1: The operational definition of Cleaner Production

The operational definition[1] of Cleaner Production is as follows:

- For **production processes**, Cleaner Production results from one or a combination of conserving raw materials and energy, substituting toxic hazardous materials with more benign materials, and reducing the quantity and / or toxicity of all emissions and wastes before they leave the production process;
- For **products**, Cleaner Production focuses on reducing environmental impacts along the entire life cycle of the product (from raw material extraction to its ultimate disposal) through appropriate design
- For **services**, Cleaner Production incorporates environmental concerns into the design and delivery aspects

This definition of Cleaner Production makes the following pertinent points.

- Cleaner Production is a continuous application, not a one-time activity.
- Cleaner Production addresses life cycle impacts, health and safety concerns and emphasizes risk reduction. In this perspective, Cleaner Production is a holistic environmental management strategy.
- Cleaner Production does not deny growth but insists that it be ecologically sustainable. It is a 'win-win-win' strategy protecting the environment, the health and safety of consumers and workers while improving efficiency, profitability, and competitiveness.

Cleaner Production makes sound business sense to industries and service providers as it often results in cost reduction, improved productivity and enhanced competitiveness of wider markets. Cleaner Production assists regulators in developing proactive strategies for complementing enforcement, or command and control.

At the time UNEP embarked on the overarching concept of cleaner production in 1990, a number of quite similar concepts were existent and many others subsequently emerged. In the real world, some of these concepts are better applied in some places rather than others. It is important therefore to clarify what is cleaner production is in relation to some of these concepts.

Many preventive terms — such as eco-efficiency, pollution prevention, waste minimization, and source reduction — are in use today. However, the definition of Cleaner Production adopted by UNEP DTIE provides a more systemic and holistic approach to process oriented concepts of waste minimization / pollution prevention / eco-efficiency.

Concepts similar to cleaner production may be grouped into six parts: parallel approaches, allied approaches, developmental approaches, product-related approaches, service-related approaches and associated tools. These approaches are discussed below.

Parallel Approaches

Green Productivity: It is a term used by the Asian Productivity Organization (APO) to address the challenge of achieving sustainable production. APO started its Green Productivity Programme in 1994. Just like cleaner production, green productivity is a strategy for enhancing productivity and environmental performance for overall socio-economic development. The concept of green productivity and cleaner production are almost synonymous.

Eco-efficiency: The term was coined by the World Business Council for Sustainable Development (WBCSD) in 1992. It is defined as the delivery of competitively priced goods and services that satisfy human needs and ensure quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity. This concept is favoured by many in the industrial sector. The concepts of eco-efficiency and cleaner production are almost synonymous.

Waste Minimization: The concept of waste minimization was introduced by the U.S. Environmental Protection Agency (USEPA). In this concept, waste and pollution reduction occurs on-site, at the source through changes of input raw materials, and / or technology changes, good operating practices and product changes. Compared to cleaner production, waste minimization is in one sense broader, in that it also includes off-site recycling of waste, but in another sense, it is narrower, since it does not cover product (re)design to minimize all life cycle impacts.

Pollution Prevention: The terms cleaner production and pollution prevention are often used interchangeably. The distinction between the two tends to be geographic - pollution prevention tends to be used in North America, while cleaner production is used in other parts of the world. Both concepts focus on a strategy of continuously reducing pollution and environmental impact through source reduction - i.e. eliminating waste within the process rather than at the end-of-pipe. However, cleaner production includes the aspect of reduction of impacts and risks across the life cycle of a product, and in this sense is a more comprehensive concept than pollution prevention5.

Source Reduction: Source reduction is a term that is rather synonymous with cleaner production - reducing generation of wastes or contaminants at the source, and thereby reducing releases that could pose hazards to the environment and public health.

Toxics Use Reduction: Toxics use reduction is the elimination or avoidance of toxic substances in products or processes so as to reduce risks to the health of workers, consumers, and the public, and to minimize adverse effects on the environment. Toxics use reduction is a special case of cleaner production since it focuses specifically on the aspect of reducing toxicity / hazards.

Allied Approaches

Energy Efficiency: Energy efficiency is essentially a sub-set of cleaner production. The concepts of energy conservation and renewable energy often have strong elements of cleaner production.

Occupational Health and Safety: It is often the case that efforts to protect the health and safety of workers will require reducing emissions at the source, by changing raw materials or modifying the process. To all intents and purposes, this is cleaner production. In a more indirect way, efforts to make the working environment safer for workers will result in better productivity.

Materials Management Since the purpose of materials management is to manage materials more efficiently and reduce losses and waste, it comes very close to cleaner production.

[5] Note that the acronym P2 is often used for pollution prevention.

Product-Related Approaches

Design for the Environment (DFE): DFE is the systematic consideration, during product design, of issues associated with the environment over the entire life cycle of a product. This approach attempts to create financial and environmental savings by redesigning products to reduce environmental impact. The object is to minimize or eliminate anticipated waste generation and resource consumption in all the phases of the life cycle; viz. raw material sourcing, production, product distribution, use, and disposal. DFE is also called eco-design.

Product-Service Systems: This concept focuses on creating a community-wide system for ensuring the best use and reuse of products. As with DFE, this concept focuses on the product element of cleaner production.

Service-Related Approaches

Sustainable Tourism: This term has strong links with cleaner production. Sustainable tourism requires tourist services to reduce their use of material and energy intensity and to reduce generation of pollution.

Developmental Approaches

Sustainable Development: This term is defined as development that meets the needs of present generations without compromising the ability of future generations to meet their own needs. The strategy of cleaner production is driven by the vision of sustainable development.

Industrial Rationalization: This is a term that deals with large-scale shifts in patterns of industrial production. Since it is often used in circumstances where inefficient industrial sectors are being phased out, it often has a strong, but generally unrecognized, component of cleaner production.

Mise à Niveau: A French term that corresponds to industrial upgrading, this term is used in circumstances where entire industrial sectors are being upgraded and modernized. Such modernization (again) often contains a generally unrecognized component of cleaner production, since modern technologies are often more efficient in their consumption of material inputs.

Associated Concepts

Triple Bottom Line: A methodology for measuring and reporting on financial, environmental and social performance, this tool can have incorporated into it strong elements of cleaner production. Indeed, several cleaner production Centres today have been experimenting with this tool as a way of pushing forward the cleaner production agenda.

Figure 1.1 illustrates the position of cleaner production with respect to some of the concepts outlined above. The blue line represents the boundaries of Cleaner Production.

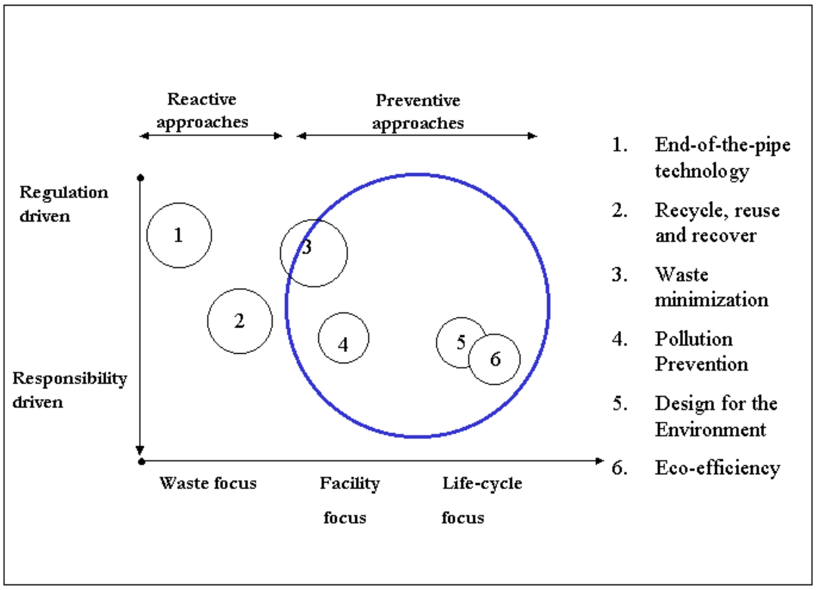

Figure 1.1 Cleaner Production with respect to some other concepts

1.4 Why Adopt Cleaner Production?

Conventional approaches to industrial pollution management tend to focus on end-of-pipe (EOP) treatment of wastes. Here, there is no attempt to reduce waste streams at the source and / or undertake resource recovery. EOP treatment typically consists of sedimentation and neutralization units, bio-oxidation or chemical oxidation reactors. The costs for EOP treatment can be high and tend to escalate as environmental standards become stricter.

In the context of MSMEs in Egypt, setting up new infrastructure for EOP treatment facilities for individual units is an expensive. Training human resources to operate and maintain EOP treatment plants is also very difficult. As noted earlier in **Section 1.2**, pressures such as market competition and rising costs of raw materials require that the MSMEs approach pollution management in an anticipatory or proactive manner. Only then will they earn benefits such as improved environmental performance, enhanced productivity and cost-effectiveness.

Indeed, Cleaner Production presents the MSMEs in Egypt an appropriate strategy to meet environmental as well as economic objectives instead of resorting alone to EOP solutions.

In many cases, EOP approach is necessary in addition to cleaner production to meet the required emission standards. Using cleaner production approach here, helps reduce the investments and costs of end of pipe treatment and also leads to improvement in productivity and profitability of the enterprise.

Figure 1.2 presents the strategic advantages of adopting cleaner production.

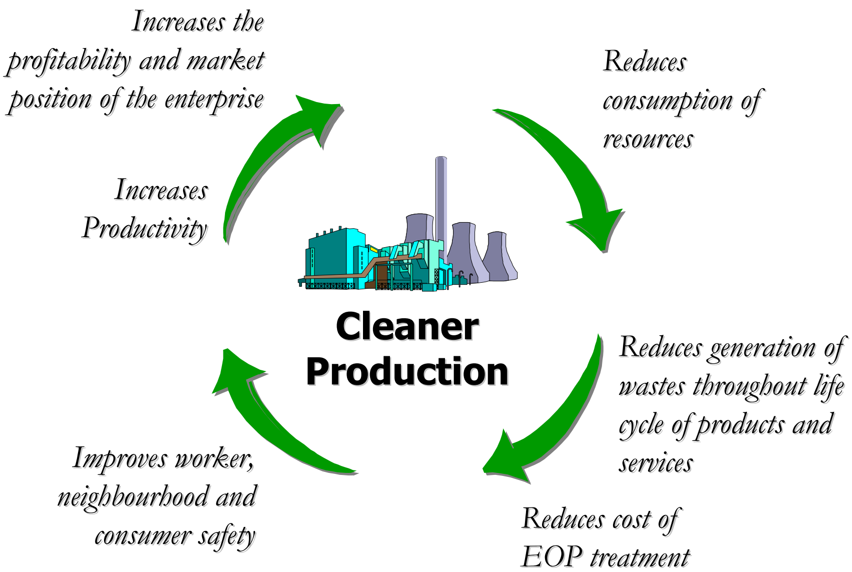

Figure 1.2: Strategic advantages in adopting Cleaner Production

1.5 What are the Barriers to Mainstreaming Cleaner Production?

Cleaner Production is essentially a voluntary initiative and not made mandatory today by Egyptian law. One of the barriers to Cleaner Production has been the *resistance to change*. There are additional barriers such as lack of skills and exposure. Personnel who are assigned the task of pollution prevention and control are generally unfamiliar with the production processes. On the other hand, personnel engaged in production are not exposed to environmental considerations within their industrial unit. Team building is therefore necessary for mainstreaming cleaner production. Finally, barriers exist due to problems such as access to technology and finance.

Box 1.2 gives us a short summary of barriers to Cleaner Production.

Box 1.2: Summary of barriers to Cleaner Production

- Resistance to change
- Lack of information, expertise and adequate training in Cleaner Production
- Lack of communication within the business / units / enterprises
- Competing business priorities; in particular, the pressure for short-term profits
- Perception of risk
- Difficulty in accessing cleaner technologies
- Accounting systems that fail to capture environmental costs and benefits

- Difficulties in accessing external finance
- Failure of existing regulatory approaches, e.g. over-regulation
- Perverse economic incentives (e.g. economic subsidies for business resource inputs (e.g. subsidies on the price of energy / fuel / water)

Cleaner Production Opportunity Assessments and Implementation Projects play a crucial role in resolving most of the above barriers.

1.6 What are Cleaner Production Options?

Cleaner Production may be achieved by adopting one option or a combination of various options, as explained in **Table 1.2.** In reality, Cleaner Production is realized through a basket of options that are implemented and tracked over a period of time. Again implementation of options requires commitment from the top management, availability of finance and training of technical staff for needed adaptation during operation.

Table 1.2: Options for the implementation of Cleaner Production

Type of Cleaner Production option	*Description*
Housekeeping	Improvements to work practices and methods and proper maintenance of equipment can produce significant benefits in terms of saving resources. Housekeeping options are low cost and provide low-to-moderate benefits.
Process rationalization and optimization	Process optimization involves rationalization of the process sequence (for e.g., the elimination of a redundant washing sequence), combining or modifying process operations to save on resources and time, and improve the process efficiency. In some cases, the changes may best be produced by piloting or demonstrating on a small scale. These options are typically low-to-medium cost and provide moderate-to-high benefits.
Raw material substitution	Raw materials may be substituted if better options exist in terms of costs, process efficiency, and reduced health and safety related hazards. Such an approach may be necessary if the materials already in use are difficult to source, or become expensive, or come under the purview of new environmental regulations. It is important to assess the options through laboratory / bench-scale studies and pilots to ensure that the product quality is not changed and is acceptable to the market.
Recovery of useful byproducts and onsite	Much of the waste generated can be transformed into raw materials, by-products, products by practicing direct or indirect recycling,

Type of Cleaner Production option	*Description*
recycling	recovery and reuse. Recovery of useful byproducts would involve the recovery of by-products, which may have useful applications within the industry itself or outside it. Such recovered material may be reused / recycled and thus lead to minimization of waste as well as cost savings. These options are typically medium cost and can provide moderate to high benefits. Recycling and reuse involves the return of a waste material either to the originating process as a substitute for an input material, or to another process as an input material. These options are typically low to medium cost and can provide moderate to high benefits.
New technology	Adopting and transferring new technologies can often reduce consumption, minimize wastes as well as increase the throughput of productivity. These options are often capital intensive, but can lead to potentially high benefits.
New product design	Changing the product design can cause impacts both on the upstream as well as the downstream side of the product life cycle. Product redesign can reduce the toxicity of materials in the product, or reduce the use of energy, water and other materials, or reduce the packaging requirements, or increase the "recyclability" of the used components. This can lead to benefits such as the reduced consumption of natural resources, increased productivity and reduced environmental risks. Often, this helps to both establish as well as widen the market. Product redesign is however a major business strategy and may require feasibility studies and market surveys, especially if the supply chain around the product is already established and complex in nature.

1.7 What is a Cleaner Production Opportunity Assessment?

Cleaner Production Opportunity Assessment (CPOA) is a management tool consisting of a systematic and objective review of manufacturing processes, products and services. It is designed to identify opportunities for increasing productivity and profitability, while reducing the environmental impacts and associated risks to the enterprise.

CPOA is typically a one-time activity and may be conducted at least once a year. Adoption of an Environmental Management System (EMS), such as ISO 14001, can provide a framework to conduct CPOAs on a proactive and continuous basis.

1.8 Why Not Use the Term "Environmental Audit" Instead of CPOA?

An Environmental Audit is defined by the UNEP DTIE as

"A management tool comprising a systematic, documented, periodic and objective evaluation of how well environmental organization, management and equipment are performing with the aim of helping to safeguard the environment by:

1. *Facilitating management control of environmental practices;*
2. *Assessing compliance with company policies, which would include meeting regulatory requirements"*[6]

An environmental audit is basically **compliance-oriented** is often considered as a fault-finding exercise. It ends with the situation analysis of the firm's environmental impacts and provides an idea as to the position of the firm with respect to the relevant environmental legislation. It does not initiate a problem-solving process. Finally, the MSMEs are rather averse to terms such as "audit" and treat audits as inspections.

On the other hand, the CPOA is a proactive approach to reduce environmental impacts at source itself and enhance productivity. **CPOA, as the name suggests, is an opportunity-finding rather than a fault-finding exercise.** Hence, the term "Environmental Audit" should not be used to describe the intent and scope of CPOA.

1.9 The Ten-step Implementation Process for Promoting Cleaner Production Across MSMEs in Egypt

Given the barriers to Cleaner Production as outlined in **Section 1.5**, its promotion requires a strategic approach. Clearly, ad hoc interventions are not effective to drive the message across MSMEs.

This section presents a strategic approach to promote and implement Cleaner Production across MSMEs. In many ways it provides an overview of this guidance manual. Conduct of CPOA plays a critical role as a "driver" to the entire process as well as a "capacity building tool". Besides CPOA, the approach considers promotion of implementation projects as a vehicle to show case benefits of Cleaner Production. Implementation projects are basically realization of innovative Cleaner Production options identified through CPOA.

This strategic approach can be described through 4 **distinct milestones and 10 steps**.

1. **Milestone 1 (Getting Started and Scoping with the Rapid CPOA)** concerns the preparation for the entire process; namely, **step 1** (Identifying target MSMEs and promoting the CP concept to them), **step 2** (Preparing for the Rapid CPOA), **step 3** (Conducting the Rapid CPOA) and **step 4** (Deciding the next steps).

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[6] Source: Analytical Tools for Identifying Cleaner Production Opportunities (www.uneptie.org)

2. **Milestone 2 (Carrying out a Focused CPOA)** concerns carrying out activities for the focused CPOA; namely **step 5** (Preparing for the Comprehensive CPOA), **step 6** (Conducting the Comprehensive CPOA).

3. **Milestone 3 (Preparing Projects for Implementation)** includes **step 7** (preparing the project proposal to acquire funding) and **step 8** (Preparing for the Implementation Project).

4. **Milestone 4 (Implementing Projects)** involves **step 11** (Actual Implementation of the Project) and **step 12** (Evaluating the Implementation Project).

The above steps and milestones are shown in **Figure 1.3** and are further described below.

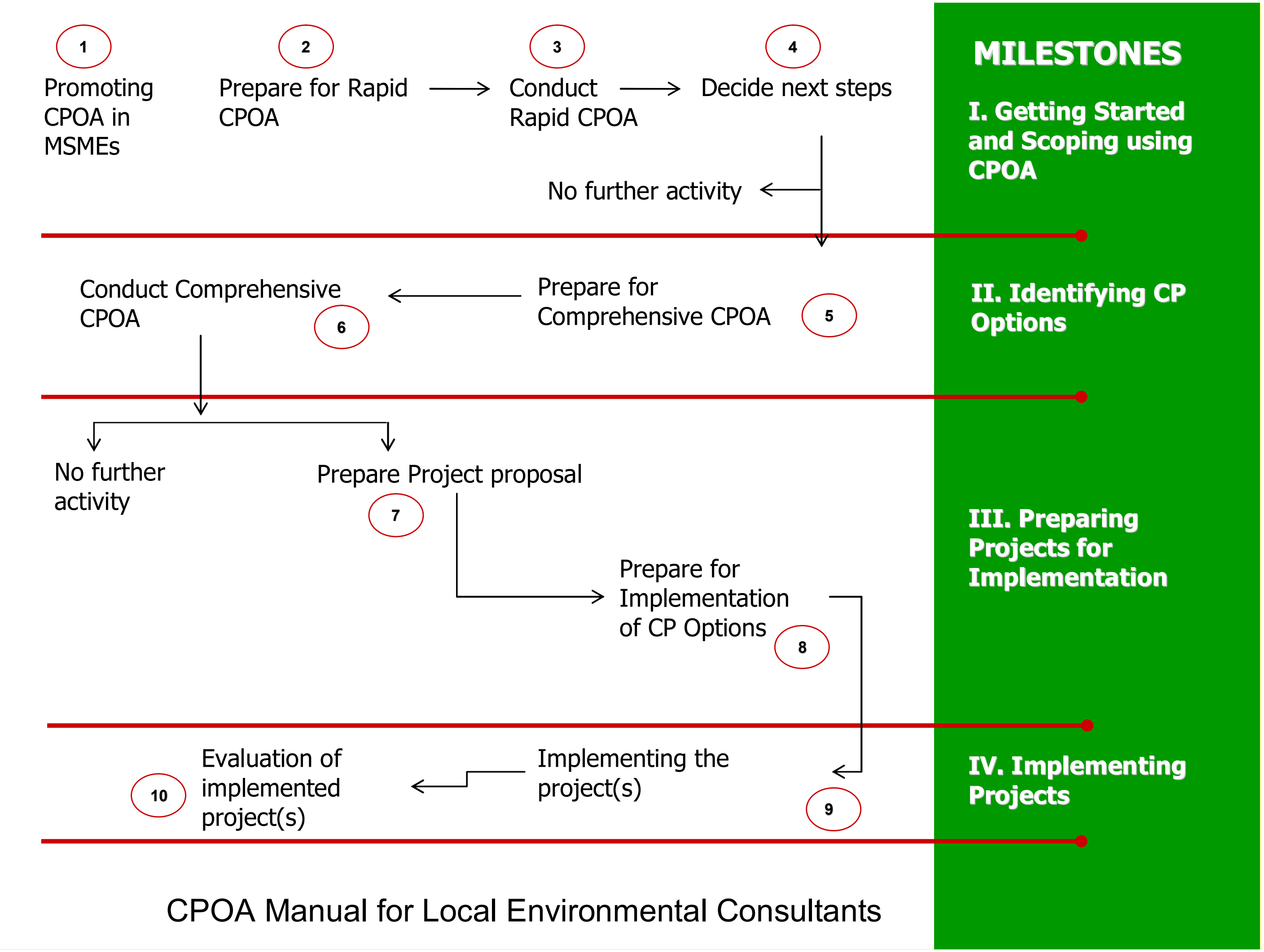


Figure 1.3 Ten-step implementation process for Consultants to promote and implement Cleaner Production in MSMEs

Step 1: Promoting CPOAs in MSMEs

The first step for the consultants is to approach the MSMEs and promote the concept of cleaner production, particularly its benefits to their business. The consultant will need to develop a presentation for this purpose to explain the need for Cleaner Production, methodology of implementation, benefits and costs involved etc. to the MSMEs. For the MSMEs that show interest in knowing more, the next step involves conducting a Rapid CPOA. **Section 2.1** of this manual provides guidelines for promoting Cleaner Production to MSMEs.

Step 2: Prepare for Rapid CPOA

The Rapid CPOA is a quick appraisal of environmental and productivity-related opportunities available to the interested MSMEs. It is based predominantly on observations made during a walkthrough as well as discussions with the owner. **Section 2.2** of this manual provides guidance on preparing for Rapid CPOAs in MSMEs.

Step 3: Conducting Rapid CPOA and Preparing the Rapid CPOA Report

The Rapid CPOA is generally conducted with the assistance of Cleaner Production practitioners or consultants, with the co-operation of the MSMEs. **Sections 2.3 and 2.4** of this manual provide guidelines for conducting a Rapid CPOA and preparing its summary report. A detailed discussion on the Rapid CPOA report is presented in **Format 2.2** and a sample Rapid CPOA report is presented in **Annex 4** of this manual.

Step 4: Deciding the Next Steps

Based on the findings of the Rapid CPOA, decisions are taken in terms of the nature of assistance possible for each selected MSME. These decisions could be of either of the following forms:

- No further investigation is warranted; i.e. all further investigations stop at this point. This conclusion is reached if the Rapid CPOA shows that there are no innovative opportunities related to Cleaner Production at the MSME or the owner of the MSME is not interested or is supportive of the identified projects.
- Opportunities for implementing Cleaner Production exist. Some of these options may be readily implemented by the MSME since they will pose nil/low cost to the MSME.
- Opportunities for implementing Cleaner Production exist. However, their implementation will require a more detailed assessment in the form of a Comprehensive CPOA. This exercise includes a more detailed assessment of Cleaner Production options. It also involves an analysis of costs and benefits and the preparation of an implementation plan.

Step 5: Preparing for the Comprehensive CPOA

Before proceeding to actually conduct a Comprehensive CPOA, it is necessary to complete certain preparatory activities in the interested MSME. Such activities could include conducting opening meetings to brief the MSME owner and staff on the proposed plan of conduct, methodology, establish a team, seek to fill information gaps, prepare for sampling and monitoring, scheduling the assessment etc. These details are covered in **Section 3.1** of this manual.

Step 6: Conducting the Comprehensive CPOA

The guidelines for conducting Comprehensive CPOA are provided in **Section 3.2** of this manual. The Comprehensive CPOA is generally conducted with the assistance of Cleaner Production practitioners or consultants, with cooperation from the MSMEs. The review of Comprehensive CPOA report should lead to the identification of projects for implementation at the MSME. **Sections 3.2.9** to **3.2.13** and **Section 4.1** of this manual discuss the criteria for the identification of such projects.

Box 1.3 explains the importance of Rapid and Comprehensive CPOAs.

Box 1.3: Why do we need Rapid and Comprehensive CPOAs?

The Rapid CPOA is essentially a **scoping and screening tool** that helps to give a better focus to the Comprehensive CPOA. Rapid CPOA is a low cost exercise. The costs of conducting Comprehensive CPOAs are generally higher than Rapid CPOAs. On the other hand, the costs of implementation of implementation projects are typically manifold higher than costs of conducting Rapid CPOA. In the context f MSMEs, typically, probabilities of striking a low quality implementation project are high, given the barriers on information, finance and willingness as well as poor technical capacity.

A strategy of deploying more number of Rapid CPOAs helps in scoping few Comprehensive CPOAs to implement "quality" implementation projects. Implementation of projects through a two step sequence of Rapid and Comprehensive CPOAs is therefore a cost-effective strategy.

Both Rapid and Comprehensive CPOA provide hands-on training to the Cleaner Production practitioner, and are therefore useful in building local capacities, especially to achieve a multiplier effect.

Step 7: Preparing a Project Proposal for Project Implementation

Certain identified projects are likely to involve costs that the MSME may not be able to bear by itself. Typically, such costs may involve the acquisition of new machinery, expensive retrofits to existing equipment, etc. In order to finance and implement such a project, it becomes necessary to prepare a project proposal. This project proposal is generally submitted for approval, to an external agency for financial / technical assistance. The proposal should address the need, implementation methodology, cost-benefit analysis, financing mechanisms required, responsibilities etc. of the project. **Section 4.3** of this manual provides guidance on preparing project proposals.

Step 8: Preparing for the implementation of the project(s)

As with the Rapid and Comprehensive CPOAs, some preparatory activities need to be undertaken before the implementation of the project begins. **Section 4.4** of this manual provides guidance on preparing for the implementation of projects.

Step 9: Implement the project

This step involves executing the project at the selected MSMEs. This is one of the most crucial phases of the entire exercise as it involves the actual demonstration of benefits possible through proposed Cleaner Production options. **Section 5.1** of this manual provides guidance on conducting projects.

Step 10: Evaluating the project

The project has to be evaluated based on certain criteria. The evaluation helps to understand whether the project has been successful in achieving its aims and objectives, and (at times) whether it is appropriate for replication (e.g. for other MSMEs within the same business sector). Guidance for the evaluation of an implementation project is provided in **Section 5.2** of this manual.

Chapter 2

What will we learn from Chapter 2?

2.0 Getting Started and Scoping using the Rapid CPOA Tool

2.1 Identifying Target MSMEs and Promoting the Cleaner Production Concept to Them

2.2 Preparing for the Rapid CPOA

2.3 Conducting the Rapid CPOA

2.4 Deciding the Next Steps

2.0 Getting Started and Scoping Using the Rapid CPOA Tool

Milestone 1[7] concerns the preparation for the entire process; namely, **step 1** (Identifying target MSMEs and promoting the Cleaner Production concept to them), **step 2** (Preparing for the Rapid CPOA), **step 3** (Conducting the Rapid CPOA) and **step 4** (Deciding the next steps).

2.1 Identifying target MSMEs and promoting the Cleaner Production concept to them

To identify MSMEs for promoting and implementing Cleaner Production, the consultants would first need to obtain information and apply certain criteria to shortlist enterprises. It is necessary for the consultants to decide the focus area (e.g. governorate), industrial sector and identify the target MSMEs in that region and sector.

Deciding the area of focus could be done based on the extent of industrial presence and environmental sensitivity of the areas.

The consultant should study various industrial sectors in terms of profile or distribution, market demands, technological status, extent of research and development practices so as to understand the need of Cleaner Production in the sectors as well as the factors that could help in promoting it. For such purpose information could be accessed from documents on sector profiles published by the government and private organizations from time to time.

Finally, the consultant should meet the local industrial and environmental authorities to identify target MSMEs based on aspects such as instances of environmental non-compliance, neighbourhood complaints, reporting of low productivity, expansion proposals for export etc.

Consultants should conduct Cleaner Production awareness workshops and present the benefits and efforts involved in implementing Cleaner Production to such target MSMEs. This will help promote the concept of Cleaner Production and identify candidate MSMEs for Cleaner Production implementation.

2.2 Preparing for the Rapid CPOA

The Rapid CPOA methodology consists of **three** basic tasks.

- Getting the preliminary information and carrying out a diagnosis of the problem(s),
- Conducting a walkthrough, and
- Developing the Rapid CPOA report.

[7] Taken from **Section 1.9** of **Chapter 1** of this manual.

While preparing for and conducting the Rapid CPOAs, it is recommended that there be at least **three points** of contact with the MSME.

- The first point of contact (viz. **Task 1**) is a meeting with the owner of the industry / enterprise. Here, one would obtain preliminary information, carry out a very preliminary diagnosis of the problem(s) involved, and try to identify the focus of the walkthrough. This meeting provides an input to the walkthrough at the industry / enterprise.
- The second contact (viz. **Task 2**) is the walkthrough in the industrial unit, a tour which will cover all areas of operations.
- The third contact is generally during the submission and disclosure of the Rapid CPOA report (**Task 3**).

A team of a minimum two CPOA practitioners is recommended for conducting Rapid CPOA. These practitioners should have received training on CPOA from the Programme.

Each of the above tasks is described in detail below.

2.2.1 How to collect preliminary information and carry out a diagnosis of the problems involved?

Collection of preliminary information should be done by holding a meeting with the owner of MSME. The task of collecting preliminary information will basically cover the following:

- **Checking and confirming data** that was used in the selection/identification of the MSMEs. This could include information concerning ownership status, number of employees, turnover, legal status, etc., and
- **Obtaining information on principal problems** to help decide the **focus of the walkthrough.** This could include information on skill level of staff, condition of equipment, availability of resources, quality of products, non-compliance etc.

The following points may be followed to establish cooperation with the owner of the MSME and acquire such information.

- Official representing the Cleaner Production Programme should introduce the Programme and the CPOA practitioners.
- It is necessary to explain the role of the CPOA practitioners and that of industry staff during the Rapid CPOA.
- Clear statements on how the company can benefit by partnering with the Programme are important.
- It may be important to emphasize that the information collected during the Rapid CPOA as well as the Rapid CPOA report, will be kept confidential and will only be released to the owner of the industrial unit.

The following aspects may be considered while fixing and conducting the meeting:

- The owner should be met at his / her time of convenience.
- Peak production times should be avoided for holding the meeting.

- ☝ Typically it is worth fixing time at the end of the day when the discussion can spill over without any disturbances to the meeting.
- ☝ The intention of the meeting must be made clear before taking an appointment. The keywords to emphasize are opportunities, enhanced productivity and profitability. Reduction in costs associated with environmental compliance, improvements in the health and safety of workers, and enhancement of the neighbouring environment could be additional points to stress on.
- ☝ This information is to be collected through casual conversations. Sensitive information is not to be recorded or written in front of the owner. It is to be remembered and recorded immediately after closing the interview.
- ☝ At the end of the meeting it is important to fix a mutually agreed time for carrying out the walkthrough.

At this stage, the CPOA practitioners should be able to arrive at some understanding of the possible areas which should be focused on during the walkthrough.

Example: For instance, poor or inconsistent product quality could be a major issue or the underutilization of the equipment may be one of the major concerns to the owner. High water and chemical consumption could be another possible issue that is understood to influence the competitiveness of the industry.

2.3 Conducting the Rapid CPOA

2.3.1 The Walkthrough

As is evident from the title, a walkthrough is a tour of the industry covering all areas of operations. The objectives of the walkthrough are to familiarize the CPOA practitioners with the industry's equipment and operations and to facilitate problem identification and opportunity assessment.

The walkthrough consists of the following three elements:

- The opening meeting,
- Conducting the walkthrough, and
- The closing meeting.

Importance of the opening meeting

The walkthrough should begin with an opening meeting. The purpose of this meeting is to understand the industry's regulations and requirements (e.g. use of helmets, use of safety shoes, codes of practice concerning movement in restricted areas of the industrial unit, etc.) and abide by them. The CPOA practitioners for instance should seek permission from the owner to carry and use a camera.

Conducting the walkthrough

Walkthrough should not be done when the operations are closed (e.g. on the weekend or say during low production cycles or night shifts). The idea here is to get a representative picture to the company's normal operations.

A walkthrough must begin from the raw materials receiving area and end at the department of finished products. The sequence should essential follow the manufacturing process.

A walkthrough in the processing area should focus on three basic areas viz. **equipment**, **process** and **materials**. While following the manufacturing sequence, the walkthrough should first focus on the status and operation of equipment in the unit. The process details should be investigated next, followed by materials and products; i.e. consumption of key materials, amount and quality of production.

Regarding the equipment, it is important to examine make, supplier, and date of procurement. It is useful to know about the extent of in-house utilization and external use of the equipment i.e. in the form of "jobbing". Maintenance records of the equipment should be checked to know, when the last breakdown was, what were the reasons, and the frequency of equipment overhauling. If records do not exist, then this information should be obtained through conversation with the operators or supervisors.

While checking the status of the equipment, it is important to collect information on the process, design and operating parameters. This can be done by asking questions on key raw materials (e.g. water), principle operating parameters (e.g. pH, temperature), processing time, material conversion efficiencies (e.g. 70%), amount and quality of products. It is also useful to take notes on process variations that are followed depending on the raw materials and market requirements.

The information obtain on each equipment may be recorded in a format (see **Format 2.1**).

Format 2.1: Recording Details on Equipment, Process and Materials

Items	*Information collected*	*Notes for follow up*
Equipment name and its purpose	…	…
Make and supplier	…	…
Year of installing and purchase price	…	…
Level of maintenance		
Extent of in-house utilization	…	…
Extent of external utilization (e.g. jobbing)	…	…
Brief process description	…	…
Key process operating steps	…	…
Typical process variations	…	…
Typical processing time	…	…
Key process operating parameters	…	…
Principle materials used (per batch / per day / per week / per month)		
Inputs from utilities i.e. water , steam, energy		

Items	*Information collectea*	*Notes for follow up*
Products / by-products / intermediates produced (per batch / per day / per week / per month)		
Wastes / emissions released (nature, characteristics, special conditions)		

Finally, the walkthrough should also cover all the support utilities such as boiler, power generator, fuel /chemical storage areas, refrigeration plant, raw water treatment plant, wastewater treatment facility, etc. **Many of the easy to improve possibilities are often seen in the utilities area.** Examples include power factor correction to minimize energy consumption, water softening to improve right first time of production as well as reduce costs of boiler operation, etc.

What should be asked? What should be avoided?

Questions posed should be such that they are able to extract the required information without intimidating the operators and staff in the industry. **Box 2.1** provides a checklist of recommended questions while conducting the walkthrough.

Box 2.1: Additional guidelines for lead questions to be asked and / or observations to be made during the walkthrough:

Work floor or shop floor -

- Is the floor dirty or ponded?
- Can the workers move about easily? Is there unnecessary piling or raw materials and stocks?
- Is the layout optimum? i.e. can the workflow be improved to minimize walking time?

Storage areas -

- Is the storage system FIFO (i.e. first in first out; raw material is utilized based on the date of procurement, giving preference to old stock) or LIFO (last in first out; fresh raw material is utilized first, while the old stock of raw material remains unutilized)?
- How are the raw materials which are received checked for quality?
- Are there frequent instances of receiving raw materials which are contrary to the material specifications? What happens to the rejects?

Equipment and process -

- Is the process operated as per the Standard Operating Practice laid down by the equipment/technology provider? What are the reasons if there are any variations?

Are quality assurance / quality control done for the finished and intermediate products? How frequently? What are the current results?

Boiler and steam distribution system -

- Are there any leaking joints, glands, valves, safety valves?

Box 2.1: Additional guidelines for lead questions to be asked and / or observations to be made during the walkthrough:

- Is the condensate being returned to the maximum extent possible?
- Are the condensate return lines and feed tanks jacketed or lagged?
- Are steam traps of correct types being used for each process?
- What is the fuel used? Is it of a consistent quality and composition?
- What is the source of water? Is the raw water treated before use?
- What is the type of boiler (e.g. single pass / double pass, etc.)? How frequently does the boiler blow down?

Waste and emissions –

- Is the waste properly collected, segregated and transported?
- Is the waste generation continuous? Or in spurts?
- Are any measurements made of waste generated or emissions emitted?
- Are any valuable raw materials or products wasted as part of the emissions? Is it possible to reuse or recycle them if recovered?
- Do the wastes generated and / or emissions emitted make the workplace undesirable to work in?
- Are there any potential neighborhood impacts due to the wastes / emissions?

The above checklist can be expanded based on additional resources and the experience of the CPOA practitioner.

The following points should be remembered in asking questions and conducting a walkthrough.

- Do not find faults. Walkthrough is not for faultfinding. It is to generate ideas on efficiency gains, higher profitability and overall environmental improvement. Idea of walkthrough is also to "make friends" for future contacts and possible partnerships. Hence one should not be critical but be constructive and suggestive.
- Do not dominate or take over the conversation. During the walkthrough, give a chance for the industry staff to speak and explain.
- Do not ask questions to show your knowledge about the process or digress by sharing information that you know but it is not relevant.
- Ask questions only when you must. If you do not understand explanations provided and feel that they are absolutely critical, then make a request to explain again. Do not feel shy to express your inability to understand.
- Do not leave the group during walkthrough. It often projects not so polite image.
- Ensure that you meet the timeline earlier agreed to meet the owner.

What should you observe and take note of?

- Always keep track of the outputs you are expected to produce.
- Sketches should be therefore made prepare a layout and the process flow diagram.
- Notes should be taken (such as in **Format 2.1**) to allow computation of key material balances, prioritize raw materials and obtain information on operations and operational sequences covering range of products and abnormal situations.

The following resources may be employed while conducting a walkthrough:

- A camera,
- An A3 size scrap book to make quick sketches of layouts, eco-maps and process flow diagrams,
- Colour pens / highlighters to mark important points, and
- A tape recorder to record site observations.

Why is the closing meeting important after the walkthrough?

The closing meeting is as important as the opening meeting in the walkthrough. The objectives of the closing meeting are as follows:

- To take up questions those were postponed due to want of longer explanations.
- To provide the industry with immediate observations – stated politely and constructively.
- To make any further appointments and agreements. For example, the industry may promise that information will be compiled and made available.
- To communicate when will you contact the owner / production head for sharing the draft report on CPOA. It is important to be realistic in promising the date. Again, the protocol of routing the document should be made clear.

The next few paragraphs provide details on using some of the tools mentioned above such as layout, process flow diagram, preliminary level material and energy balance, etc.

2.3.2 The Layout

A neat industrial layout, indicating each department / processing area, showing the manufacturing sequence and enlarged maps for each department should be prepared. On the layout, it is important to show the North direction, key neighborhood landmarks, entry and exit points. The layout should provide a clear picture of the processing sequence and the material handling practices.

As far as possible, layout maps should be drawn to scale, preferably on A3 size sheets, covering the following:

- *Key map*: Key map should show the location of the enterprise; access roads; neighbourhood characteristics, especially sensitive receptors. It is useful to show data on a local wind rose (wind frequency across 8 or 16 directions over a seasonal or annual basis) on this map to understand the dispersal of air pollutants and odour.

- *Layout map of the entire operations in the organization*: This map should show the internal roads, entry and exits; waste storage, processing, disposal facilities; utilities such as boilers; stack positions; storm water drains and wastewater outlets. It is useful if contours or key ground levels are shown on this map to understand the sloping or rising of the terrain.

Layout map of key departments: For enterprises with a number of large departments, layout maps may be drawn for departments of concern indicating the positions of the major equipment, water piping; steam lines; drains and vents/stacks. Care should be taken to show water lines in different colours corresponding to conveyance of fresh water, softened water, demineralised water, bore well water, etc. Similarly, steam lines should be distinguished as high pressure and low pressure lines. If the equipment, water, steam and drainage clutter the layout map, then separate maps may be prepared for equipment and for water, steam and drainage lines. Again, if the department has multiple floors then a separate layout map is required to be drawn for each floor. **Figure 2.1** shows an illustration of a typical plant layout.

If there are any existing layout maps, then it is important that the practitioners use / add / verify the various details by actual inspection. This is necessary because many a time, records are not always updated.

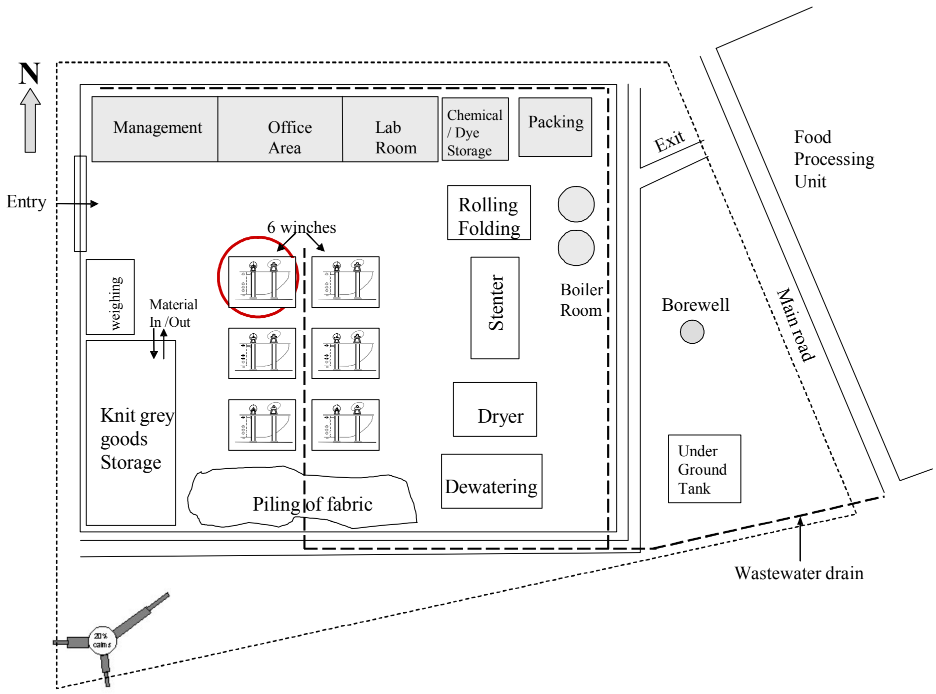


Figure 2.1: Typical Layout of a MSME

2.3.3 Process flow diagram

A process flow diagram (PFD) should show the most commonly followed manufacturing sequence. To construct a PFD, it is best to start by listing of important unit operations, right from receipt of raw materials to the storage / dispatch of final products. Next, each of the unit operations can be shown in a block diagram indicating detailed steps with relevant inputs and outputs. By connecting the block diagrams of individual unit operations, a PFD can be constructed. Sometimes, the best way to create and firm up a PFD is to conduct a number of walkthroughs.

While preparing a PFD following points should be kept in mind:

- Use blocks to denote the operations. For each block, write name of the operation and any special operating conditions that need to be highlighted; for instance, for a dyeing operation, it may be pertinent to indicate the operating conditions of 90 °C and 1.2 atmospheric pressure (bar).
- Show points of inspection or quality control in the PFD [see **Figure 2.2 (a)**]. Indicate what happens if the material quality is not according to standards. You may need to show whether the materials are rejected, or whether the materials are preprocessed with and without certain additions. Flow charts should be developed to provide a better insight to the actual operation of a PDF. A flow chart in **Figure 2.2 (b)** shows for instance when bleaching is skipped or when finishing operations are changed depending on the customer requirements.
- Show all inputs and outputs at each block indicating major raw materials, intermediate and final products, water and steam as applicable and generated wastewater, air and solid waste emissions. Wherever possible, obtain estimates on the extent of consumption and generation (say on a daily / weekly or monthly basis) and indicate so on the side of the PDF or list as attachment.
- The PFD [see **Figure 2.2 (a)**] should use various symbols to add more information about the process. Indicate clearly whether the operations are batch or continuous. Solid and dotted lined for instance can be shown to show continuous or intermittent release of emissions, respectively. Colour codes may also be used to make clear distinctions; e.g. green lines to indicate recycled streams and red lines to indicate release of wastes, etc. All these symbols need to be reflected in a legend to the PFD. It is also useful to show the time required for each operation as a typical range, e.g. 2 to 4 hours, to improve the understanding of the process. In doing so, it should be possible to estimate the total time taken for the production of a batch of goods.
- Due attention should be paid to capture start up, shut down and maintenance related activities, seasonal product or production related changes, etc. This is best down by preparing flow-charts that indicate how a PFD is operated for a special situation.

Figure 2.2 (a) shows an illustration of a PFD for a wet-textile processing factory.

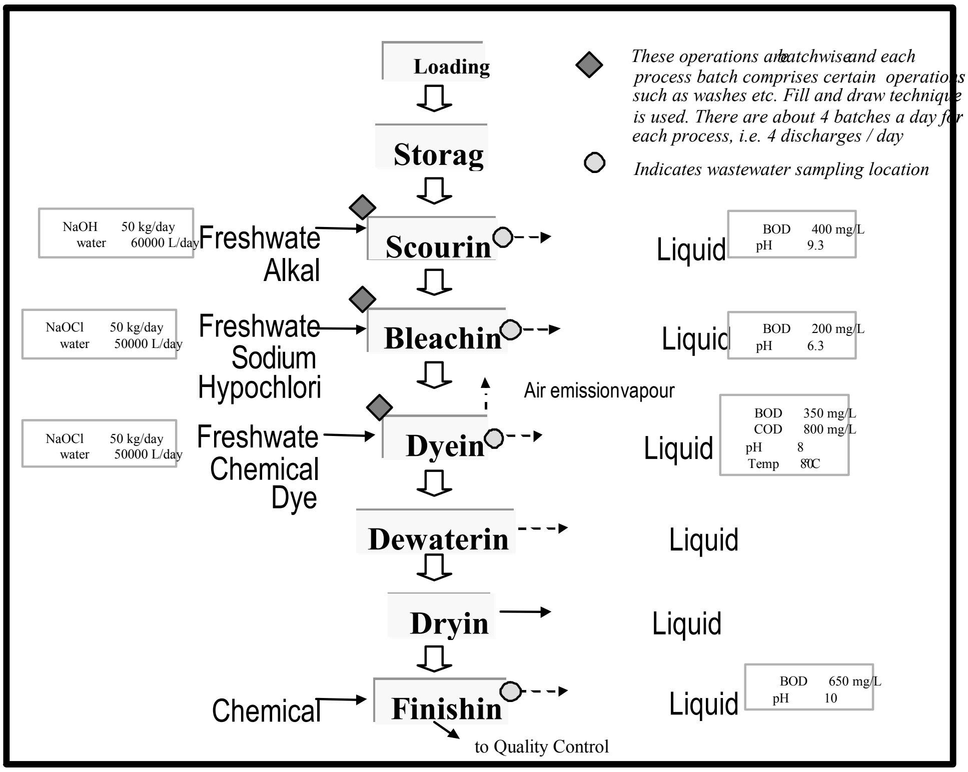


Figure 2.2 (a): A Typical Process Flow Diagram for a Wet-Textile Processing Factory

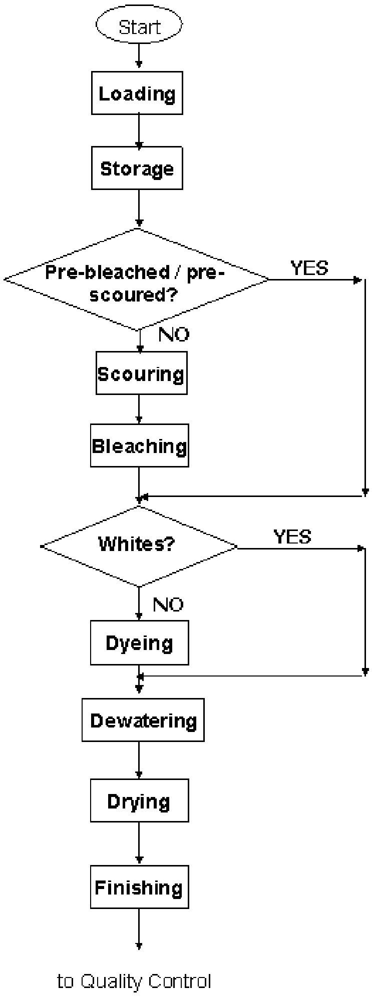


Figure 2.2 (b): Flow chart showing Wet-Textile Processing options in special conditions

2.3.4 Preliminary material and energy balance

An overall and departmental level material and energy (M&E) balance for priority raw materials should be prepared. The M&E balance is a basic inventory tool, which allows for the quantitative assessment of material inputs and outputs as illustrated in the PFD. The crux of the M&E balance is to check that "what goes in must come out somewhere." **Figure 2.3** provides an example of a preliminary M&E balance in a boiler house[8].

[8] Refer to **Section 1.3** of **Annex 1** for details on conducting a material and energy balance.

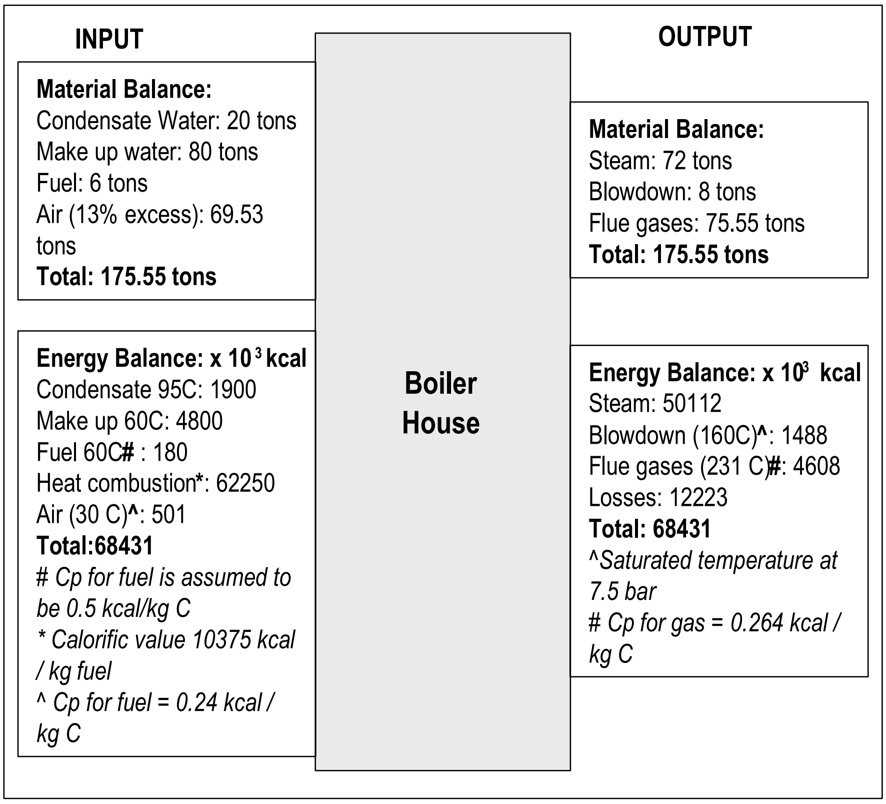


Figure 2.3: An Example of a Preliminary M&E Balance in a Boiler House

At this stage of the Rapid CPOA, an M&E balance at the *plant level* is often adequate to better understand the *focus* of CPOA. A plant level balance would need to consider the overall consumption of resources including energy, production and generation of waste across all media.

Here, records on purchases, consumption and sale could be used. Generally, M&E balances at this level are best set by examining three months data and computing monthly averages. Water and energy bills paid could give some idea of their consumption pattern. Similarly, production figures or orders serviced over a certain period of time could give an estimate of average production. These numbers need to be reconciled by information collected during the walkthrough. Thus, the purpose of M&E balance is to verify the information collected so far.

Quantification of inputs and outputs can be done by using equipment-operating data and by holding discussions during the walkthrough. Field measurements are not always needed.

It could be possible that there will be substantial discrepancies in the plant level M&E balance. **However, this should not be a major concern as the idea is help understand the focus of the CPOA.** In Rapid CPOAs, even 70% accuracy should be acceptable as a first cut. If the M&E balance shows significant gaps, then it is necessary that additional supporting information needs to be acquired in the Comprehensive CPOA.

Finally it is important to clearly state the assumptions made in setting up the M&E balance. **Figure 2.3** shows an illustration for a preliminary material and energy balance for a boiler house.

2.3.5 Identification of Cleaner Production opportunities

Opportunities in the Rapid CPOA may be identified by focusing on those processes that fulfill one or more of the following criteria:

- Correspond to high consumption of materials and energy,
- Use hazardous chemicals and / or generate hazardous waste,
- Require a long processing sequence or use inefficient / outdated processing equipment, and / or
- Entail a high financial loss due to poor quality of product(s).

Often, several options emerge (see **Section 1.6** of this manual) while analyzing problems and their causes and identifying Cleaner Production opportunities. Options could be based on approach, technology, materials, operating practices etc. Each option has its advantages and disadvantages.

The Rapid CPOA report forms a basis to take decisions regarding the way forward – i.e. scope the problems and available opportunities. At this stage, the solutions to look forward to are generally less technology intensive. Rather, they are more related to housekeeping, rationalization and optimization of process operations direct recycle, reuse and recovery adding on minor modifications to the equipment, and selecting better quality raw materials.

Issue	*Illustrative options in Rapid CPOA*	*Information needed to firm up the option*
High consumption of materials and energy	▪ Improved housekeeping ▪ Recycling and reuse of materials ▪ Recovery of heat	▪ Estimates on possible reduction ▪ Deviation from operating benchmarks
Use of hazardous chemicals / generation of hazardous waste	▪ Substitution of raw materials ▪ Modification of the process ▪ Improved housekeeping	▪ Material availability and costs of substitute materials ▪ Any process related risks or advantages
Long processing sequence / low productivity	▪ Explore elimination of operations ▪ Explore combining of operations	▪ Possible savings in time materials and labor ▪ Any process related risks or advantages
Poor product quality	▪ Check quality of raw materials ▪ Improved preparation of raw materials ▪ Process rationalization and optimization	▪ Estimates of present and projected right first times ▪ Possible reduction in wastes and increase in present value

2.3.6 Screening level Cost Benefit Analysis (CBA)

In order to develop the Cleaner Production opportunities at the project level, a preliminary cost benefit analysis (CBA) should be carried out for the identified options. Such an analysis can consist of the following:

- Estimation of capital costs,
- Estimation of operating savings per month, and
- Simple payback which is calculated as,

Payback Period in years = (Capital Investment / Annual Savings – annual operating costs)

The pay back period should be generally considered only as a rough assessment, as it ignores depreciation of the investment made and time value of money. **Typically, the payback period should be less than 12 months.**

Consider an example of CPOA in a textile dyeing unit. The dyeing process depends on various factors such as dyes, auxiliaries, salt, pressure, contact and processing time. Quality of the raw water used is critical to the outcome of the process. If hardness above 50 parts per million (ppm) is present in the raw water used in the dyeing bath, the dyeing quality and dye fixation can be seriously affected. One way to tackle this problem is by installing a water softening unit that pre-treats the raw water before use in the dyeing process. A Rapid CPOA assists in identifying use of hard water in dyeing as a problem area.

Based on water consumed for dyeing a 10 cu. m. capacity softening unit is estimated. The capital cost of such a unit would be about 18,500 LE. Other installation costs include pumps, civil work and initial resin cost. The total capital cost amounts to about 42,000 LE.

Operating costs include power, resin regeneration and labour totalling to about 5,000 LE per year. Savings are expected due to reduction in dye consumption, improvement in efficiency of boiler, reduction in amount of acetic acid and other auxiliaries during dyeing and most critically an improvement in the Right First Time of production. Total savings work out to 50,000 LE per year.

In the above case the payback period would be about 10 months. Thus within a year of operation of the softener would return the investment made initially. It is important to affirm the assumptions made in the above analysis. This will have to be done in the Comprehensive CPOA.

2.3.7 Preparing the Rapid CPOA Report

Rapid CPOA report should be a crisp and concise document that should include critical information, its analysis and representation to reach specific conclusions. Given below is sample for a Rapid CPOA report (see **Format 2.2**).

Format 2.2: Sample Format for a Rapid CPOA Report

1. Details of the industry/ unit:

- Name:
- Address:
- Governorate:
- Ownership (Private / Public):
- Name and contact details of the owner:
- Sector / sub-sector (e.g. textile sector – dyeing sub-sector)
- Year of establishment:
- Legal position (e.g. registration)
- Plot area (in sq. m.):
- Date visited:
- Time taken for the visit: (days)
- A background description of the industry with respect to its establishment, history of operation, management, industry location map etc.
- Information on labour and staff in terms of number of employees (permanent / contractual), skill / education levels

2. Production profile:

Sr. No.	Product list	Production volume per month	Units
1.	Product A	2000	Kilogram (kg)
2.	…	…	…

- Layout of the industry work floor or shop floor:
- Brief description of the process accompanied by process flow diagram (PFD):
- List of equipment, make, capacities, existing conditions and year of installation (include utility areas such as boilers, water treatment plants etc.):

Material consumption patterns

Sr. No.	Materials	Consumption per month	Units
1.	Water	1000	cu. m. (m^3)
2.	…	…	…

Preliminary material and energy balance

- Plant level material inputs – raw materials, water, fuel
- Plant level outputs – products, by-products, wastes, heat

3. Financial profile:

- Order of capital investment = _________ LE
- Order of turnover = _________ LE
- Overall structure of operating costs covering items such as
  - Water
  - Fuels
  - Electricity
  - Chemicals
  - Salaries
  - Maintenance of equipment
  - Costs associated with sampling, measurements and laboratory analyses
  - Fees to external consultants
- Provide details on the cost structure in absolute figures to the extent possible. If that is not possible, then request information in terms of a percentage. If this also fails, then ask for a rating from 1 to 3, where "1" is the least costly and "3" is the most costly item. You may also prefer to use descriptors such as "high" / "average" / "low" instead of numbers).

4. Market profile:

- **Materials / products supplied to the**
  - Local market (indicate percentage)
  - Medium / large scale industries (list names)
  - Export market (indicate percentage)
- **Market position**
  - As over the past 3 years:
  - Is there a downfall? - Yes / No - Reasons:
  - Is the position improving? - Yes / No - Reasons:
- **Any upcoming impositions from buyers?**
  - On quality?
  - On delivery time?
  - On environmental accounts?
  - On social (e.g. labour accounts)?
  - None

5. Quality control and testing

- Are the raw materials tested for input quality requirements before processing?
- Are the products / by-products tested for quality as per the customer requirements?

6. Identification and evaluation of environmental issues
▪ Environmental issues due to operation of the industry ▪ Major sources of pollution ▪ List of measures taken for pollution reduction or control ▪ Legal position (e.g. complying with EEAA regulations) ▪ Neighborhood description and location map ▪ Any sensitive receptor(s) (e.g. schools, hospitals, slum pockets) ▪ Any past records of fire, leaks, accidents ▪ Any complaints already lodged
7. Cleaner Production opportunities
▪ Potential Cleaner Production opportunities to resolve issues identified ▪ Potential investments (costs) and benefits of the Cleaner Production opportunities ▪ Information requirements for implementation of Cleaner Production opportunities or detailing them further
8. Screening level Cost Benefit Analysis
▪ All costs required to implement a Cleaner Production option ▪ Benefits in terms of savings or benefits accrued due to increase in profitability ▪ Focus on tangible benefits at this stage ▪ Compute simple payback period for return on investments
9. Next steps
▪ Possibility of conducting an Implementation Project and / or the requirement of a Comprehensive CPOA should be presented[9]

The Rapid CPOA report should be supported by photographs of equipment, hazardous or pollution generating process operations, waste disposal facility, utilities and the surrounding neighborhood.

2.4 Deciding the next steps

The Rapid CPOA report needs to be reviewed at this stage so as to decide the next steps. A Rapid CPOA could sometimes directly lead to a project for implementation if the Cleaner Production options and their benefits are clearly evident. Most of the time however, there could be a need to do a more detailed assessment. Three possibilities can arise based on the above outcomes:

1. **No further activity beyond the Rapid CPOA:** This outcome will result if the findings of the Rapid CPOA indicate that no substantial Cleaner Production opportunities are possible.

[9] Refer to **Section 3.2** of this manual for further explanations

2. **Conducting the Comprehensive CPOA:** This outcome will result if the findings of the Rapid CPOA are such that there is a promising scope for expanding on these findings but more information is needed to proceed. These gaps in information identified during the Rapid CPOA review should be addressed in the Comprehensive CPOA.

Preparation of a project implementation proposal: This outcome will result if the findings of the Rapid CPOA indicate that the available information is sufficient in all respects and that it is worthwhile to conduct one or more Implementation Projects, based on the identified Cleaner Production options at the MSME. Conducting an Implementation Project essentially mandates the preparation of a project proposal

Chapter 3

What will we learn from Chapter 3?

3.0 Carrying Out a More Focused CPOA Using the Comprehensive CPOA Tool

3.1 Preparing for the Comprehensive CPOA

3.2 Conducting the Comprehensive CPOA

3.0 Carrying Out a More Focused CPOA Using the Comprehensive CPOA Tool

Milestone 2[10] **(Carrying out a Focused CPOA)** concerns carrying out activities for the focused CPOA; namely **step 5** (Preparing for the Comprehensive CPOA), **step 6** (Conducting the Comprehensive CPOA).

3.1 Preparing for the Comprehensive CPOA

The outcome of the review of the Rapid CPOA report should be shared with the industry owner, emphasizing the identified Cleaner Production opportunities. This should be followed by a presentation on why a Comprehensive CPOA is needed, what will be done and what will be the outcomes or the benefits.

It is important that a commitment from the owner should be obtained for Comprehensive CPOA **before commencing** the same.

Having selected the MSMEs for conducting a Comprehensive CPOA, the next step is to identify and carry out preparatory activities.

3.1.1 Background

An opening meeting should be organized at the selected MSME, once it is decided to conduct a Comprehensive CPOA. The objective of this meeting is to plan various preparatory activities before commencing with the Comprehensive CPOA. This meeting may be used to emphasize scope and benefits of Comprehensive CPOA.

The agenda of the meeting should focus on the following:

- Highlighting the results or findings of the Rapid CPOA,
- Explaining the methodology of Comprehensive CPOA to the owner, especially regarding the CPOA team formation and collection of information,
- Forming a CPOA team,
- Deciding, scheduling and allocating preparatory activities for meeting the information gaps identified in the Rapid CPOA,
- Scheduling an intermediate meeting for examining the commencement and progress of the agreed preparatory activities, and
- Deciding on the implementation schedule of CPOA, with sharing of responsibilities.

Some of the important activities from the above checklist are explained below.

[10] Taken from **Section 1.9** of **Chapter 1** of this manual.

Highlighting the results or findings of Rapid CPOA

The outcomes and recommendations of the Rapid CPOA, particularly the Cleaner Production opportunities identified and their preliminary analysis should be highlighted and explained to the owner. This will help give clarity in direction to the Comprehensive CPOA.

Explaining the Comprehensive CPOA methodology to the owner of the industrial unit

Having discussed the outcome of the Rapid CPOA, it is essential that the owner is explained the need of a Comprehensive CPOA, benefits to the industrial unit and the proposed methodology. Aspects that should be explained are:

- Why a Comprehensive CPOA?
- What is the difference between Rapid and Comprehensive CPOA?
- What are the time and resource requirements for Comprehensive CPOA?
- What will happen after the Comprehensive CPOA is completed?

Figure 3.1 shows the linkages between Rapid CPOA and Comprehensive CPOA.

Rapid CPOA		Comprehensive CPOA
Primary objective is to screen selected MSMEs within sector based on potential CP opportunities		*Primary objective is to assess selected MSMEs within the selected sector for feasibility of implementation of CP opportunities as a demonstration project*
Basic information of the MSME (largely qualitative information, from secondary sources) and walkthrough	➡	Team formation, On the job training and capacity building for staff Detailed information of the MSME (quantitative information)
Key location map, Layout map Preparation of Process Flow Diagram	➡	Filling in the gaps and preparing detailed Ecomap, Preparation of Operational Flow Diagram Cause-effect analysis – Fishbone diagram and brainstorming
Preparation of Preliminary Material and Energy Balance	➡	Preparation of detailed Material and Energy Balance for Focus Area(s)
Identification of CP opportunities and Screening level cost benefit analysis	➡	Identification / Expanding and Evaluation of CP opportunities based on cost benefit analysis. Identification of Demo projects,

Figure 3.1: Linkages between Rapid CPOA and Comprehensive CPOA[11]

Forming a CPOA team

An important step at this point of time is to urge the industry owner to appreciate the need to establish a CPOA team. While Rapid CPOA is more of an externally driven exercise, the Comprehensive CPOA hedges on the formation of an **internal** CPOA team in the industry, so as to **build needed capacity** and **have a sense of ownership**. The role of external consultants; i.e. the Cleaner Production practitioners (in this case), **is more of counseling and supervision rather than undertaking all responsibilities.** A CPOA team should be formed with representation from **all** relevant departments or functional areas. The owner or the operations manager should head the team with the help of the external consultants or Cleaner Production practitioners.

Deciding preparatory activities for filling in the gaps from the Rapid CPOA

The information gaps identified in the Rapid CPOA need to be addressed in the preparatory activities of Comprehensive CPOA. Typically, quantification of process operations in terms of material inputs, production and generation of wastes / emissions would be the areas that need more detailed information before commencing the Comprehensive CPOA.

[11] The abbreviation "CP" refers to Cleaner Production.

Note that the information requirements need **not necessarily be limited** to the concerned industrial unit.

For instance, information may need to be compiled on:

- Sector specific-benchmarks (national as well as international), relevant to processes, equipment and products, relevant to the industry,
- New equipment available in the market,
- Mor recent practices in operating and controlling processes, and
- Suppliers of alternate chemicals that are cheaper or less hazardous or more effective.

Benchmarks relevant to the sector could be obtained from industry organizations or research institutions in particular industrial sectors, best practice manuals or guidance documents (See **Annex 3** for a **List of Resources** compiled for various sectors).

The following benchmarks are used **per kilogram** of fabric in the knit fabric dyeing industry:

- Energy consumption – 50MJ
- Dye consumption – 3g
- Water consumption – 100L

The industry CPOA team members should take the initiative in most of the information-gathering and preparatory tasks. These include:

- Sourcing, development or compilation of Standard Operating Practices (SOPs) regarding the processes where opportunities or deviations have been identified in the Rapid CPOA,
- Developing quantitative details on inputs and outputs where detailed process / equipment level material balance is recommended by Rapid CPOA. This may involve making more accurate estimation, installing meters, and
- Identifying a suitable laboratory for analysis of the samples taken during the CPOA, if adequate analytical facilities are not available at the industrial unit. The identified laboratory should preferably be in the vicinity of the industry.

In order to enable an M&E balance in the industrial unit, a monitoring programme involving observations, measurements, sampling and analysis should be initiated during the Comprehensive CPOA.

Planning a monitoring programme

Samples need to be taken for inputs (raw materials), outputs (products, by-products, wastes) and process operating conditions (if access and safety rules permit). Both concentration and volume of materials should be measured.

The sector-specific benchmarks researched earlier should guide the monitoring of process related activities. To enable comparison with benchmarks, sampling should be conducted to seek information such as raw water characteristics, process bath concentrations, control parameters (such as pH, etc.), processing time, energy consumption, productivity, raw material consumed, labour required and product quality criteria.

It is important to make a note of the process used or product being processed at the time of sampling. This helps in a better understanding of the relationships between process parameters / waste generation and the type of the product being manufactured. For instance, in a cheese manufacturing unit, the composition of whey would be different for hard and soft cheese.

Composite samples should be taken for continuously running outflows. For example, a small volume 100 mL may be collected every hour through the production period of 10 hours to gain 1 L of *composite* sample. This sample would represent the average wastewater concentrations over that time. Where significant flow variations occur during the discharge period, consideration should be given to varying the size of individual samples in proportion to the flow rate to ensure that a representative composite sample is obtained. For batch tanks and periodic drains, a single spot or grab sample may be adequate.

The sample bottles or containers should be properly rinsed, labeled and dispatched in ice-box to the laboratory for analysis as required by the sample type.

Format 3.1 may be used to capture the sampling plan.

Format 3.1: Preparing the Sampling Plan

Process / Equipment where sample is drawn	*Sampling type (grab/composite)*	*Sampling frequency*	*Parameter sampled*	*Sample preservation*	*Analytical method*	*Staff responsible*
…	…	…	…	…	…	…

Checklist of instruments and accessories

A checklist of required instruments and accessories is provided below.

- Measuring tapes – 2 nos. at least of 10 m length.
- Stopwatches or timer watches – at least two are recommended.
- Industrial scale thermometers.
- Water flow meters as per the number of observation points. The meters could be used to measure the bulk raw water intake. They may be placed at distribution points to major water consuming processes or departments, or entry points to most commonly used processing equipment.
- Portable water quality monitoring kit to measure (for instance) the pH, temperature, conductivity. It is important that the monitoring kit be suitably calibrated before taking to the field.
- Two buckets of different capacities – for instance, 15L and 25L.
- Sampling bottles of plastic or glass for collecting samples. These bottles may need to be prepared before sample collection, depending on the parameters to be analyzed; e.g. washed by mild acid and / or autoclaved.

- Equipment[12] for flue gas sample and analysis for gaseous emissions such as CO_2 / O_2 content, moisture, temperature and flow rate, etc.

Installation and testing of certain equipment such as flow meters should be done during the preparatory activities by the CPOA team. Other equipment (such as monitoring kits) needs to be procured and calibrated before moving the same to the field.

After the opening meeting is concluded, the plan for preparatory activities should be documented and communicated to all the team members, with their responsibilities clearly identified.

A second meeting is recommended just before the actual conduct of the Comprehensive CPOA to check whether all the decided activities have been conducted as required and whether all necessary information has been collected.

3.2 Conducting the Comprehensive CPOA

3.2.1 Scheduling the Comprehensive CPOA

The following points need to be considered while deciding the tentative schedule for the conduct of the Comprehensive CPOA:

- Check availability of owner and staff from the industry unit, especially those who will be participating in the CPOA team.

- Provide sufficient time period for completion of all preparatory activities. There should not be any surprises!

- Ensure "representative operating pattern" in the industry; it is essential that typical product operations be practiced during the conduct of Comprehensive CPOA.

3.2.2 Elements of the Comprehensive CPOA

The Comprehensive CPOA should commence with a walkthrough to check readiness of the preparatory activities, and include a visit to the processes under focus in order to gain more insight and capture points of concern. An eco-map is an effective way to capture such details, using the layout developed in Rapid CPOA.

The Comprehensive CPOA should be conducted as per the plan decided in the opening meeting. The following subtasks are involved in a Comprehensive CPOA:

- Carrying out a walkthrough and preparing the eco-map,

- Re-assessing the focus of the Comprehensive CPOA based on the information collected in the preliminary meeting and during the walkthrough,

- Developing operational flow diagrams (OFDs) for processes that have Cleaner Production potential,

[12] Desirable but not essential if an assessment of stack emission is required.

- Developing a **detailed** M&E balance for the **focus** process areas,
- Identifying problems and causes (i.e. doing a cause diagnosis),
- Generating Cleaner Production options by building on the findings of the Comprehensive CPOA,
- Evaluating the Cleaner Production options from environmental and economic point of view,
- Preparing an implementation plan and identifying training requirements, and
- Preparing the Comprehensive CPOA report.

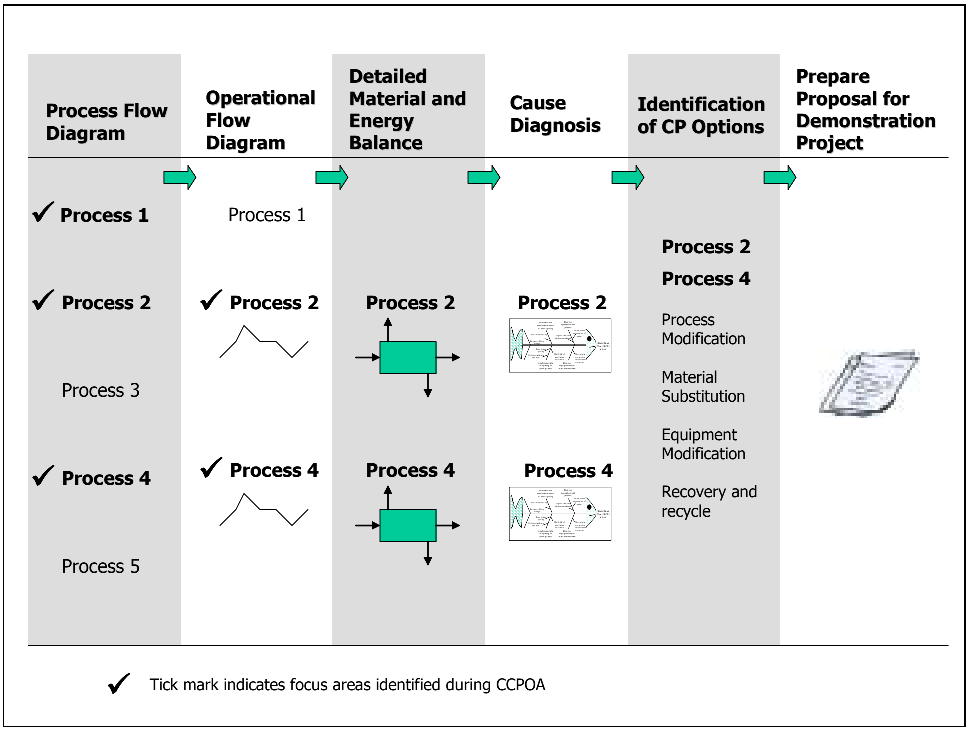


Figure 3.2: Milestones in the Conduct of Comprehensive CPOA[13]

The Comprehensive CPOA should be built upon the work done during the Rapid CPOA. **While doing so the idea is to narrow down from a plant level assessment to a specific process, equipment or operating practice using various tools. Figure 3.2** illustrates typical milestones of conducting Comprehensive CPOA. Using the PFD, processes that are leading to problems (identified in Rapid CPOA) could be selected. OFDs may then be developed for these processes depending on their nature - batch or continuous. The OFD allows one to understand better the deviations from standard operating practices. A detailed M&E balance is then built across relevant processes to understand the material consumption and conversion efficiencies. This helps in comparison with benchmarks or norms. Having built this far, a fishbone diagram should now be used to diagnose the causes of the problems with respect to process (method), machine, material or human related aspects

[13] The abbreviation "CCPOA" refers to Comprehensive CPOA.

(man). Cleaner Production options (see **Sections 1.6** of this manual) could then be developed based on this analysis.

The following section explains details of the above aspects.

3.2.3 The Eco-map

The Eco-map is an effective way to capture these details using the layout developed in the Rapid CPOA.

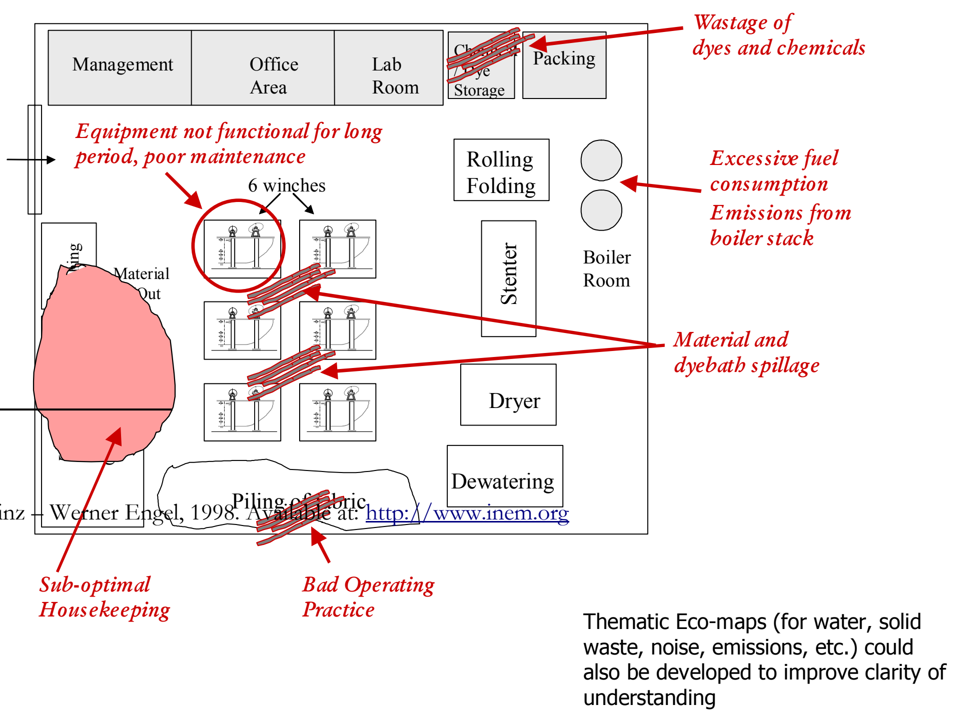
The eco-map developed by Engel[14] builds upon the layout map by **spatially** highlighting the locations of concern (such as high resource consumption) as well as noting the good practices being followed.

Eco-mapping is a very useful tool, especially to capture the observations during the walkthrough. Using an eco-map, corrective measures can be implemented to improve not only the environmental performance of a company but also the efficiency of its operations, as well as improve workspace safety.

Eco-maps can be developed for specific themes as listed below:

- Water consumption and wastewater discharge
- Energy use
- Solid waste generation
- Odours, noise and dust
- Safety and environmental risks

For each eco-map, everything that is related to that problem should be included. For example, the eco-map for water consumption and wastewater discharge should pinpoint the location of overflows, spills or excessive use of water, etc. These areas can be further marked using colour codes or distinct symbols to show areas that have to be monitored or areas where problems will have to be dealt with as soon as possible (see **Figure 3.3** below).



[14] Eco-mapping by Heinz – Werner Engel, 1998. Available at: http://www.inem.org

Figure 3.3: Illustration of an Eco-map Using the Layout of an MSME[15]

3.2.4 Operational Flow Diagram

The OFD looks at each individual process and captures the material and product flow, highlighting the inputs, outputs and the time period. The OFD is built in the Comprehensive CPOA based on actual observations.

Take the example of the jet dyeing operation in the textile industry (see **Figure 3.4**). The fabric is loaded into the jet. Then, 2 cu. m. of water is added in 5 minutes (5'). The jet is run and the steam is opened to raise the temperature to 80ºC in 5 minutes. The carrier and acetic acid are added at this stage. After 4 to 10 minutes, the dye is added. After 5 minutes, the temperature is raised to 130ºC, at a pressure of 2 bar, in 15 minutes. Then, the steam is closed while the jet still operates. After 15 minutes, the pressure drops to 1 bar and the solution is discharged. Overflow rinsing is conducted for 5 minutes. The fabric is then unloaded and taken for centrifugation.

[15] Refer to **Section 1.2** of **Annex 1** for details on preparing eco-maps.

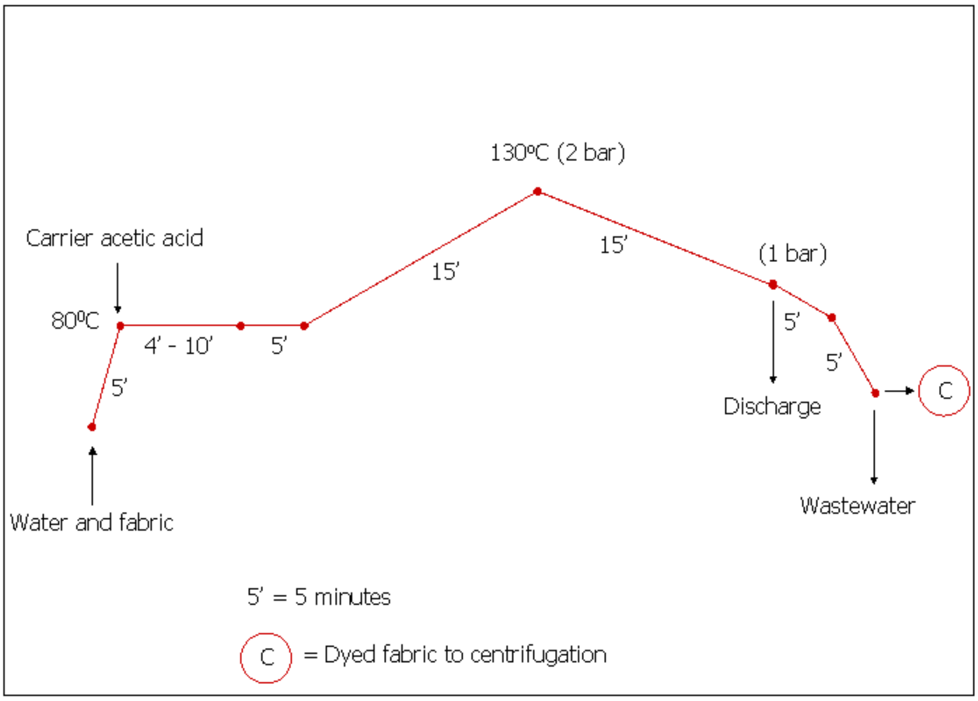


Figure 3.4: OFD for a Jet Dyeing Operation in the Textile Industry

3.2.5 Preparing the detailed M&E balance for the focus process areas

The next step of the Comprehensive CPOA is to prepare detailed material and energy balances around the PFD. Developing an M&E balance for each operation is however not practical and not always relevant. The critical operations are generally decided based on:

- Focus of the Rapid CPOA arrived at the earlier sections, especially related Cleaner Production,
- The information collected before commencement of the Comprehensive CPOA, and
- Types of materials used; i.e. operations are selected where hazardous materials are used, or where materials used are expensive, or where materials are used in abundance.

The PFD is therefore carefully analyzed and requisite data collected to progressively move from plant level to department level, and finally to critical operations level.

An M&E balance normally requires a tie compound that is used to establish the balance. The tie compound is chosen such that it is:

- An expensive resource,
- A toxic or hazardous compound,
- A resource common to most of the processes, and
- A parameter which is easy to measure / record.

Care should be taken to ensure that all quantification is done by expressing the right units that they are uniform and the associated costs are provided. The detailed M&E balances are generally done over a production lot or a day's production.

Figures 3.5(a) and (b) illustrate detailed material and energy balances at departmental levels of a textile processing unit. It can be seen that discrepancies exist between the input – output values for some of the processes. In these cases further investigations are required to identify the problem areas where assumptions or estimations have been incorrect.

Illustrated below is a detailed material balance for a wet-textile processing unit.

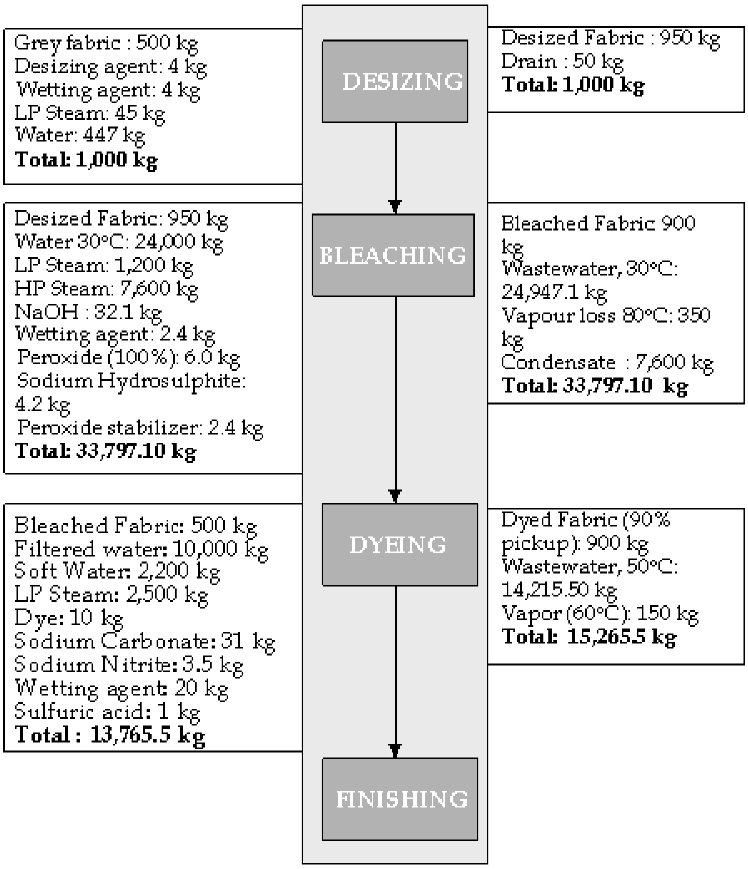


Figure 3.5(a): Material Balance in a Wet-textile Processing Unit

The following steps should be followed to prepare an energy balance.

- For each type of fuel used (e.g. electricity, gas, diesel, fuel oil etc.), the amount consumed over a given period, along with the per unit cost and the total cost could be included in the exercise, and the fuels used in each area of operations could be shown for the period along with energy flows between the areas.
- Estimate the proportion of each fuel used in each area of the operations. To do this task, prepare a list of the rated energy consumption of the equipment, number of equipments and the type of the fuel used. Once done for each of the areas the percentage usage of each fuel in each area can be calculated.

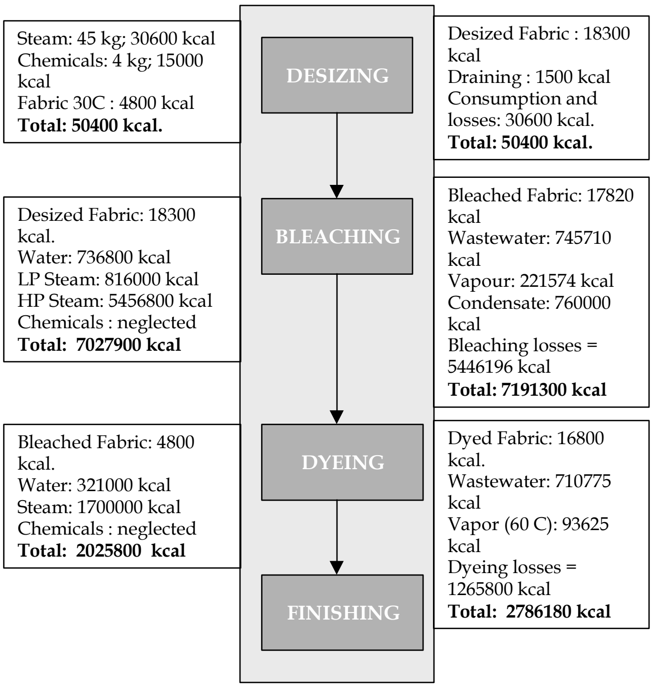


Figure 3.5(b): Energy Balance in a Wet-textile Processing Unit

3.2.6 Comparing with benchmarks

In the industrial or service sector context, a simple ratio of output to input in an organization gives a measure of the productivity or efficiency. Similarly, a ratio of waste generated to products is an indicator of inputs that could not be converted into products.

Losing valuable raw materials and products in the form of waste has three types of costs.

- Firstly, the cost of inputs; i.e. procurement,
- Opportunity lost in the sale of products, and
- Lastly, the cost of treating the generated waste.

Unfortunately, many organizations, in particular the small and medium enterprises, are not aware of how much money is simply lost in this manner. Typically, enterprises consider only the costs charged by external waste contractors as "environmental costs". Actual costs **could be much more** as outlined above.

The extent of off-set of the present production practices can be best understood by comparing against benchmarks specific to the sector. These benchmarks are available today for specific (i.e. over unit level of production) material / energy consumption, as well as specific waste generation activities. The plant level M&E balances help in preparing existing specific consumption levels so as to compare the same with applicable benchmarks.

Indicators that reflect on the efficiency of industrial operations are generally called as "benchmarks" (see **Annex 1** on **Tools** for details). During preparatory activities, these benchmarks should be identified by referring to literature and consulting experts. During the Comprehensive CPOA, the actual operating practices observed in the industry should be compared with these benchmarks to identify deviations or points of differences.

For the knit-ware industry, the industry norm for specific water consumption for operations of scouring, bleaching and dyeing is 120 L per kg of knit fabric processed. If an industry in this category finds is specific water consumption as 180 litre per kg, then water consumption should be identified as the problem area requiring a further analysis.

Further, comparison with the process specific benchmarks (e.g. for scouring, bleaching and dyeing) may show that the specific water consumption on scouring is close to the norm, but the specific water consumption for bleaching and dyeing operations are above benchmarks by 30% and 60% respectively. The focal area of water consumption problem should therefore be the dyeing section.

3.2.7 How to identify problems and opportunities in the industry?

A multi-pronged approach of observations, interviews and monitoring should be used to identify and evaluate problems related to productivity and environmental performance in the industry. The points raised during the review of documents in the previous steps and the Rapid CPOA should be further discussed by conducting one to one meetings with the concerned staff so as to seek clarification and crystallize the understanding of the information collected. Queries unanswered during internal meetings could be discussed with external experts if required or found appropriate, with the consent of the industry owner.

Elaborate on the three major focus areas considered in the Rapid CPOA; viz. equipment, process and materials.

Next, it is important to capture information on the manufacturing processes, quality control and inspection practices used in the industrial unit, and carry out a comparison of the same against the industry benchmarks. **Format 3.2** could be used for this purpose.

Format 3.2: Capturing Relevant Information and Comparing against the Norm

Process	*Inspection point*	*Parameter for inspection*	*Frequency of inspection*	*Norm compared with*
Winch dyeing	Inlet	Water hardness	Once a week	50 mg/L

3.2.8 Checking the operating conditions

Operating conditions should be checked with the SOPs, where major deviation from the norms may be found.

For instance, if we were to expand the example for inspecting the hardness of water at the inlet of a winch dyeing unit (**Format 3.2** given above), we could note the following important points (see **Format 3.3** given below).

Format 3.3: Checking Deviating Operating Conditions with SOPs and Devising Corrective Actions

Parameter for inspection	*Frequency of inspection*	*Norm compared with*	*Comments*	*Corrective action*	*Responsibility*
Water hardness	Once a week	50 mg/L	The norm is incorrect. It should be between 0 – 25 mg/L	Check more frequently and explore the feasibility of water softening	Person in the industrial unit responsible for corrective actions

In the textile dyeing industry, the material to liquor ratio is an important parameter to decide the amounts of raw fabric, chemicals, dye and water to be added. While the chemicals and dyes are dosed properly as a function of the weight of the raw fabric, the water level in the dyeing equipment is often maintained as uniform. This drastically changes the dye concentrations in the bath and subsequently affects the dyeing process.

To capture the deviation from SOPs in the industrial unit, it is critical to understand the actual practices in the unit. Information gathered during the walkthrough could be tabulated as shown below.

Further, interviewing the operating staff in the industrial unit may be necessary to understand the reasons for deviation, effects of the deviation on product quality or resource consumption and corrective actions possible. **Format 3.4** could be used for this purpose.

Format 3.4: Understanding the Reasons for Deviation from SOPs

Process	*SOP*	*Actual practice*	*Reason for deviation*	*Effects of deviation*	*Proposed corrective actions*
…	…	…	…	…	

The process flow diagram developed in the Rapid CPOA should be used and processes highlighted as problem areas. The corresponding processes should be used to build the operational flow diagram (OFD).

3.2.9 Identifying problems and causes by conducting a cause diagnosis

The cause diagnosis is an important step after the detailed M&E balance, as it leads to generation of Cleaner Production options. As the name suggests, the cause diagnosis exercise involves asking the question "why?" i.e. "why did such a problem or outcome occur?" It is essentially an exercise to hypothesize over the root causes of any problem. In performing a cause diagnosis key questions to ask are:

- Is the cause of a concern due to human errors, faulty equipment, suboptimal processes or non-rational practices or a combination of all?
- If human errors are involved, then are they due to poor skill levels or lack of training or absence of supervision?
- How regular and methodical is the equipment maintenance and upkeep? Are standard operating practices followed?
- Is sub-standard raw material being used?

Cause diagnosis can be effectively conducted by using tools such as the **fishbone diagram**. Fishbone diagram use of the experience and expertise of the people who are responsible for carrying out or inspecting the operations. The technique is geared for a team approach and allows capturing of brainstorming discussion. Fishbone diagrams are excellent methods to diagnose the causes in complex situations where a number of factors may be involved. Once diagnosed, these diagrams can be effectively used for the generation of Cleaner Production options.

1. Identify the principal problem that is to be diagnosed and write it next to the head of the fish. For instance, one of the common problems in textile dyeing is that of shade of the dyed fabric does not match with the shade specified by the client. This is referred to as "low Right First Time (RFT)".

2. Identify the primary causes of the problem. Primary causes are typically categorized generically as Man, Method, Material and Machine. To illustrate further, primary causes to the principal problem of low RFT could be:

a) "Lack of supervision" (Category = Man);

b) "Dyeing operation not properly carried out" (Category = Method);

c) "Poor quality of input materials" (Category = Material); and

d) "Uneven pulling of fabric in the dye liquor" (Category = Machine).

These primary causes are to be listed on the "primary fish bones", as shown in **Figure 3.6**.

3. Every primary cause is the outcome of one or more secondary causes. Consequently, this step involves identifying the secondary cause(s) attributable to each primary cause. To carry the illustration further from point (2b) noted above, it is theorized that the dyeing operation may not have been properly carried out due to:

i. Excessive use of salt in the dyeing operation;

ii. Incorrectness of the procedure followed while dosing the chemicals; and

Similarly, for point (2c) noted above, it may be theorized that the poor quality of input materials may have been the result of::

iii. Impurities in the dyes used for the dyeing operation;

iv. Auxiliaries for the dyeing operation having exceeding their shelf-life;

v. Improper storage of fabric used in the dyeing operation; and

vi. Poor quality of water used in the dyeing operation.

Note that the technique in identifying the possible primary / secondary causes of any problem involves asking the question **"why?"; i.e. "why did such a problem or outcome occur?"**

Interestingly, it is probable that certain causes may commonly appear in the diagnosis of primary (or perhaps even secondary) causes. Common examples include "poor water quality used in the dyeing operation" and "lack of clear and concise work instructions".

In a textile dyeing industry, the Right First Time (RFT) was found to be very low. RFT is an important indicator of resource consumption and process efficiency. A fishbone diagram was generated to understand the causes of the low RFT. Major causes identified were: suboptimal dyeing operation, poor raw material quality, poor finished fabric quality, and lastly faulty or poorly maintained equipment. Further analysis showed underlying causes of each of the major causes. For instance, sub-optimal dyeing operation could result due to incorrect dye recipe or large fluctuations in material to liquor ratio.

Figure 3.6 shows the fishbone developed in the above example.

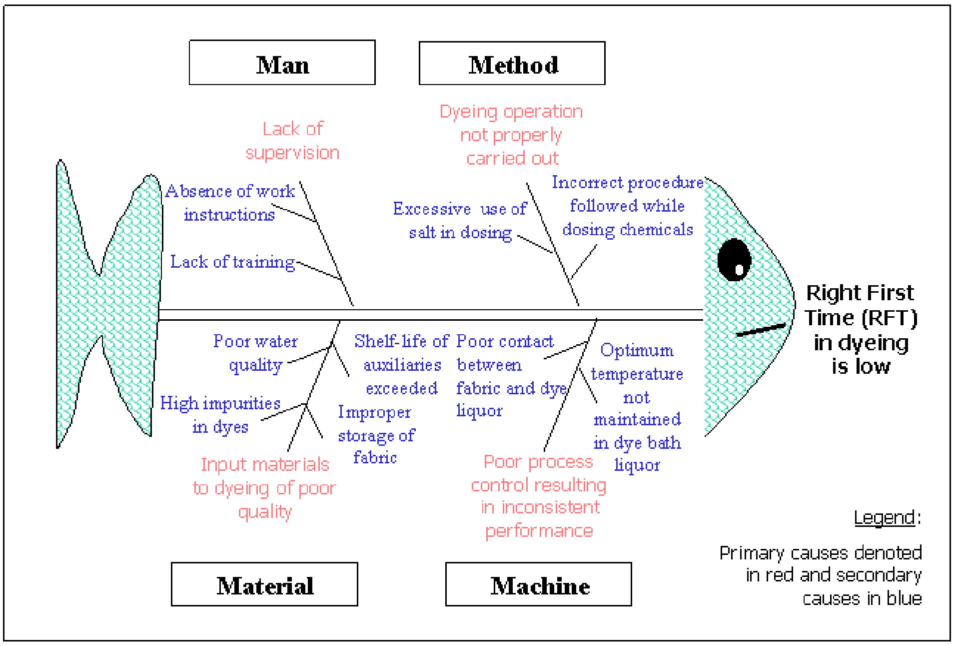


Figure 3.6: Illustration of a fishbone diagram[16]

3.2.10 Generating Cleaner Production options

Option generation is a creative process, and is best performed, as in the case of the cause diagnosis, by the CPOA team. The option generation exercise is conducted through **brainstorming**, a commonly used tool for generating ideas (see **Figure 3.7**). Given a particular item which needs to be resolved, the team and the enterprise personnel have to deliberate on the ways and means of obtaining a solution to it. In this sense, cause diagnosis described in the earlier section provides a starting framework for the brainstorming exercise.

[16] Refer to **Section 1.4** of **Annex 1** for details on developing a fishbone diagram.

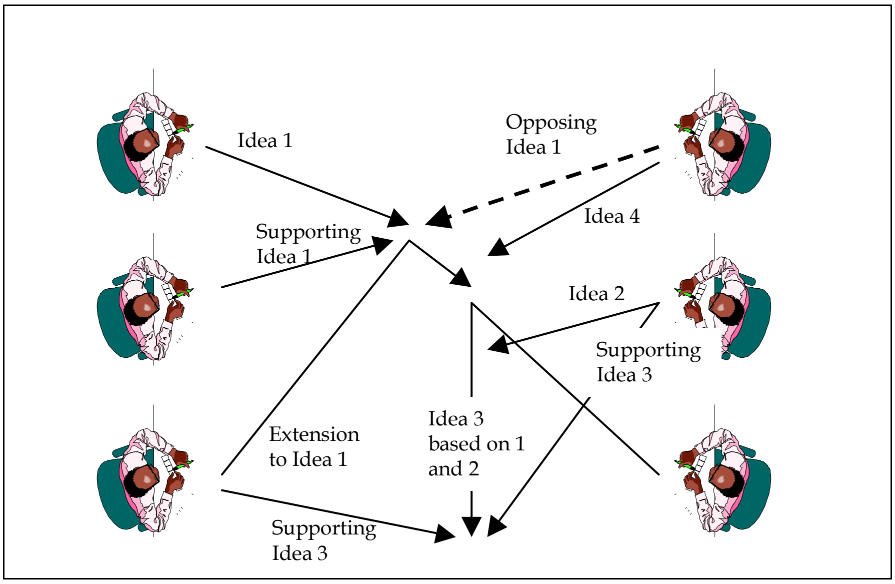


Figure 3.7: Generating options through brainstorming

Note that the value of the ideas is not assessed at this level. The primary objective is to generate as many options or ideas on a particular problem at hand. However to structure the discussions, it is recommended that a logical process (as outlined below) be used.

The fist step could be to tighten housekeeping and maintenance related activities. This can include fixing the leaks, spillages, overflows, steam traps, insulation over heated pipes and tanks etc. This also involves employee training, supervision etc. that could fall under the category of management and personnel practices.

The second step would be to study all the operating procedures practiced in the organization and compare with the SOPs that need to be adhered to in operating the processes and associated equipment. Such an examination will help in identification of discrepancies and deviations from SOPs. These need to be corrected as a first step and form the first set of options.

Having standardized the operating procedures, the next step is to eliminate or avoid operations that may be redundant. For example, certain washing operations may be not required due to changes in raw materials or product specifications. It is also possible that some of the processing steps could be eliminated if their function is achieved by process modifications. An example is given below to illustrate this point.

A textile wet processing unit uses a reactive dyeing process followed by two washes (see Figure 3.8).

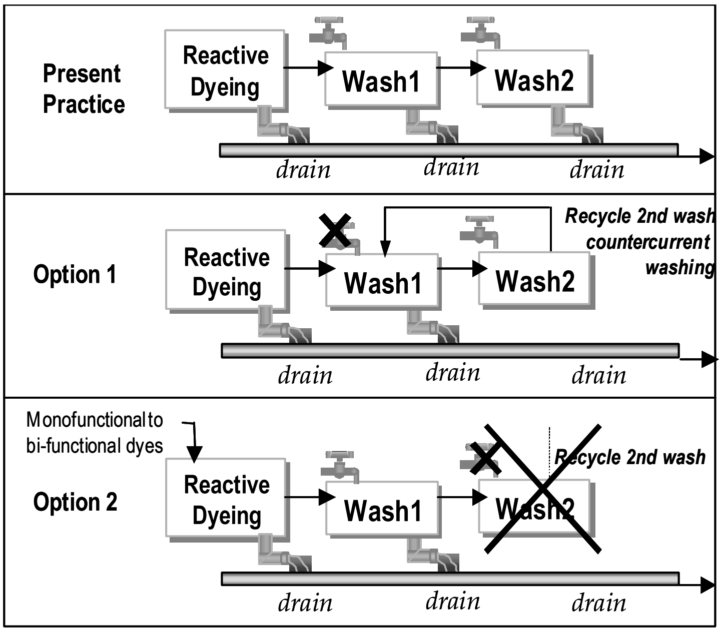


Figure 3.8: Illustration of a textile wet processing unit

The wastewater discharge may be reduced by (a) recycling the wash water from the second wash to the first wash, or (b) changing from the currently used mono-functional dyes to bi-functional dyes, which will allow the elimination of the second wash completely (given the superior fixation properties of the new dyestuff). Such options will reduce water consumption as well as the amount of wastewater generated.

The next step is to consider modifications in the operating procedures - changing operating parameters or practices by generating new ideas, so as to improve a particular process and improve its efficiency. Such a change may require a trial or a pilot to ascertain its applicability and impact on the products. For example, it may be observed that dyeing may be performed at lower temperatures to obtain comparable results, by replacing "hot dyes" with "cold dyes".

Analysis of waste streams could reveal avenues of recycling and explore reuse /recovery of raw materials / by-products. Recycling could be practiced in form of direct or indirect recycling. Direct recycle involves using part of the process output directly as input in the same or different process. In an electroplating factory, for instance the metal solution dragged out with the jobs being plated can be directly returned to the metal bath using drain boards. Indirect recycling is required when the waste stream is slightly contaminated and needs to be cleaned up before recycle. An example of the above option could be that of using last washes in a textile factory where the wash water may require pH adjustment and filtration prior to its use in the same or other operation. Examples of recovery from waste streams could include heat recovery from hot streams and recovering by-products or raw materials by separation technologies (e.g. membrane filtration).

Once such basic approaches have been considered, the options that could require major changes in the processes or equipment or product redesign should be considered.

These options are grouped into various categories as shown below (outlined in Section 1.6 of the manual).

- Management and personnel practices
- Process / equipment change
- Raw material substitution
- New technology
- New product design

An illustration of generating Cleaner Production options (based on a fishbone analysis and followed by brainstorming) for one of the generic categories is presented below:

Generic categories as per the fishbone diagram	*Primary causes*	*Secondary causes*	*Possible Cleaner Production options*	*Category of Cleaner Production options*
Man	Lack of supervision	Absence of clear work instructions	Develop work instructions as Standard Operating Practices (SOPs). Get the SOPs reviewed by external experts, Closely monitor improvements or identify problems faced if any in the implementation of the SOPs, Build a record keeping system to monitor SOP related compliance	Management and personnel practices

To summarize, for generating Cleaner Production options the questions one should ask are:

- What changes in the product specifications are conceivable to reduce waste generation and the overall environmental impact of the business?
- How do input material specifications have to change to reduce waste generation and the overall environmental impact of the business?
- What changes in technology and equipment are needed to reduce waste generation and the overall environmental impact of the business?
- How can equipment operation and maintenance practices be improved to reduce waster generation and overall environmental impact of the business?
- How can valuable components be reused, recycled or recovered?

3.2.11 Evaluating Cleaner Production options from the environmental and economic point of view

Once you have generated options they need to be screened to determine which options are technically feasible (in terms of benefits and risks) and economically realistic (e.g. where funds are available or possible to source).

In this perspective, screening achieves weeding out the risky, infeasible or rather expensive options, and prioritizes and groups options that are feasible.

The following questions should be used in the process of screening.

- **Which of the causes are eliminated or mitigated by the options and how effectively?** This will give an insight whether all the causes have been addressed by this option or additional options are required to completely resolve the issue
- **What are the main outcomes from the implementation of this option?** This will give an indication of actual improvements in terms of resource efficiency or productivity or reduction in waste generation or improved health and safety etc
- **What are risks in implementing this option?** Some options are not fully proven and may require a demonstration or piloting to assess the outcomes before a full scale implementation is carried out.
- **What are the expected capital and operating costs of the option?** This will help in deciding the financing mechanism for the option - whether the option can be implemented solely on internal finances or other external instruments need to be used (in the form of bank loans, grants, joint ventures with technology suppliers or venture capital).
- **Will the option affect the key production process or product features?** This will be crucial to decide on the implementation plan of the options. If the option requires major changes in the processes that requires production pattern to be interrupted or changed, then loss in production needs to be factored in the economic analysis of the option.

Screening of the options at this stage requires a technical evaluation and a broad understanding of risks and costs involved to understand whether further investigation is necessary. A detailed economic and environmental evaluation will be performed later in the feasibility analysis phase of screened options.

Technical Evaluation

In order to assess whether an option can be put into practice the technical evaluation should be based on the following aspects:

- **Nature of option** such as operational control, housekeeping, technology, equipment change, material substitution or a combination.
- **Ease of implementation**; i.e. the scale of implementation - pilot or lab scale or full scale, technical support required, whether production or business will be interrupted.
- **Time required for implementation;** i.e. the time required if equipment or material needs to be procured, installed or commissioned.
- **Human resources required**; whether the option(s) can be implemented by in-house staff or external expertise or collaboration with Partner organization is required.
- **Cross-linkages with other options**; whether a particular option is linked to implementation of other options and / or whether the option is best implemented standalone or in consideration with other options.

Feasibility Analysis

Economic Evaluation

The economic evaluation consists of analyses and computations of the evaluation criteria like pay back period, Net Present Value (NPV), Internal Rate of Return (IRR), etc. based on the project costs and benefits17.

This can be easily done by conducting a detailed CBA building upon the preliminary work done during the Rapid CPOA. CBA facilitates the comparison of alternatives in terms of the monetary costs involved and the benefits obtained. The costs and benefits, whether environmental, social or economic, must be quantified in monetary terms to the extent possible.

CBA therefore consists of building information on:

- Capital costs,
- Net revenue that is computed as a difference between total revenue (that is generally higher than the base case) and the operating costs (that are typically lower in the changed scenario), and
- Rates of interest and depreciation to enable computation of the Present Value.

A better approach is to use the concepts of NPV and IRR. These concepts consider the time value of cash inflows and outflows during the useful life of the investment made.

The following equation may be used for computation of NPV:

$$NPV = -(CF_0) + \sum_{i=0}^{i=n} \frac{Net\,Cashflow_i}{(1+r)^i}$$

where

CF_o = Cash outflow in the first year (capital investment)

r = opportunity cost of capital

n = useful life of the investment in years

For an investment to be economically feasible NPV must be greater than zero.

Another indicator commonly used along with NPV is the **Profitability Index (PI).** PI is computed as the ratio of the present value of the total cash inflows and the present value of the total cash outflows. For an investment to be economically feasible PI must be greater than 1.

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[17] Refer to **Section 1.5** of **Annex 1** for details on conducting economic evaluation.

IRR is essentially the rate of return of investment during its life by way of net cash inflows (i.e. **inflows – outflows**). This rate is to be compared with the rate of interest of the borrowings that may be needed from the market.

It is useful to carry out a sensitivity analysis to understand the "ruggedness" of an option. This can be done by varying the expected efficiencies or yields, prices that the by-products may fetch in the market or the capital costs of new equipment and see how much of an effect these have on the outcome. This can help in building both optimistic and pessimistic scenarios to test how sensitive the IRR or NPV, for instance, is to the data assumed in the economic analyses.

Consider an example of changing six existing winch machines to three jet dyeing machines at a textile dyeing unit. Jet dyeing machines are superior to winch machines in productivity, resource consumption, dyeing quality and versatility. Effectively three jet machines will result in the same level of production as by six winch machines.

Figure 3.9 presents a cash flow diagram showing various inflows and outflows. The results of payback, NPV and IRR are also given.

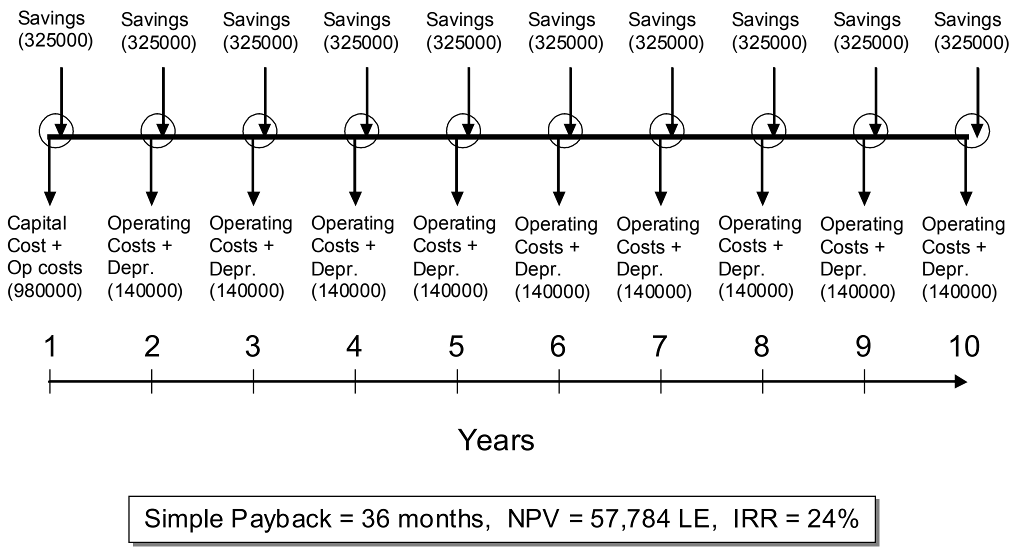

Figure 3.9: Inflows and Outflows - Replacing a Winch Machine with a Jet Dyeing Machine

Savings of LE 325,000 are possible for each year due to less water, energy and dye consumption, less cost of wastewater treatment and improved right first time. Improved RFT means less reprocessing and hence less water, energy and dye consumption. The amount of LE 140,000 corresponds to operation and maintenance cost of the jet dyeing machines over each year. The capital costs in the first year indicate the costs incurred towards purchasing new jet machines (including the installation costs) and the savings indicate the returns obtained in the sale of the existing winch machines. The example shows favourable values of NPV and IRR thus indicating the project to be economically viable.

The cash flows can be more complex than the one showed above. The costs of machine operation and maintenance could increase over time. Similarly, the savings could be more as the unit rates for water, energy and dyes are expected to increase. In such cases, software tools such as P2Finance can be used that allow for computation of NPV and IRR for non-uniform cash inflows and outflows[18].

Environmental Evaluation

The objective of environmental evaluation is to determine the positive and negative impacts on the workspace, neighbourhood and the environment. An environmental evaluation must take into account the whole life-cycle of a product or a service.

The environmental evaluation will consist of determining whether the option has net environmental benefits such as:

- Reduction in pollutants,
- Reduction in energy consumption,
- Reduction in water usage,
- Reduction in toxicity of waste and emissions, and
- Reduction of risks of using or disposing a product.

It is useful to attempt quantification of environmental benefits to the extent possible, so that these benefits could be included in the economic analyses.

Selection of feasible options

Once the technically non-feasible options, options with unfavourable IRR and the options without significant environmental benefits are eliminated, the remaining options may be considered to prepare an implementation plan.

3.2.12 Implementation of Cleaner Production options

In this phase, the feasible Cleaner Production options are to be implemented using available funds and technical skills at the enterprise. Technical capacity of the staff at the enterprise can be enhanced by instituting appropriate training programmes. The expected result of this phase is three-fold:

- Implementation of the feasible Cleaner Production options,
- Monitoring and evaluation of the progress achieved by the implementation of the feasible options, and
- Documentation and initiation of suitable management systems that will sustain Cleaner Production activities.

Preparing the Cleaner Production plan

The implementation phase will require preparation of a plan that clearly defines the timing, tasks and responsibilities. This involves:

[18] The software package for P2Finance may be downloaded from http://www.tellus.org/general/software.html

- Integrating the results of the feasibility analysis for the different options (also called as options synthesis),
- Selecting the best possible combination(s) of options,
- Planning for implementation of selected options, and
- Preparing required technical specifications, site preparation and monitoring schedules during construction and operation.

Generally, the plan should prioritize implementing options that are low cost, easy to implement and are a pre-requisite for the other options to follow. This should be followed by options that are more investment intensive, requiring laboratory or pilot trials or options that require interruption in production schedules.

Simple indicators should be used to monitor progress and to keep the management as well as other interested parties regularly informed about progress of implementation.

3.2.13 Preparing the Comprehensive CPOA Report

The comprehensive report is the document that absorbs all the findings of the Comprehensive CPOA conducted in an industry. Ideally, the industry CPOA team leader should write the report after discussing with the other team members.

A sample format is presented below (see **Format 3.5**).

Format 3.5: Sample Format for a Comprehensive CPOA Report

The Comprehensive CPOA Report
1. Preliminary details and background of the industry ▪ **Name:** ▪ **Address:** ▪ **Governorate:** ▪ **Ownership (Private / Public):** ▪ **Name and contact details of the owner:** ▪ **Sector / sub-sector (e.g. textile sector – dyeing sub-sector)** ▪ **Year of establishment:** ▪ **Legal position (e.g. registration)** ▪ **Plot area (in sq. m.):** ▪ **Date visited:** ▪ **Time taken for the visit (days):**
2. Profiles of production, finance, market and other information related to equipment, utilities, quality control and testing etc.

The Comprehensive CPOA Report

This section is to be built using the Rapid CPOA report and the additional information procured during the Comprehensive CPOA.

- **A background / history of the company with information such as name and background on owners, year of establishment.**
- **Staff details, skill level, training aspects on operation of equipment or process.**
- **Production capacity for each product, any variations due to market demand or other external / internal factors, season etc. Also include which markets the product(s) are to be sold to; i.e. local markets or for export.**
- **List of raw material and products. Include whether raw material is local or imported, quality requirements, cost etc. Any pre-testing of raw material(s), number (s) of rejects to suppliers.**
- **Quality assurance and control procedures used, status of product quality of the factory in the market, price fetched, parameters used to measure quality etc. any rejects or complaints from customers.**
- **Quantity of water used per day, quality of raw water, whether any treatment is done, why and how.**
- **Energy and steam consumptions to be included here including boiler details and operating efficiency.**
- **Nature and number of equipment including whether new or second hand, price, present status, maintenance and training requirements, capacity, energy consumption and other details.**
- **Step by step description on the present process of manufacturing.**
- **Profile of the company in terms of market position, present conditions and plans of expansion, financial position.**

3. Identification and evaluation of environmental issues

- **Present problem areas regarding equipment, process and materials in this section.**
- **Indicate non-standard operating procedures, housekeeping status, deviation from benchmarks.**
- **Cause diagnosis using fishbone diagram to highlight root causes of problems.**
- **Include generation of multimedia emissions with estimates of quantity and treatment applied if any, points of discharge, neighbourhood, environmental impacts, disposal and major health complaints by the workers.**
- **Include land-use and population characteristics of the neighbouring area.**

4. Cleaner Production Opportunities

- **Include here the significant Cleaner Production opportunities identified in the factory during the Rapid CPOA.**
- **Include additional opportunities identified during Comprehensive CPOA.**
- **In listing the opportunities, provide an estimate on the costs that will need to be incurred, time for implementation, benefits that would be accrued and any training that will need to be given prior to**

The Comprehensive CPOA Report

the implementation of the Cleaner Production options.

5. CBA of Cleaner Production options

- **Include the detailed CBAs for the options to check their economic feasibility. The CBA should clearly bring out the nature of investments and savings, cash flows required and the payback period.**

6. Implementation Plan and Recommendations

Based on the findings of the Comprehensive CPOA and the CBA, indicate the suitability of the factory for:

- **Implementation Project with full / partial financial assistance, or**
- **Only Technical Assistance and training**
- **Comment on the replication potential of the Cleaner Production implementation in the industrial unit, in other industrial units within the sector.**

7. Annexes

Include photographs, layout, location diagram, PFD, OFDs, detailed M&E balance, Eco-maps, Fishbone diagrams, etc.

3.2.14 Reviewing the Comprehensive CPOA Report

A review of the Comprehensive CPOA report is necessary in order to consolidate the outcomes of the same, and to decide on the future course of action to be taken. Future course of action could be Implementation Projects, technical / equipment / training assistance, or information dissemination workshops.

The following points need to be taken into consideration while reviewing a Comprehensive CPOA report:

- The format and structure of the document should be presentable and easily understood.
- The project objectives should be within the scope of objectives set down by the sponsoring organizations (donor agencies and / or national government).
- All information collected should be accurate and as complete as possible.
- Any assumptions made should be valid and relevant.
- Any benchmarks used for comparison should be relevant and up-to-date.
- The conclusions mentioned therein should be rational and feasible.
- The total cost requirement if the recommended course of action is selected, the contribution from the unit / enterprise, and the fraction of cost which is to be funded by external donors (international organizations) and / or the national government?
- The multiplication factor of the project – if the same is deemed as "high", then an Implementation Project can be conducted from the findings of the Comprehensive CPOA.

The conclusions are then ratified and the future course of action is decided based on these considerations. If there is a possibility of conducting an Implementation Project, the next step would be to prepare a project proposal to communicate the project to the funding agency.

Chapter 4

What will we learn from Chapter 4?

4.0 Preparing Projects for Implementation

4.1 Introduction

4.2 Models for the Identification of Implementation Projects

4.3 Preparing the Project Proposal to Acquire Funding

4.4 Preparing for the Implementation Project

4.0 Preparing Projects for Implementation

4.1 Introduction

Milestone 3[19] **(Preparing Projects for Implementation)** includes **step 7** (preparing the project proposal for to acquire funding) and **step 8** (Preparing for the Implementation Project).

Experience has indicated that the best way to persuade enterprises and institutions to adopt and implement Cleaner Production is by showing them the results from practical implementations. A common barrier to Cleaner Production is the lack of local examples demonstrating that Cleaner Production can be applied to any industrial sector and that waste can be turned into profit. Local entrepreneurs are usually not aware of the scope and potential of Cleaner Production. A key activity of the Cleaner Production consultants, particularly in the beginning, is in-plant Implementation Projects which assess Cleaner Production opportunities in a local company and help it to implement them.

An Implementation Project is basically the **testing** of an idea or a methodology (such as CPOA) that is innovative, but which is not fully proven. Sometimes the idea may warrant implementation because it is developed or proven elsewhere but has not been yet adapted to the local situation. Sometimes an implementation may be needed because not enough technical and financial information is available on **implementing** an idea. Finally, implementation may involve an idea that has an element of risk of the unknown that dissuades the stakeholder[20] from its application. **An implementation in this case is essentially a confidence building measure.**

We should again **not restrict** the term implementation to technologies or equipment. Cleaner Production can also include improving work methods, implementing innovative types of action training or introducing new formats of partnership. For instance, the application of Rapid and Comprehensive CPOAs could also be considered as 'Implementation Projects' in some sense.

It is important that we clearly distinguish between the terms "Implementation" and "piloting". Piloting is just one way to implement the Implementation Projects. Piloting is a good approach for high cost high-risk Cleaner Production ideas. However, for ideas that correspond to low to medium cost and risk, implementations can be always implemented directly on a full scale.

Identification of appropriate Implementation Projects (see also **Sections 3.2.9** to **3.2.13**) is a most crucial task. Typically, an idea may be considered for implementation if:

It has not been tried so far and appears worthy for trial.

It has been successfully tried elsewhere, but not in the country or local context where conditions are slightly different.

[19] Taken from **Section 1.9** of **Chapter 1** of this manual.

[20] The terms 'Stakeholders' or 'Target Stakeholders' in this part, refer to all the organizations involved in or the direct / indirect beneficiaries of the Implementation project

It is an idea which has been proved only in medium-scale or large-scale industries, but needs to be studied for small-scale industries as well.

It has a low risk of technological obsolescence.

It has a high replication potential given the characteristics of the sector.

Understanding of environmental benefits that are anticipated (e.g. health and safety, worker concerns, neighbourhood concerns, etc.) are presently inadequate.

The primary objective of the Implementation Projects is to show, at the local level, the potential, relevance and applicability of Cleaner Production approaches for their wider adoption across the target stakeholders.

In this perspective, the Implementation Projects have several benefits:

- They provide an opportunity to build locally relevant case studies for preparing content for awareness-raising materials. In this sense, Implementation Projects are awareness-raising mechanism.
- Enterprises that participate in the implementation realize that "Cleaner Production advantage" and help in spreading the message across the sector or in the geographical cluster.
- They help in establishing partnerships and networks with other local consultants.
- They help in building capacities at the participating enterprises to adopt Cleaner Production.

4.2 Models for the Identification of Implementation Projects

Implementation Projects are generally identified after a Rapid CPOA or a Comprehensive CPOA.

Box 4.1: Implementation Projects visualized in two steps

Conception stage:

- *The direct beneficiary*: For instance, this could be the unit / enterprise industry at whose facility the Implementation Project will be implemented.
- *Technology / equipment provider/ management consultant:* For example, a technology provider on ozone bleaching may be an interested party or a management consultant practicing Total Quality Management (TQM) or 5S[21] may be interested to "test" the environmental and economic benefits of the methods or tools. The technology / equipment providers or the management consultants are the indirect beneficiaries.

Multiplication stage:

- *The financial institution(s):* The financial institutions with environmental related funds (e.g. Green House Gas Reduction or Ozone Protection) will be interested in providing a soft loan under these schemes.
- *Partner(s) and sector association(s)*: The partner may be a research and development organization in a specific sector, willing to commercialize its lab scale technology. The sector association could be an export-oriented sector that may be interested in obtaining ecolabels for its product using Cleaner Production.
- *Government agency*: This could be apex body for triggering environmental or health and safety regulations, which could reform the policies for favouring the replication of the Implementation Project in and across the sector.

The Implementation Project can be conceived using two different models. These two models are shown in **Figure 4.1.**

[21] A Japanese concept that focuses on improving housekeeping in workplace

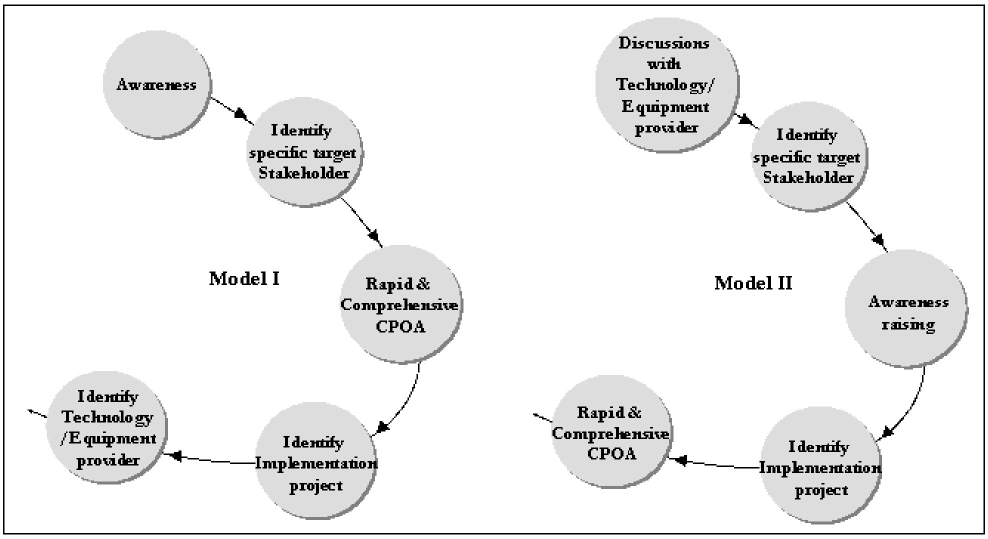

Figure 4.1: Implementation Project Conception Models

A review of each model is provided in this section. Note that on many occasions, a hybrid model will probably be used.

Model I:

As shown in **Figure 4.1**, Model I begins with the premise that awareness generation has to precede any activity towards implementing cleaner production. Having spread awareness about the role and benefit of cleaner production in industry, identity Implementation Projects as an outcome of the CPOA, which are already practiced as a consequence of awareness / training related initiatives. Thus, in this model, the Implementation ideas and the specific target stakeholders are already identified. The next step is to structure the Implementation Project by preparing the required proposal (e.g. application for financial support from the programme, Memorandum of Understanding or MoU between the specific target stakeholder and the technology /equipment provider or the management consultant, etc).

This step is followed by implementation, monitoring and evaluation, documentation and the promotion of the results from evaluating the implementation project.

Thus in this model, the idea of the Implementation Project and the specific target stakeholders are identified at the same time, essentially through the process of CPOA.

Model II:

Identify Implementation Projects first based on interactions with the technology / equipment providers and / or management consultants.

For example, discussions with a membrane technology provider may reveal that caustic recovery technology using membranes could be cost-effective to medium to large textile processing industries. A discussion with Dairy Research Association may indicate that use of automatic knives may be a potential intervention at cottage cheese manufacturing units to increase yield of cheese and reduce pollution load of whey.

In this case, it becomes necessary to operate the awareness, training and CPOA activities first to identify specific target stakeholders and obtain a commitment. The following are the next steps in this model:

- Hold promotional events, typically seminars / workshops, in the geographic area of interest by inviting the target stakeholders. These events are organized in partnership with the technology / equipment providers and / or management consultants or with the financing institutions / government authorities who may sponsor Implementation Projects. Depending on the type of Implementation Project, the workshops could involve stakeholders across the supply chain.

- Obtain the commitment of the specific target stakeholders for the joint implementation of Implementation Project through an MoU.

- Carry out the CPOA / training at for specific target stakeholders to prepare a detailed proposal for the Implementation Project.

- Structure the Implementation Project by preparing the required proposal (e.g. application for financial support from the Programme, MoU between the specific target stakeholder and the technology / equipment provider or the management consultant, etc.).

This step is then followed (as before, in **Model I**) by implementation, monitoring and evaluation, documentation and promotion.

In this approach, it is useful to focus on cross-sectoral or hub technologies (e.g. membrane technology) or utility based improvements (e.g. improvement in boiler design and operation) or commonly adopted management systems and methods (e.g. Environmental Management Systems like ISO 14001 or 5S, etc.) as the first candidates for Implementation Projects. The Implementation Project based on the above will have a wider reach as the applications will cut across the sector and greater multiplication potential.

Model II presents a more strategic or programmatic approach. **Model II should be ideally initiated after deepening Model I.** Model I helps in building the insight, experience and clientele at the geographical area or sector of focus. Model II is more private sector and technology driven with wider sectoral outreach.

4.3 Preparing the Project Proposal

4.3.1 What is a project proposal?

The project proposal is typically submitted by a project proponent to an agency disbursing financial assistance, defines the project's aim, intended actions, expected outcomes and required inputs from various sources.

The project proposal is a critical output at this stage of the CPOA, and must be structured with care.

The project proposal is a confidential document. It will **not** involve the units identified for the Implementation Project(s) nor the national consultants in any way.

4.3.2 Why is a project proposal required?

The project proposal is used by the sponsoring agency to evaluate the financial viability of the project, potential risks and accordingly to accept or reject the proposal. It is therefore important that the financial details of the project be worked out thoroughly, the scope of the project clearly stated, and all expected outcomes defined in as quantitative manner as possible.

As noted earlier, while an international donor and / or the national government may partially finance the Implementation Project, some financial input from the unit owners should be emphasized, to endorse their commitment to implementation and sustenance of Cleaner Production initiatives.

The project proposal forms the basis for a formal agreement between the donors and the individual units, formalizing their respective responsibilities and financial input.

International donors generally mandate the preparation of a Project Concept Note (PCN), which is essentially a project proposal with complete financial details. The PCN is then assessed by the donor(s) and used to accept or reject a proposal. The next section provides information on how to develop a PCN.

4.3.3 How to develop a project proposal?

The items to be highlighted in the preparation of the PCN are noted in **Format 4.0** below.

Format 4.0: Format for a Project Proposal

1.0 Preliminary Information
- 1.1 Project Summary
- 1.2 Project Description

2.0 Rationale and Justification for the Proposal
- 2.1 Background Information
- 2.2 Stakeholders and Promoters
- 2.3 Project aspects for compliance with Donor Objectives

3.0 Purpose, Outputs and Replicability

4.0 Activities
- 4.1 Improve Operating Procedures
- 4.2 Training
- 4.3 Documentation and Dissemination

5.0 Risks and Conditions

6.0 Project Financing
- 6.1 Cost Benefit Analysis

7.0 Sustainability
- 7.1 Planned Implementation and Management

8.0 Outline Terms of Reference (ToR) for the Local Consultant

4.4 Preparing for the Implementation Project

The following are the essential points to be remembered while preparing for any Implementation project.

It is extremely important to choose very carefully the enterprises that will participate in an Implementation Project. If participants do not support the project then value of the whole Implementation Project is jeopardized.

It is important to secure commitment and willingness for the Implementation Project with the highest levels of the enterprise; for instance, the owner in a small enterprise, the top manager, and so on.

It is good to choose wherever possible enterprises whose ownership / top management is dynamic, forward-looking, who are risk takers, and seen perhaps by the local competitors as "leaders". Such persons will be more willing to take on the "unknown" and carry through the commitment.

It is wise to formalize the agreement on the part of an enterprise to take part in an Implementation Project, by signing an MoU. This will not only commit the enterprise to the Implementation Project, but it will also outline what the Programme is committing to do during the project. Thus, the MoU helps in establishing a clear understanding on individual as well as collective responsibilities.

In case of an MoU with the government or sponsoring agency, the MoU should state the role of the Programme in assisting the government agency in formulating a policy that will assist in the replication of the Implementation Project. The MoU with financial institutions should define the role of the Programme in formulating a scheme for the Cleaner Production Implementation Project that may be accessed by those interested to replicate it.

The MoU need not be limited between two stakeholders as these can even be tripartite. It may involve the Programme, the financial institution and the technology provider. The outcomes of the tripartite MoU should essentially have a commitment of funds from the financial institutions, a commitment on information disclosure and sharing of information from the technology provider or the enterprise.

Finally, the MoU may be annexed by agreements that specify the financing mechanisms. Typically, the cost of the Implementation Project is shared by the enterprise, technology provider, government agency or a financing institution. These costs include fees to be paid to the Programme for project management as well as technical advice.

Chapter 5

What will we learn from Chapter 5?

5.0 Conducting Implementation Projects

5.1 Conducting the Implementation Project

5.2 Evaluating the Implementation Project

5.3 The Logical Outcome of the Implementation Project Cycle

5.0 Conducting Implementation Projects

Milestone 4[22] **(Implementing Projects)** involves **step 11** (Actual Implementation of the Project) and **step 12** (Evaluating the Implementation Project).

5.1 Conducting the Implementation Project

After the commitment of the owner of the unit / enterprise towards the Implementation Project exercise has been secured, attention should be shifted to the conduct of the Implementation Project. This activity may involve drawing up specifications, carrying out monitoring, procurement and inspections, preparing the site at the unit, installing equipment (if applicable), taking trial runs, monitoring production and product quality, carrying out optimization or refinements, and so on. **This will require the preparation of a detailed project implementation plan, specifying each task, the timing and the responsibilities.**

In general, the implementation plan would involve the following aspects:

Understanding and recording the baseline: Conduct baseline studies to capture "before" the project situation. This will include measurement of all inputs, products and wastes generated, work space and ambient environmental conditions, health and safety related aspects. This step will also include information on management systems and methods if the project involves introducing new management systems or tools. It is important that the baseline is properly documented (including photographs or videos) as it will be used to compare with "after" the project situation.

Implementation of the project itself: This step will include sequence of implementation routes such as lab-scale studies, pilot trials or full scale application. Implementation may have to be preceded by training programmes, especially if the Implementation involves introduction of an entirely new process or installation of new equipment. It is important to track this step with thorough documentation and visual recording as it involves adjustments, refinements, lessons on what should not be done, etc.

Measuring the change: This step involves measurement of all inputs, products and wastes generated, work space and ambient environmental conditions, health and safety related aspects similar to the baseline study. This step will also include information on management systems and methods if the project involves introducing new management systems or tools. It is important that the changed scenario is properly documented (including photographs or videos) as it will be used to compare with "before" the project situation.

Evaluating the project: The Implementation Project should be ideally evaluated by a third party to maintain the required objectivity. In some cases, e.g. projects that include product redesign, the evaluation may not be limited to facility based assessment. Rather, it may also involve determining the market response, monitoring customer satisfaction, etc. The aspect of evaluating the Implementation Project is further explained in the sections below.

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[22] Taken from **Section 1.9** of **Chapter 1** of this manual.

Box 5.1 provides a guideline of dos and don'ts for Practitioners conducting Implementation Projects on Cleaner Production.

Box 5.1: Dos and Don'ts for Conducting Cleaner Production Implementation Projects

- The Practitioner should be involved in the Implementation Project as a mentor, a facilitator as well as a professional manager.
- The **roles and responsibilities** of all parties involved in the Implementation Project should be **clearly specified, understood and agreed upon.**
- **Publicize to the other units across the sector** that an Implementation Project will be held for them.
- Take time to **develop good relationships** with all the involved parties – the number of Implementation Projects is **less** important than their effectiveness.
- **Involve the unit's financial managers** in the Implementation Project, so that the unit may accurately calculate its economic interest in adopting Cleaner Production options.
- If capital intensive Cleaner Production options are not taken up as Implementation Projects due to lack of finance, the Practitioner should **develop the expertise to convert such options into bankable loan proposals, and act as an intermediary between financial institutions and units.**
- Take measures to **ensure that the results of the Implementation Project get communicated outside the unit to the wider industry.** Ensure that the necessary photographs, videos, etc. are taken during the implementation of the project so as to track its progress and also to use it as promotional material in the future.

5.2 Evaluating the Implementation Project

Evaluation is based on the objectives and expected outcomes from the Implementation Project as stated in the project proposal; the success or failure of the project depends on the degree to which it meets the objectives set out.

Evaluation proves the relative benefits or risks of the Cleaner Production options tested in the Implementation Projects. It lays the foundations for dissemination activities and outreach programs to promote Cleaner Production across MSMEs in Egypt.

Evaluation is also useful in identifying aspects, barriers and impacts that were not anticipated at the onset of the Implementation Project.

5.2.1 Criteria for evaluation

Evaluation should be based on the following criteria:

Economic

- Was the payback period set down in the project proposal realised?
- Was the expected Internal Rate of Return realised?
- Was the cost benefit analysis conducted accurate? Were there other costs not foreseen in the selection stage?

Environmental (Process/ Product related)

- Were there any unexpected changes to the process schedule?
- Were any changes in the product quality seen?
- Is access to raw material, fuels, etc convenient? Were there any hidden costs missed in the pre-implementation stage?
- Were there any impacts on material vendors, clients, or other components of the supply chain?

Labour welfare related

- Has the work environment improved?
- Have there been any evident changes in occupational safety?
- Have any safety drills/ precautionary measures been initiated? Who manages these? How are they documented?

Management input

- Does the management currently demonstrate a commitment to sustaining all the Cleaner Production activities being demonstrated?
- Is environmental management now discussed or considered in planning?
- Is the unit likely to improve its environmental management to integrate management systems, etc., in future?

Policy related

- Were any policy level barriers experienced?
- Does the project in any way encourage changes in policy that will in turn encourage replication?

5.2.2 Who conducts the evaluation?

A **neutral** team not involved with earlier phases of the project must necessarily conduct evaluation. These could be sector experts and national, or international experts. Practitioners / Project officers and other members of the CPOA team would **not** be part of the evaluation.

5.2.3 What is the expected outcome of evaluation?

The evaluation should be documented in a report that would serve as a case study for future Implementation Projects.

5.3 The Logical Outcome of the Implementation Project Cycle

The logical outcome of the Implementation Project cycle is to **replicate** successful Implementation Projects from one unit across all such similar units in the sector. In this manner, the positive outcomes of the project can be transferred to all concerned parties. In sum, the Cleaner Production practitioner / consultant should aim to play the following roles.

1. **Writing project proposals** for submission to financial institutions on behalf of the MSMEs; or alternatively, approaching the MSMEs with a project proposal on behalf of the financial institution;

2. **Seeking other possible interested partners** who could take a direct stake in the Implementation Project and help achieve success in its multiplication; such partners could be technology and / or equipment providers interested in commercializing laboratory-scale or pilot-scale technology;

3. **Interacting with financial institutions** for funding the Implementation Project on behalf of the MSMEs; **or alternatively, interacting with the MSMEs** in matters concerning funding and evaluating the Implementation Project on behalf of the financial institution;

4. Helping the MSMEs to **plan the Implementation Project** within a reasonable timeframe;

5. Helping the MSMEs to **identify and meet training requirements** for their workers;

6. **Writing Guidance Manuals**; and

7. **Promoting Guidance Manuals** for knowledge dissemination across the sector.

Thus, Cleaner Production practitioners / consultants can provide useful and much needed services to MSMEs, technology providers and financial institutions.

Annex

1

Problem Diagnostic Tools for Comprehensive CPOA

Benchmarks

Ecomaps

Material Balance

Ishikawa Diagram

Cost Benefit Analysis

Annex 1: Problem Diagnostic Tools for Comprehensive CPOA

This annex presents some of the important problem diagnostic tools such as benchmarks, ecomap, ishikawa diagram, material balance and pareto charts.

1.1 Benchmarks

Benchmarks are the industrial process and operating parameters that are indicative of 'Best Practices'. The purpose of benchmarking is to improve products and processes to better meet quality criteria and customer needs without compromising on environmental protection. The linkage of the business process to environmental and customer needs is critical to effective benchmarking.

Enlisted below are various types of benchmarking, commonly used in industry:

Internal: between functions, departments or a similar organization as a means of improving performance; it could be time based such as performance last year vis-à-vis present performance.

Competitive: comparison across industries within a given sector aimed at establishing best practice through identification of gaps in performance. This can be on product, functional, departmental or on a company-wide basis. Information could be accessed from industry organizations, sector specific literature etc.

Comparative: across all business sectors aimed at establishing best practice in all areas of operation (this type of benchmarking is restricted to common processes or technologies that are used across sectors – such as washing, cleaning, drying, mixing etc.

How are Benchmarks obtained?

Collection of information focuses on identifying sources of norms[23] - these could be regulatory authorities, sector-specific industry associations, research and development institutes or other industries. While, most of these organizations are easily accessible, procuring norms on best practices from other industries could be most difficult. However, techniques such as questionnaires, interviews could be used to facilitate the process.

Do's and Don'ts in Benchmarking

To achieve accurate, representative and relevant benchmarking, certain rules need to be followed. These do's and don'ts are presented below.

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[23] *Norms are best practices applicable to the particular process / parameter studied*

Do's in Benchmarking

Benchmarking requires that the parameters compared be from similar operating conditions in terms of:

Raw materials used

Products / by-products (quantity as well as quality)

Technology / process

Size of production

Units of parameters to be compared should be same and specific in nature (i.e. per unit production)

Don'ts in Benchmarking

Do not consider the benchmarks to be sacrosanct in all cases. Certain deviations could be allowed for specific conditions in the industry.

Do not use benchmarks from unreliable or unknown sources (ensure applicability to your industry)

Do not refer to old or backdated benchmarks

Dyeing Machine	Water consumption (m^3/tonne)	Liquor/goods ratio
Continuous	137	1:1
Beck	234	17:1
Jet	200	12:1
Jig	100	5:1
Beam	167	10:1
Package	184	10:1
Paddle	292	40:1
Stock	167	12:1
Skein	250	17:1

▪

Table A1 Illustration of Benchmarks - Water Use and Liquor Ratios of Dyeing Machines

1.2 Ecomaps

Eco-mapping is a very useful tool, specifically for MSMEs. It is a simple and practical visual tool to analyze environmental performance. Eco-mapping is a visual tool that provides a bird's eye view of the industry's operations and thus gives a quick inventory of practices and problems. Using this information, corrective measures can be implemented to improve not only the environmental performance of a company but also the efficiency of its operations.

Eco-maps are often direct indicators of the housekeeping status of the company and based on observations from the various eco-maps, various housekeeping techniques could be employed as options.

Steps in developing Ecomaps

- Draw a layout map of the factory or work-site. It should include roads, parking lots and nearby buildings. Show North direction on the map.
- The interior spaces of the factory should be drawn to scale as accurately as possible. One or two significant objects may have to be integrated so that anyone looking at the map can immediately orient themselves in the site.
- If the factory covers two or more floors a map of each floor should be made and marked accordingly.
- Use a copy of the layout to develop an eco-map for example for each of the problem areas:
    - Water consumption and wastewater discharge
    - Energy use
    - Solid waste management
    - Odors, noise and dust
    - Safety and environmental risks
    - Any other valid problems may also be added.
    - For each eco-map, everything that is related to that problem should be included.

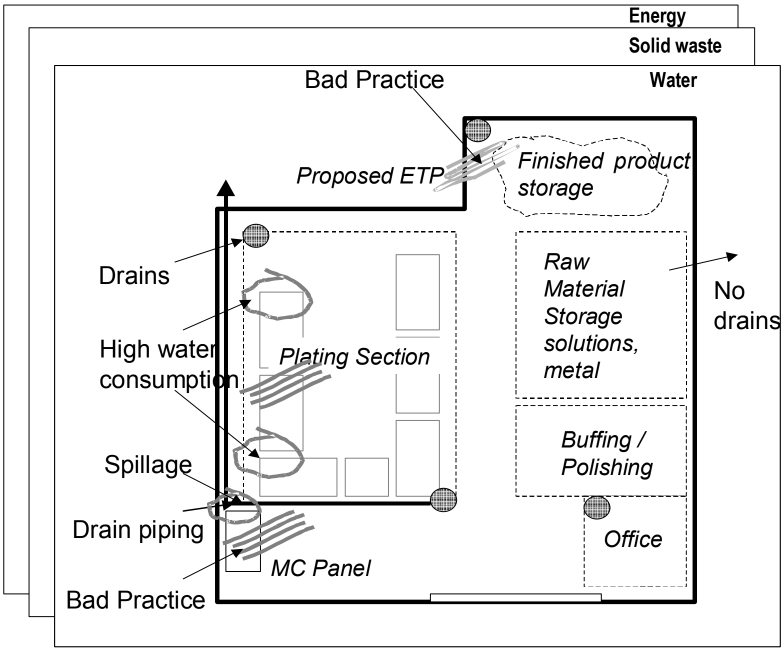


Figure A1: Illustration of Ecomap

The eco-maps should then be analyzed to understand the company's current practices pinpoint where the problems are and identify areas where improvements can be made

These can then be marked using distinct symbols to (a) show areas that have to be monitored or for problems that have to be studied further and (b) for problems that have to be dealt with as soon as possible. Colour-coding can be used to depict the seriousness of the problem so that they can be prioritised on the eco-map.

The next step is to conduct sampling of process liquor and waste streams for establishing a material balance.

1.3 Material Balance

Material balance is a basic inventory tool, which allows for the quantitative assessment of material inputs and outputs. The basis of the material balance for a process based environmental management program is the development of a process flow diagram.

Two special extensions of the concept of material balance are worth a mention. One is the Energy balance and the second Toxic Release Inventory (TRI). While, the energy balance is useful to find options to minimize use of energy or to recuperate the energy lost in the system, the TRI helps in inventorying and focusing on the use and generation of toxic substances that require phase out or control strategies.

Material balance is typically carried out as an inventory of material flows (raw materials, chemicals, water, energy etc.) entering and leaving a manufacturing / service company. It can however be done (i) at the level of each process operation in the manufacturing process; as well as (ii) at each stage in the life-cycle of a product from raw material extraction, through manufacturing to product use and disposal. Material balance is normally recommended in all cases, since it helps identify several problem areas in the process.

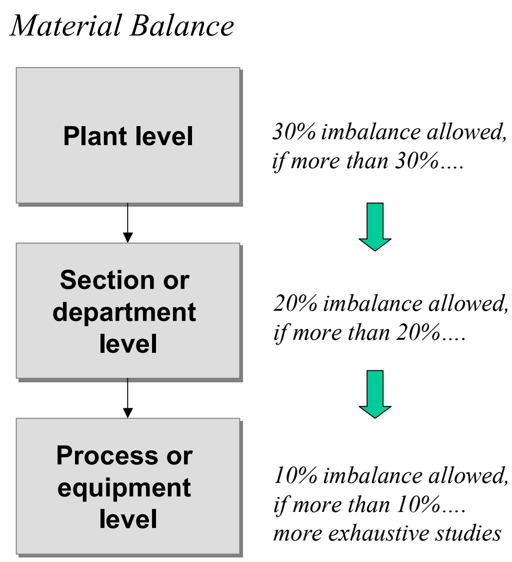


Figure A2: Material Balance in a plant

The above figure shows the types of material balances that can be done in a plant. This analysis allows a step-by-step identification of issues by narrowing down from the plant level to unit processes or equipment.

In the Figure shown in the example below, a plant level material balance indicates water consumption as the area that needs attention. A further study across the unit processes shows that dyeing process is consuming more water than the norms. The next level of material balance narrows down on the winch as the culprit equipment that is water intensive. Thus a 'whole to part' approach allowed identification of focus issues and areas.

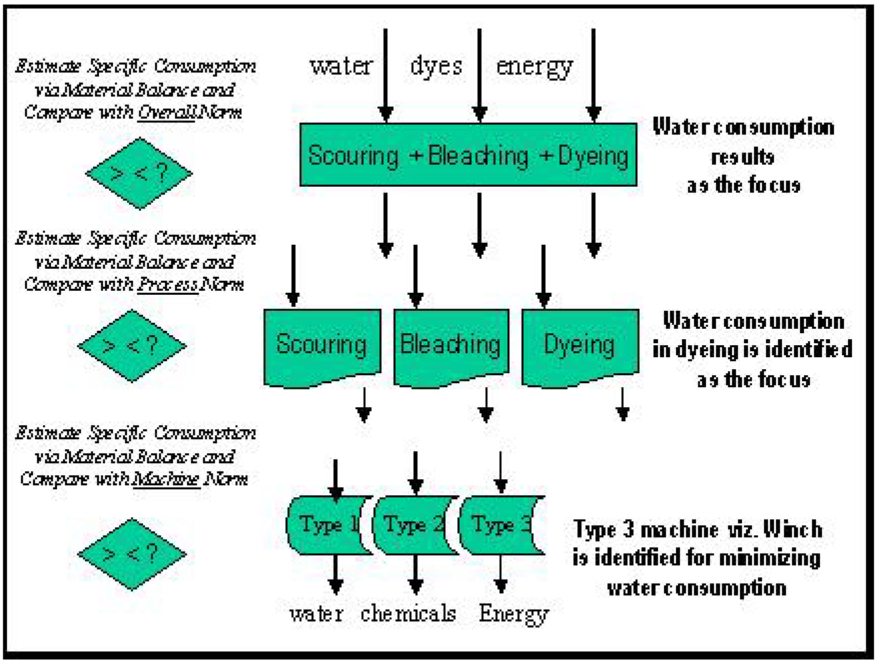


Figure A3: Problem Diagnosis with Material Balance

1.4 Ishikawa diagram (Cause and Effect or Fishbone diagrams)

Ishikawa diagram is a cause analysis tool to uncover the reasons behind problems. It makes use of the experience and expertise of the people who work with the problem. Cause and effect analysis allows the problem to be considered fully and all options considered rather than proposing quick fix solutions to get around problems.

It can be used when a team is trying to find potential solutions to a problem and is looking for the root cause. It is extremely useful when there is a fairly large-scale problem, perhaps involving a number of activities, which would have a number of causes.

Ishikawa or fishbone diagram is primarily used to identify causes of problems in the problem identification task or in the generation of options, where options stem out of avoiding or eliminating the causes of the problems.

The main steps in this tool are:

- Define problem and put it on right of the diagram, at the end of a horizontal line.

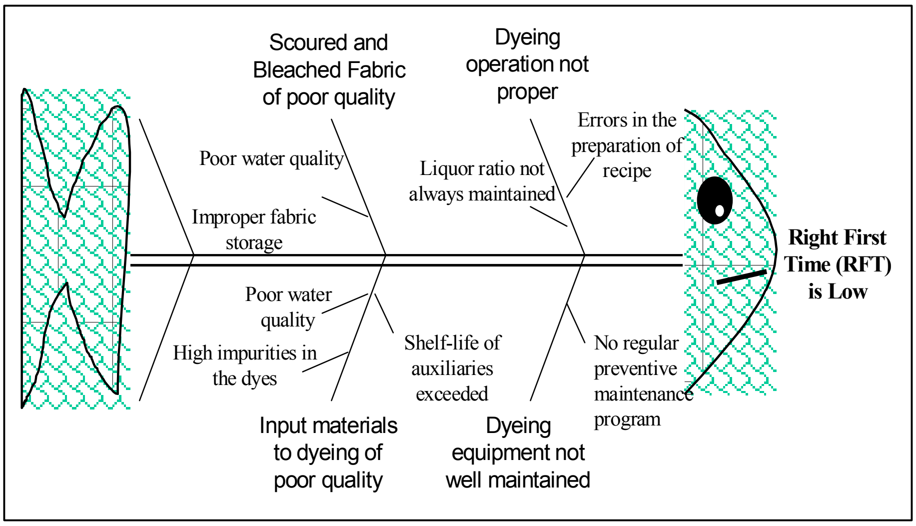


Figure A4: Ishikawa Diagram

- Identify main causes and join to horizontal line by sloping lines.
- Brainstorm subordinate causes and attach to main cause lines.
- Look for root causes by identifying causes which occur more than once or which are related.
- Propose solutions to root causes.

In a knit fabric processing industry, the Right First Time (RFT) in dyeing was found to be rather low, close to 60%. Following were identified as the likely main causes:

- Poor quality of scoured and bleached fabric;
- Poor operation of the dyeing machines;
- Poor quality of input materials used in dyeing;
- Poor maintenance of the dyeing machines.

Further analysis and brainstorming led to development of a detailed Ishikawa diagram.

The primary causes were further studied and the secondary level causes identified as follows:

Cause for poor quality of bleached fabric

- Poor water quality, as raw water contains impurities;
- Improper fabric storage, due to dirtying of fabric during storage.

Causes for improper dyeing operation

- Errors in preparation of recipe;
- Liquor ratio is not always maintained.

Causes for poor quality of input material to dyeing

- Poor water quality;
- High impurities in the dyes;
- Shelf life of auxiliaries exceeded.

Causes for dyeing equipment not well maintained

- No regular preventive maintenance program.

1.5 Cost Benefit Analysis (CBA)

Cost-Benefit Analysis facilitates the comparison of alternatives in terms of the monetary costs involved and the benefits obtained. The costs and benefits whether environmental, social or economic must be quantified in monetary terms to the extent possible. This tool contributes to sound decision making both at the level of an individual organization as well as in public policy. Its usefulness as a tool is strengthened in turn by improved scientific understanding of risk, more effective methods for ecological valuation and a better understanding of the relationship amongst industrial processes. Typically it is used as a tool in feasibility studies for selection of an alternative together with for e.g., LCA, audits etc.

For CBA to be effective, monetary values have to be allocated to all the possible costs associated with an alternative be it technology, process or product and the potential benefits associated with them. In some cases it is difficult to obtain adequate information about an alternative to attribute monetary costs to it.

CBA is used to estimate the profitability of a potential investment for an option. Simple pay back period indicates the time required for getting returns on the investment. If detailed calculations are required, parameters such as Net Present Value or Internal Rate of Return can be used. Software such as P2 Finance[24], developed by the Tellus Institute, Boston could be used for this purpose.

The illustration below presents how Cost benefit analysis can be conducted for a CP option of installation of new equipment for a process operation.

Capital Costs		
New efficient Equipment	345985	USD
Materials	374822	USD
Piping, Electrical, Instruments and Structural		

[24] http://es.inel.gov/partners/acctg

Installation	397148	USD
Engineering	211046	USD
Contingency	140403	USD
Total Capital Costs	**1469404**	USD
Annual Savings *	**350670**	USD
Simple Payback period	4.19 years	
Financial Indicators		
Net Present Value - Years 1-5	476408	USD
Net Present Value - Years 1-10	47240	USD
Net Present Value - Years 1-15	359544	USD
Internal Rate of Return - Years 1-5	1%	
Internal Rate of Return - Years 1-10	17%	
Internal Rate of Return - Years 1-15	21%	
Simple Payback	4	Years
***Annual operating cash flow before interest and taxes.**		

Annex 2

Sector wise Cleaner Production Checklist

Cleaner Production Checklist for Cheese manufacturing industries

Cleaner Production Checklist for Foundries

Cleaner Production Checklist for Furniture industries

Cleaner Production Checklist for Meat processing industries

Cleaner Production Checklist for Textile industries

Annex 2: Sector wise Cleaner Production Checklist

1 Cleaner Production Checklist for Cheese manufacturing industries

1.1 House keeping / material handling and storage

- A optimal detergent concentration should be used for cleaning operations
- Brushing the floors to collect the solid waste (curd, cheese particles) instead of drain them into the drain.
- Keep work areas tidy and uncluttered. Pre-soak floors and equipment to loosen dirt before the final clean.
- Optimise and standardize equipment settings for each shift.
- Identify and mark all valves and equipment settings to reduce the risk that they will be set incorrectly by inexperienced staff.
- Segregate waste for reuse and recycling.
- Install drip pans or trays to collect drips and spills.
- Keep work areas tidy and uncluttered to avoid accidents.
- Maintain good inventory control of consumables, such as cleaning chemicals, packaging materials, food additives etc., to avoid waste.
- Ensure that employees are aware of the environmental aspects of the company's operations and their personal responsibilities.
- Train staff in good cleaning practices.
- Schedule regular maintenance activities to avoid inefficiencies and breakdowns.

1.2 Improved operating procedures / Scheduling improvements

- Keeping doors of the cold room closed.
- Undertaking regular deforesting and maintenance of refrigeration systems.
- Draining the equipment thoroughly before starting rising and washings

1.3 Recycling reuse, recovery/ Waste stream segregation

- Collect the cheese scrapings from the packaging section for utilization as a raw material for processed cheese.
- Collect the spills of solid materials (cheese curd and powders) for reprocessing or use as stock feed
- Recover the lactose and protein content of whey to reuse in white cheese manufacturing.
- Collect the first rinse water for animal feed.
- Reuse relatively clean wastewaters (such as those from final rinses) for other cleaning steps or in non-critical applications.

1.4 Process and equipment modification

- Use milk cans having a higher slope gradient to allow complete draining of milk.
- Use of Ultra filtration (UF) for recovery of protein from sweet whey, followed by spray drying of the protein.
- Optimise the salt addition time during the curding process, for producing sweet whey.
- Install good insulation for the refrigeration unit.

2 Cleaner Production Checklist for Foundries

2.1 House keeping / material handling and storage

- Segregate hazardous and non-hazardous wastes at source, this reduces the volume of material that must be dealt with as a hazardous.
- Store scrap under cover to avoid contamination of storm water.
- Provide hoods for cupolas or doghouse enclosures and induction furnaces.
- Store chemicals and other materials in such a way that spills, if any, can be collected.
- Keep work areas tidy and uncluttered to avoid accidents.
- Ensure that employees are aware of the environmental aspects of the company's operations and their personal responsibilities.
- Train staff in good cleaning practices.
- Schedule regular maintenance activities to avoid inefficiencies and breakdowns.

2.2 Improved operating procedures / Scheduling improvements

- Screen the charge and use better tap hole practices.

- Contain the spent sand in covered, sheltered conditions on a raised platform with sides to reduce fugitive dust, seepage water, runoff and drift.
- Avoid, where possible, galvanized scrap metal as charge material for the melt furnaces to reduce the lead, zinc and cadmium wastes
- Use a magnetic separation system to separate the metal dust from the shot grit and recycle the metal in the melt furnace.
- Preheat the scrap, with afterburning of exhaust gases.

2.3 Recycling reuse, recovery/ Waste stream segregation

- Recovery of the thermal energy in the gas from the blast furnace before using it as a fuel.
- Recycle iron-rich materials such as iron ore fines and scale in a sinter plant
- Recycle lime free slag into the process
- Recycle the spent shot blast grit, melting furnace slag and molding sand in concrete or asphalt manufacturing,
- Reuse the machining wastes and melting furnace baghouse dust in melting furnaces

2.4 Input material changes / substitution

- Improve blast furnace efficiency by using coal and other fuels (such as oil or gas) for heating instead of coke.
- Used improved feedstock, use clean scraps to avoid emissions.

2.5 Process and equipment modification

- Replace the cold-box method for core manufacture, where feasible.
- Use, an induction furnace to reduce waste emissions, where possible.
- Use dry dust collection methods such as fabric filters instead of scrubbers.
- Use continuous casting for semi finished and finished products wherever feasible.
- Reduce nitrogen oxide (NOx) emissions by use of natural gas as fuel, use low-NOx burners.

3 Cleaner Production Checklist for Furniture industries

3.1 House keeping / material handling and storage

- Good ventilation within the cutting process area should be provided to reduce dust, which would accumulate on wood.
- The feed tanks should be kept clean of contamination such as dirt, dried coating particles, and dust, by keeping them covered whenever possible.
- The tanks should be kept agitated to prevent skim from forming and solids from settling.
- The compressor should be placed, where it can intake clean air and maintain it properly by checking filters and draining condensate.
- Select the appropriate spray gun attachments - needle, nozzle, air cap - for each coating utilized.
- Maintain proper fluid and air pressures, correlate air pressure at the spray gun with the air pressure of the coating tank to maintain proper air pressure.
- The solvent pump should be maintained to prevent leakage.
- Prevent leakage from the spray gun by placing only the front end of the gun in solvent when cleaning, lubricate bearings and packings of the spray gun daily.
- Spraying of lacquer and varnish in the same booth should be avoided as it may cause spontaneous combustion.
- Whenever possible, avoid spraying different types of coatings in the same booth as it may make the resulting wastes mixed and more difficult and costly to dispose of or recycle.
- Use closed paint gun cleaning units to control VOC emissions and exposure.
- Equipment should be cleaned as soon as possible after use before coating cures as its difficult to remove.
- Minimize the number of cleanings of the equipment by finishing with a light coating first, then progressively use darker coatings whenever possible.
- Flush equipment first with dirty solvent, then with clean solvent and use clean solvent as final equipment cleaning, then use as paint thinner.
- Use high velocities instead of high volumes of solvent cleaners.
- Centralize solvent cleaning operations to reduce losses and standardize cleaning methods and type of solvent used.
- Use mechanical cleaning such as scraping and wiping instead of solvent soaking or rinsing.
- Utilize teflon lined tanks to improve drainage and minimize waste coating build-up on tank walls.
- Use rubber wipers to remove coatings off tank walls instead of rags.

- Keep glue containers covered whenever possible to prevent chemical vapours from escaping.
- Keep work areas tidy and uncluttered to avoid accidents.
- Ensure that employees are aware of the environmental aspects of the company's operations and their personal responsibilities.
- Train staff in good cleaning practices.

3.2 Improved operating procedures / Scheduling improvements

- Reducing the tip size will allow the operator to maintain familiar spray speeds and patterns while spraying a thinner wet coat. This helps to achieve the recommended dry film thickness of the new coating.
- Use high solids coatings to reduce amount and number of coatings required.
- Use a two-stage cleaning system: use first-pass solvent as long as possible, then a cleaner solvent for final clean.
- Schedule product throughput from light to dark colours to reduce line flushing.
- Reduce colour changes to reduce cleaning needs.
- Blow wood with air to further reduce saw dust on wood prior to application of surface protection finishes.
- Significant wood can be saved if care is taken when removing defects as the rough lumber is cut.
- Use of finger jointing for less wastage and better material utilization.
- Proper coating material preparation: Too much thinning or reduction can cause running and sagging, while too little reduction can cause defects such as orange peeling. These defects can result in rejects and waste.
- Direct delivery of the coating material to the spray gun or application device (e.g., instead of filling an interim container from a drum or tank, transporting the container to the work area, transferring the coating material from the interim container to the spray gun or application device reservoir) will reduce in material wastage.
- Heat, instead of solvent, can be used in some cases to adjust and maintain the incoming coating to the desired viscosity.

3.3 Recycling reuse, recovery/ Waste stream segregation

- Recycle xylene, methylene chloride, or lacquer thinner. Reuse clean-up solvents or solvent distillation sludge for coating secondary surfaces, where appearance is not a factor.
- Extending solvent life by settling, filtration of solids, and using for jobs not requiring virgin solvent (e.g., rough cleaning)

- Collect sawdust for reuse in particle board, chipcore, laminates, absorptive materials, use in pulp and paper manufacturing (usually softwood only), sludge stabilizer, decorative landscaping material.
- Collect waste wood waste for reuse in mulches or animal bedding.
- Using as fuel for energy and heat recovery either for on-site or off-site energy
- Emptied containers of the finishes / lacquers should be returned to the supplier.

3.4 Input material changes / substitution

- Alternative adhesive, (PVA glues) switch to an adhesive that are capable of bonding high moisture furnish eliminates the need to dry wood to low moisture content.
- Conventional PF resins can be substituted by natural resins as low-VOC binder, manufactured from furfuryl alcohol.
- Oil-borne preservatives can be substituted by wood preserving: water-borne preservatives.
- The traditional nitrocellulose finishes can be substituted by high solid finishes such as polyurethanes and polyesters can be to reduce VOC emission.
- Replace 1,1,1-Trichloroethane with Citrus-Based Solvents.
- Use waterborne coatings and high solids solvent based coatings to reduce VOC emissions.
- Use high solid solvent based coatings to increase application of coatings having less VOC emissions and solvent waste.
- Methylene Chloride. Can be substituted by N - methyl pyrrolidone (NMP) and Gamma – Butyrolactone can be used as coating strippers, these are non toxic, water soluble, biodegradable solvents.

3.5 Process and equipment modification

- Use High Volume Low Pressure (HVLP) Spray guns, as these guns atomise materials with warm, dry air between 0.1 and 10 psi. The low pressure air of HVLP systems transfers the coating to the substrate with low velocity and prevents the rapid expansion of spray caused by higher pressure guns, resulting in less over spray, less bounce back, and better transfer efficiency (40 -70%).
- The spraying booth design should be improved for reducing hazardous solvent emissions to air, improving working conditions for the workers and reduction in chemical use.

4 Cleaner Production Checklist for Meat Processing Industries

4.1 House keeping / material handling and storage

- Undertake dry cleaning of floors and equipments prior to washing with water.
- Use of high pressure rather than high volume for cleaning surfaces.
- Maximise the segregation of blood by designing suitable blood collection facilities and allowing sufficient time for bleeding, typically seven minutes.
- Fit the drains with screens and/or traps to prevent solid materials from entering the effluent system.
- Improve insulation on heating or cooling systems, pipe work etc. Insulate and cover scald tanks to prevent heat loss.
- Keep work areas tidy and uncluttered to avoid accidents.
- Maintain good inventory control of consumables, such as cleaning chemicals, packaging materials, food additives etc., to avoid waste.
- Ensure that employees are aware of the environmental aspects of the company's operations and their personal responsibilities.
- Train staff in good cleaning practices.
- Schedule regular maintenance activities to avoid inefficiencies and breakdowns.

4.2 Improved operating procedures / Scheduling improvements

- The waste within the plant can be transported using dry transfers instead of water flumes.
- The entrails and offal can be used as a fish meal.
- Use dry dumping techniques for the processing of cattle paunches and pig stomachs that avoid or minimise the use of water, instead of wet dumping techniques.
- Use water sprays with a pressure of less than 10 bar for carcass washing to avoid removal of fat from the surface.
- Segregate high-strength effluent streams, such as rendering effluent and wastewaters from paunch washing, and treating them separately.

4.3 Recycling reuse, recovery/ Waste stream segregation

- Ensure that by-products are not contaminated with water or materials that would limit or prevent their reuse.
- Store by-products correctly to maintain quality and maximise the viability of reuse opportunities.

- Reuse final rinse waters from paunch and casings washing for other non-critical cleaning steps in the casings department.
- Reuse relatively clean wastewaters from cooling systems, vacuum pumps etc. for washing livestock if possible.
- Reusing wastewaters from the slaughter floor, carcass washing, viscera tables and hand-wash basins for the washing of inedible products if possible.
- Reuse the final rinse from cleaning operations for the initial rinse on the following day.
- The cooking water can be reused repeatedly if the oil is skimmed off and the oil can be sold for fish oil production.
- Recover waste heat from effluent streams, vents, exhausts and compressors.

4.4 Input material changes / substitution

- Substitute hazardous inks with less hazardous (vegetable oil or water based) inks.
- Substitute developers with ones having less or no isopropyl alcohol.
- Use all purpose solvents in place of solvents dedicated for particular uses.
- Uses silverless processing plates to prevent silver halide contaminated fountain baths.

4.5 Process and equipment modification

- Recover evaporative energy in the rendering process using multieffect evaporators.

5 Cleaner Production Checklist for Textile industries

5.1 House keeping / material handling and storage

- The raw fibres and the finished fibres should be wrapped and stored to avoid fire hazard
- Intermediate and finished product should not be left uncovered and touching floor to avoid damage and soiling, high sided containers and plastic sheets should be used.
- In Colour kitchen spillages of dyestuff should be avoided to minimize cross contamination of made-up recipes.
- The containers of the reactive dyestuffs should be firmly closed after its use.
- Hydrogen peroxide should be stored in cool place to avoid its decomposition and explosion hazard
- Acid, direct and chrome dyes should be stored in dry conditions to avoid agglomeration of the dyestuff resulting in a reduced fibre quality.
- During mercerisation the rollers used for NaOH impregnation of fabrics should be cleaned periodically for ensuring homogenous mercerisation.

- Accidental spillages of process chemical baths from the mill operations should be avoided.
- The floors should be cleaned of grease, dirt, oils etc thereby reducing the possibility of accidental soiling of the fabric.
- Keep work areas tidy and uncluttered to avoid accidents.
- Ensure that employees are aware of the environmental aspects of the company's operations and their personal responsibilities.
- Train staff in good cleaning practices.
- Schedule regular maintenance activities to avoid inefficiencies and breakdowns.

5.2 Improved operating procedures / Scheduling improvements

- Use of standing bath techniques to recycle dyes
- Use of counter current washing for fibre preparation and washing operations
- For batch process a common water sump should be built for washing the fabric
- For major water consuming wet process identify the level of water quality to maintain the product quality
- Optimise the material to liquor ratio.
- Winch dyeing: By dropping the dye bath and avoiding overflow rinsing, water consumption could be reduced by 25%.
- By replacing the overflow with pressure jet dyeing batch wise 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.
- Jig dyeing: Changing from overflow to stepwise rinsing.
- Cheese dyeing: A reduction of around 70% is possible following intermittent rinsing.

5.3 Recycling, reuse, recovery/ Waste stream segregation

- Recovery and reuse of caustic soda from mercerising wash waters.
- Bath reuse in hydrogen peroxide bleaching/scouring.
- Printing paste remnants should be recovered and reused.
- Enzymes can be substituted for hydrogen peroxide based bleaching.

5.4 Input material changes / substitution

- Use of degradable, water soluble, sizes e.g. polyvinyl alcohol (PVA), carboxymethyl cellulose (CMC) and polyacrylate (PA).
- Use of ammonium persulphate instead of commercial desizing agents.
- Use of peroxide bleaches instead of chlorine or sulphur containing bleaches.
- Use of ammonia rather than caustic soda in mercerisation.
- Use synthetic detergents instead of soaps.
- Use ammonium sulphate in place of acetic acid for pH adjustment in disperses dyeing and pigment printing. Although the salt content of the effluent will increase, ammonium would serve as a nutrient in the biological treatment process.
- Substitution of glucose (instead of sodium sulphide) and sodium perborate or hydrogen peroxide (instead of dichromate) in sulphur black dyeing.
- Substitute aniline black dyes with sulphur dyes.
- Substitute acetic acid with formic acid in dyeing process.
- Reduce the use of formaldehyde releasing products, by substitution with polycarboxylic acid.
- Use single class dyestuff like indigsol, pigments, etc. for dyeing blended varities in pale shades in place of two stage dyeing using two different classes of dyes e.g. polyester using disperse and cellulosic using vats, reactives, etc.).
- Use all aqueous phthalogen blue dyeing in place of solvent-based phthalogen blue dyeing which requires specialty auxiliary products.
- Replace carding oils and anti-stat lubricants with non-ionic emulsifiers.

5.5 Process and equipment modification

- Use low wet pick-up technology in wet processing, such as low add-on or foam techniques, to conserve water
- Combine operations (e.g., dyeing and finishing, scouring and desizing, finishing and transfer printing).
- Use double beam rather than single beam fabric in mercerisation.
- Hot mercerisation in place of conventional mercerisation, thus eliminating the need for separate scouring treatment.
- Use padding method in place of exhaust methods for dyeing, wherever possible.
- Adopt techniques such as two-phase flash printing, pre-moistening of printed fabric prior to steaming, and chemical substitution, to reduce urea content.

Annex 3

Cleaner Production Resources

Resources for Cheese manufacturing industries

Resources for Meat manufacturing industries

Resources for Food manufacturing industries

Resources for Foundries

Resources for Furniture manufacturing industries

Resources for Textile manufacturing industries

Annex 3: Cleaner Production Resources

1 Resources for Cheese manufacturing industries

1.1 Cleaner Production Assessment in Dairy Processing

This document provides comprehensive coverage on the basic information on Cleaner Production, the topics range covered are, Overview on the production process in the industry, Cleaner Production opportunities in **cheese** production and other milk products, Cleaner Production assessment and a case study. The document also provides further information on the international dairy institutes, journals, associations and web resources for Cleaner Production. This publication is brought out by the United Nations Environment Programme Division of Technology, Industry and Economics and the Danish Environmental Protection Agency.

http://www.agrifood-forum.net/publications/guide/index.htm

1.2 Pollution Prevention and Abatement handbook, World Bank Group

This document provides brief information on the process and the typical waste water and solid waste generation from the plant. The document discusses the pollution prevention and treatment technologies.

http://wbln0018.worldbank.org/essd/essd.nsf/GlobalView/PPAH/$File/55dairy.pdf

1.3 Technical Pollution Prevention guide for the dairy processing operations in the lower Fraser Basin.

This document provides information on the dairy processing operations with a technical step-by-step pollution prevention guidance document on the development, implementation and continual monitoring of facility-specific pollution prevention plans.

http://www.p2pays.org/ref/04/03995.pdf

2. Resources for Meat processing industries

2.1 Cleaner Production Assessment in Meat Processing

A comprehensive document covering the basic information on Cleaner Production, overview on the production process in the industry and, Cleaner Production opportunities, in process and the ancillary utilities, Cleaner Production Assessment and case study. The document also provides benchmarks of a typical meat processing industries and a step wise implementation plan for Cleaner Production Assessment. This document is prepared by COWI Consulting Engineers and Planners AS, Denmark for United Nations Environment Programme Division of Technology, Industry and Economics and the Danish Environmental Protection Agency.

http://www.sectorstar.org/sector/MeatProcessing/Resource.cfm?linkadvid=26446

2.2 Guide to Resource Conservation and Cost Savings Opportunities in the Meat & Poultry Sector

This document provides check lists of opportunities in the meat and poultry sector for energy and water use reduction and pollution prevention. It includes process flow diagrams highlighting energy, water and environmental effects for four major types of processes: beef, hogs, poultry and rendering; check lists of improvement opportunities; and check list of new technologies that are either currently being researched and developed, or are being utilized elsewhere. These check lists are designed to be a starting point for plant specific assessments, undertaken by industry personnel or by outside consultants. This document is available by order.

http://www.sectorstar.org/sector/MeatProcessing/Resource.cfm?linkadvid=20264

2.3 Pollution Prevention and Abatement handbook, World Bank Group

This document provides brief information on the process and the typical waste water and solid waste generation from the plant. The document discusses the pollution prevention and treatment technologies.

http://wbln0018.worldbank.org/essd/essd.nsf/GlobalView/PPAH/$File/65_meat.pdf

2.4 Reduction in Waste Load from a Meat Processing Plant-Beef

The report discusses the waste reduction opportunities in a beef slaughterhouse and boning plant, the report details the survey of the plant, the waste source identification, its costs and recommendations for waste reduction.

http://www.p2pays.org/ref/01/00466.pdf

2.5 Recovery of Animal Fats Reduces Wastewater Generation and Reduces Energy Costs is a short case study description.

The link provides information on energy cost for treatment of the fat laden waste water and the cost avoided through recovery of fats.

http://es.epa.gov/studies/cs279.html

2.5 Cleaner Production in a Czech Slaughterhouse

The link provides a case study of a medium-sized slaughterhouse. The case study gives a series of Cleaner production options, which were implemented and the subsequent savings are provided. The case study also provides information on the reduction in the environmental impact.

http://www.inem.org/htdocs/case_studies/masna-zlin.html

3. General resources for Food industries

3.1 A Pollution Prevention Guide for Food Processors

The document is a fact sheet with general tips on improved operating procedures, process and equipment modifications.

http://www.dnrec.state.de.us/del-proc.htm

3.2 Pollution Prevention Guidebooks: Food and Kindred Products

This is a brief document describing the types of pollution prevention solutions implemented by food processing companies in New Jersey.

http://www.njit.edu/njtap/isr20.htm

3.4 Clean Technologies in U.S. Industries: Focus on Food Processing

This link gives a brief overview of the US food processing industry with an emphasis on pollution prevention and clean technologies. Contact information for key food-based organizations and clean technologies/pollution prevention is provided. Food processing environmental and health regulations are also briefly described.

http://www.p2pays.org/ref/09/08853.htm

4. Resources for Foundries

4.1 Cleaner Production Assessment in Foundries Pollution Prevention and Abatement handbook, World Bank Group

The document discusses the typical process in the foundries and the typical load of each waste generated from the processes. The document provides pollution control and treatment technologies in brief.

http://wbln0018.worldbank.org/essd/essd.nsf/GlobalView/PPAH/$File/59_found.pdf

4.2 Seminar on Energy Conservation in Iron Casting Industry

The document provides a detailed study on the different type of furnaces and energy conservation options

http://www.unido.org/userfiles/PembletP/sectorscasting.pdf

4.3 Office of Industrial Technologies (OIT)

This link provides the latest technology in the industry, which are ready for field-testing, gives a lists of reference resources for those metal casting manufacturing plants that are interested in field testing new technologies under the Best Practices Technology Deployment solicitation to improve energy efficiency of plant operations.

http://www.oit.doe.gov/metalcast/bp/genl_emerg.shtml

4.4 Cleaner Production Demonstration Project at Auscast,

This link provides the Australian case studies in eco efficiency and Cleaner Production in the foundries. The case study focuses on sand reclamation, improvement in sand quality and new resins as binders.

http://www.ea.gov.au/industry/eecp/case-studies/austcast2.html#3_0

4.5 Fact Sheet: Pollution Prevention: Strategies for the Steel Industry, Centre for Hazardous Materials Research (CHMR)

The document gives some of the most effective techniques that are simple and inexpensive to increase productivity.

http://es.epa.gov/techinfo/facts/chmr/strtgy8.html

5. Resources for Furniture industries

5.1 Environmental Self-Assessment for the Wood Furniture And Fixture Industry: A Quick and Easy Checklist of Pollution Prevention Measures for the Wood Furniture and Fixture Industry (2000) New York State Department of Environmental Conservation, Pollution Prevention Unit.

This workbook was developed by the Pacific Northwest Pollution Prevention Resource Centre to help wood furniture manufacturers determine the types and quantities of wastes generated and emitted from their shops, understand what requirements may be associated with generating pollution, and identify pollution prevention opportunities that reduce environmental liabilities, increase efficiency and reduce the cost of environmental management.

http://www.pprc.org/pprc/sbap/workbook/tocwood.html

5.2 Environmental Compliance and Pollution Prevention Guide for the Wood Furniture and Fixture Industry (2001)

New York State Department of Environmental Conservation, Pollution Prevention Unit.
The document provides a brief overview of the wood furniture manufacturing industry in the United State, relevant environmental legislation, the nature of wastes generated and tips on pollution prevention for these. The document also contains the names and addresses of technical assistance providers relevant to the wood industry.

http://www.dec.state.ny.us/website/ppu/ecppwood.pdf

5.3 New York State Department of Environmental Conservation Pollution Prevention Unit

Provides a quick and easy checklist of pollution prevention for the wood furniture and fixture industry.

http://www.dec.state.ny.us/website/ppu/esawood.pdf

5.4 Pollution Prevention Institute (PPI) at Kansas State University

Kansas SBEAP's provides technical documents for wood finishing and pollution prevention in the wood finishing industry.

http://www.sbeap.org/ppi/publications/p2_integration/InspWood.PDF

5.5 Wood Finishing Demonstration Project: Final Report

A document from a Minnesota based program funded by the USEPA, in 1995, to provide multi-media compliance and pollution prevention assistance to wood furniture manufacturers, cabinet manufacturers and millwork shops in the state.

http://www.pca.state.mn.us/air/pubs/sbap-wood.pdf

5.6 Cleaner Production Case Study: Coating Australia Private Limited Environmental Protection Agency, South Australia

The case study provides insight on new technology that has eliminated the use of solvents and thinners in applying stains and lacquers on to wood panels used in furniture production. The new technology has reduced dissipation of solvents and thinners into the atmosphere because of the curtain coater, which reduces the consumption of lacquers and stains by 30–40% and the UV roller, which reduces solvent usage by approx 80%.

http://www.environment.sa.gov.au/epa/pdfs/cpcoatings.pdf

5.7 Coatings Guide, U.S. EPA Air Pollution Prevention and Control Division (APPCD).

The Coatings Guide contains several tools to help users identify low-volatile organic compound/hazardous air pollutant coatings that ay serve as drop-in replacements for existing coating operations.

http://cage.rti.org/

5.8 The Wisconsin Department of Natural Resources

The link provides case studies by sector. The case studies available are Ashley Furniture Industries, Inc for Distillation and Reuse of Waste Solvent, Gerry Wood Products Company for Alternative coating to reduce volatile organic compound (VOC) emissions from lacquer coating operations, Madison Pre-hung Doors and Pre-finishing for Converting to a Water-based Wood Finish, and Shuttery of Nanik, for Conversion from solvent to waterborne coatings for wood finishing.

http://www.dnr.state.wi.us/org/caer/cea/casestudy/bysector.htm

5.9 Wood Furniture Manufacturing: Compliance and Pollution Prevention Workbook

The pollution Prevention Resource centre provides a downloadable manual for Pollution Prevention in wood furniture manufacturing industries this manual is divided into chapters. The chapters provide a step by step help on the following topics;

- Lowering the operating costs
- Providing safer conditions for workers
- Reducing costs of environmental compliance
- Protecting the environment
- Reducing exposure to future liability
- Improving industry's public image.

http://www.pprc.org/pprc/sbap/workbook/tocwood.html

5.10 EPA Sector Notebook, Project Profile of the Wood Furniture and Fixtures Industry

This document provides industry overview, the manufacturing process and pollution prevention opportunities.

http://es.epa.gov/oeca/sector/sectornote/pdf/wdfurnsn.pdf

5.11 Waste Reduction Guide — Wood Furniture Industries

This workbook can be used as a reference for waste reduction opportunities for the wood household furniture industry. Waste reduction opportunities and practices are provided in a summary format for each of the respective major manufacturing processes typically found in the wood household furniture industry. For each process, there is a brief description, a table that lists the respective waste reduction opportunities for that process, followed by summaries of each waste reduction opportunity. This workbook is prepared for the Tennessee Valley Authority and the U.S. EPA.

http://www.p2pays.org/ref/01/00418.pdf

6. Resources for Textile industries

6.1 Sector Notebook Project: Profile of the Textile Industry

This report is one in a series of volumes published by the U.S. Environmental Protection Agency (EPA) to provide information of general interest regarding environmental issues and pollution prevention opportunities associated with the Textile industrial sector.

http://es.epa.gov/oeca/sector/#text

6.2 Water Use in Textile Processing

The document provides excerpts from the Best Management Practices Manual of EPA, 1996.

http://www.p2pays.org/ref/01/0069203.pdf

6.3 Best Available Techniques for the Textile Industry Integrated Pollution Prevention and Control (IPPC) Draft February 2001.

http://www.ippc-ps.pl/english/a_ippc_eng.htm

6.4 Pollution Prevention and Abatement Handbook of World Bank

This document provides brief information on the process and the typical waste water and solid waste generation from the sector and discusses the pollution prevention and treatment technologies.

http://wbln0018.worldbank.org/essd/essd.nsf/GlobalView/PPAH/$File/81_text.pdf

6.5 Pollution Prevention Tips: Water Conservation for Textile Mills

http://es.epa.gov/techinfo/facts/nc/tips12.html

6.6 Troubleshooting in Preparation - A Systematic Approach J. W. Rucker and C. B. Smith

The majority of problems which occur in dyeing are due to inadequate preparation, but that in many cases problems which are not detected in preparation do lead to faulty dyeing. The authors break down the percentage of defects in textile wet processing according to origin and present their analysis in this article.

http://www.p2pays.org/ref/03/02332.pdf

6.7 Combined Process for the Continuous, Enzymatic Desizing and Demineralization of Wovens Ms. A. Fischer-Sturm, Ms. B. Holz.

The article provides information on the benefits of combining the process.

www.chtgroup.com/chtweb/spnewse.nsf/fc6cfdac34b34fb9c12569cb004baf9b/99f7b77bb04a345ec12569af00261bd7/$FILE/Desizing%202000.pdf

6.8 Dyeing Reactive Dyes Using Less Salt: Clyde B. Anderson, Miles, Inc. Rock Hill, SC

The article provides information on using less salt for addressing the environmental concerns and machinery manufacturer's promotion for lower liquor-to-goods ratio dyeing equipment. The industry in many instances has moved from 15:1 - 20:1 ratios to 8:1 - 5:1 ratios. This reduction in liquor-to-goods ratio improves the substantivity of fiber reactive dyes; therefore, salt quantities may be reduced.

http://www.p2pays.org/ref/03/02346.pdf

6.9 How to apply benchmarking to health and safety

This document is guidance manual for those who want to apply benchmarking in health and safety. Health and safety benchmarking is a five -step cycle aimed at ensuring continuous improvement. The document summarises what health and safety benchmarking is all about, and the advantages it offers. It then guides on the steps involved and pointers to success. It shows that benchmarking can be successfully applied to improve management of health and safety. There is a list of contacts and sources of further information at the back of the leaflet.

http://www/open.gov.uk/hse/hsehome.htm

6.10 Manual Handling in the Textile Industry

This manual of Health and Safety Commission, elaborates on the risks involved in manual handling and presents preventive and control measures for them.

http://www/open.gov.uk/hse/hsehome.htm

6.11 Pollution Prevention Diagnostic of a Textile Dyeing Plant

A Report of the Office of Environment and Natural Resources Bureau for
Global Programs United States Agency for International Development,
Prepared for: Haggler Bailey Consulting, Inc., Environmental Pollution
Prevention Project (EP3)

http://www.es.epa.gov/ep3/ep3-cs10.html

6.12 Hydrogen Peroxide based Scour/Bleach process for hosiery with preparation bath reuse

The technical and economic viabilities of the scouring and bleaching processes, designed to eliminate chlorine in the preparation of hosiery while directly reusing scour/bleach and finish baths, is being demonstrated in Chipman-Union Co.'s commercial plant

http://www.ntcresearch.org/pdf-rpts/Bref0694/694G94T2.pdf

6.13 Sustaining the Rag Trade, Nick Robins and Liz Humphrey

International Institute for Environment and Development for the UN Department of Policy Co-ordination and Sustainable Development
This document, also by the IIED, discusses growing trends in environmental and social accountability in the UK clothing sector, with a focus on supply chain management.

6.14 A Workbook for Pollution Prevention by Source Reduction in Textile Wet Processing by Brent Smith, October 1988

This workbook presents ideas for waste and waste source reduction in textile wet processing.
References are not individually cited, but are listed in the bibliography.

http://www.p2pays.org/ref/02/01091.pdf

6.15 Labour practices in the footwear, leather, textiles and clothing industries

This report for discussion at the Tripartite Meeting on Labour Practices in the Footwear, Leather, Textiles and Clothing Industries Geneva, 2000.

http://www.ilo.org/public/english/dialogue/sector/techmeet/tmlfi00/tmlfir.htm

Annex

4

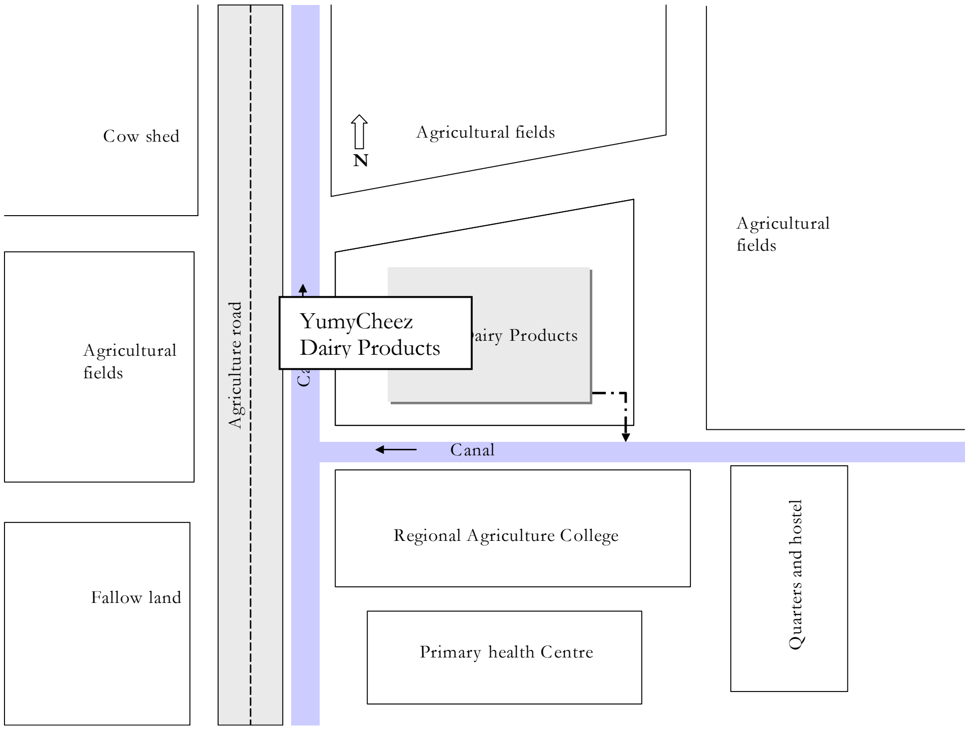
Model Rapid CPOA Report

Annex 4: Model Rapid CPOA Report

1.0 Details of the enterprise

Name:	Yumycheez Dairy Products
Address:	Agriculture road, Dairy City.
Governorate:	Foodland
Ownership:	Private, owned by Mr. Renette
Sector / sub-sector:	Dairy / cheese manufacturing
Year of establishment:	1950
Plot area in sq. m. :	100
Date visited:	2nd January, 2003
Time taken:	2.00 p.m.

Figure 1: Location map (not to scale)



Mr. Renette had an ancestral factory established in 1950. The factory used the traditional technique of cheese making. With the help of his sons, he renovated the factory in 1992, maintaining the same technique of cheese production. The new factory has a total area of 100 sq. m. and a working area of 70 sq. m. Mr. Renette stores the final product in a refrigeration unit, located near his factory.

Recently, Mr. Renette and his sons have started experiencing increasing demands in terms of quality from customers, which their old technology is not able to meet any longer. Also looming over their heads is the threat of non-compliance with the chemical oxygen demand (COD) discharge limits laid down by the regulatory authority on all dairy product manufacturers.

The factory employs eight people; they are local residents of Dairy city. The present staff is mostly illiterate and generally unskilled, but working in the factory for the last ten years they have developed necessary skills for cheese processing. The working hours of the factory are 8 a..m. to 6 p. m. The factory operates for 25 days a month. The workers can avail of sick leave in addition to the other holidays. The workers are not provided with proper clothing, gloves, and caps, they change into old clothing during the working hours and leave them at the factory after the day's work. At the end of the day, the workers take a wash in an enclosure adjoining the factory building. The staff does not undergo any annual medical tests. The working culture of the factory is informal and does not have an organizational structure.

2.0 Production profile

The factory uses 10 tons of fresh milk daily for its cheese production. The production efficiency of the factory is 20% for white cheese and 10 % for hard cheese.

The production rate is a function of the availability and quality of the raw milk. Usually unsteady, the production peaks in winter when the quality and quantity of milk is better and rich in fat contents, and drops in summer, when the quantity of the milk is less and has lower fat content. Thus in winter, 70% of production is hard cheese and during summer, 70% of production is white cheese.

No.	Product list	Production
1	During winter: White cheese (Domiaty cheese) Hard cheese (Roumy cheese)	 22.5 tons / month 52.5 tons / month
2	During summer: White cheese (Domiaty cheese) Hard cheese (Roumy cheese)	 52.5 tons / month 22.5 tons / month
3	Milk cream	0.5 tons / month

The factory has two stainless steel tanks of 1.6 tons capacity each. These tanks are water jacketed for heating the tank contents. The water in the jacket is heated by direct heating from burners. The burners are installed on the external side of the wall. The burners use light furnace oil as a fuel.

In addition, the factory uses 14 circular barrels of 220-kg capacity and 9 wooden cheese-pressing tables with removable sides and plastic barrels to curd the milk. One submersible pump is used to transfer milk from mixing tank to the barrels for curding. For hard cheese manufacturing, the factory uses 5 press machines of 20-mould capacity each. These presses are placed outside the factory during white cheese production (see Figure 2).

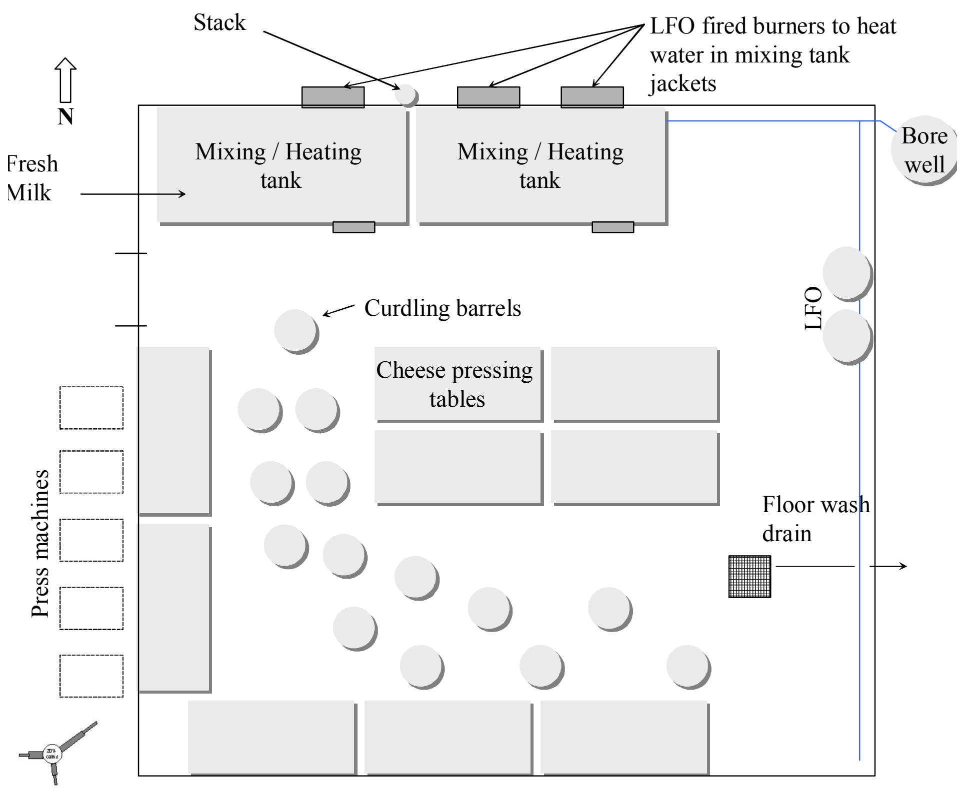


Figure 2: Factory layout (not to scale)

Utilities

- The factory entirely relies on a bore well for all its water needs. The bore well was dug in 1955 and the owner is experiencing water shortage during the summers. Groundwater is used in the water jackets for heating the milk, washing the equipment and other housekeeping purposes. The factory does not have a municipal water connection. The equipment and floors of the factory are cleaned daily at the end of the day. The extracted groundwater is pumped twice to an overhead tank of 4 cu. m. capacity and used with gravity flow. The manufacturing process does not consume water. The quantity of water used in the jackets for heating the milk is about 2 cu. m. Wastewater from washing purposes was found to be 4-6 cu. m. / day in addition to 8-9 cu. m. / day of cheese whey.

- The factory uses three light furnace oil (LFO) fueled burners for heating the milk. The daily consumption of LFO is about 80 litres (1 litre is equivalent to about 0.4 L.E). The LFO is purchased on a monthly basis and is stored in hard plastic drums outside the main production area of the factory.

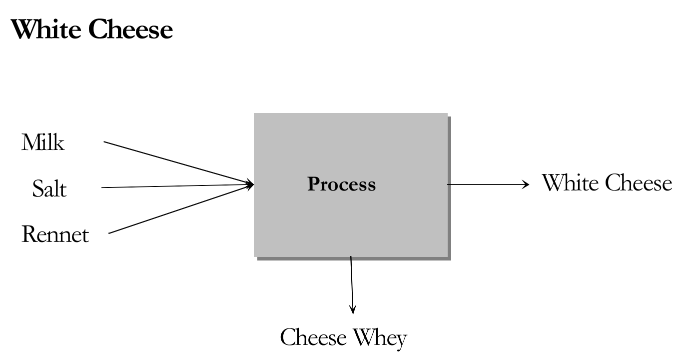
- The factory has a refrigeration unit of 70 sq. m. area. The refrigerant used is freon gas. This is used to store the final product at a temperature of about 4° C. The refrigeration unit is 3 floors high and the temperature is more or less the same throughout the facility. The cheese can be stored for a period of 6 months (during low demand).

- The consumable spares like the lights, pipes etc are purchased as and when required. The other daily consumables, like detergents for cleaning, are purchased on a monthly basis.

Process Description

Simple PFDs describing the stages of production of both white and hard cheese are shown in **Figures 3 and 4**. An overall material balance for the process is also described in **Figure 5.**

Figure 3: PFD for white cheese



The factory gets about 10 tons of fresh milk per day from the dairies in the nearby localities. The milk is brought to the factory by the farmers individually. Milk is manually loaded into the tanks in batches of 1.6 tons. The tank is heated to a temperature of 42°C by heating the water jacket using the LFO burners. It takes about 45 minutes to reach this temperature. About 8% (128 kg) of salt is added in the tank during this process. After 45 minutes, the milk is transferred into 220 kg capacity barrels using a small submersible pump. When the pump goes out of order, the transfer operation is done manually.

Later, rennet (0.5 kg per 220 kg of milk) is added to the barrels. The milk is held in the barrels for 2 hours. The rennet acts to coagulate the milk solids into curd.

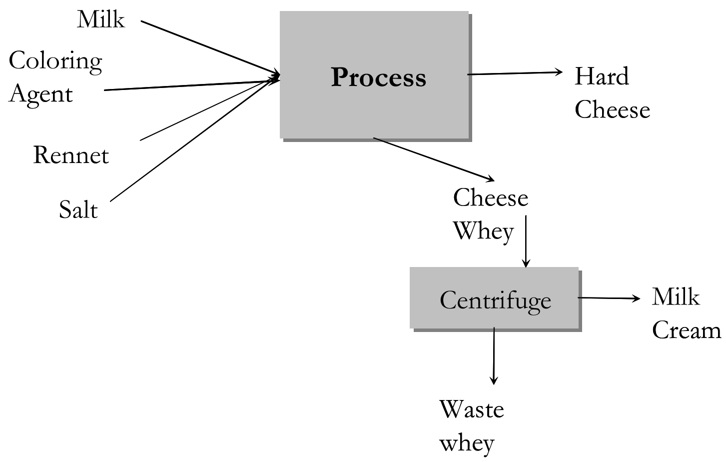


Figure 4: PFD for hard cheese

After 2 hours of retention, the semi-solid cheese is carefully transferred from the barrels to the wooden tables. These tables have perforated bottom and removable sides. Workers use flat tin handmade knives to scoop the cheese, so as to avoid disturbing its consistency. This operation requires skilled workers. However, there is significant cheese wastage in the stream during this process.

Once the whole batch is poured on the table, a wooden plank is placed on the top and weights are placed to exert pressure on the cheese. The water inside the cheese is drained through perforations into the floor drain. This water is called whey. The whey, which has a 6% solids consistency, is drained with wash water to the nearby canal through the floor drain in the factory. It was reported that about 375 kg of whey is reused for packing with the cheese cans.

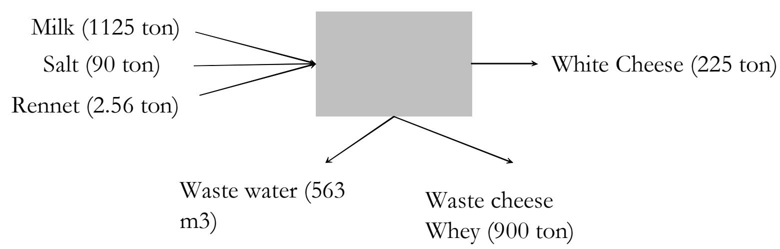
The process for making the hard cheese is similar to that of white cheese, with the only differences being the use of a colouring agent, and the curing of the cheese, which is done in the sun.

Milk cream is manufactured from the whey formed during the manufacture of the hard cheese. The whey is centrifuged to separate the milk cream.

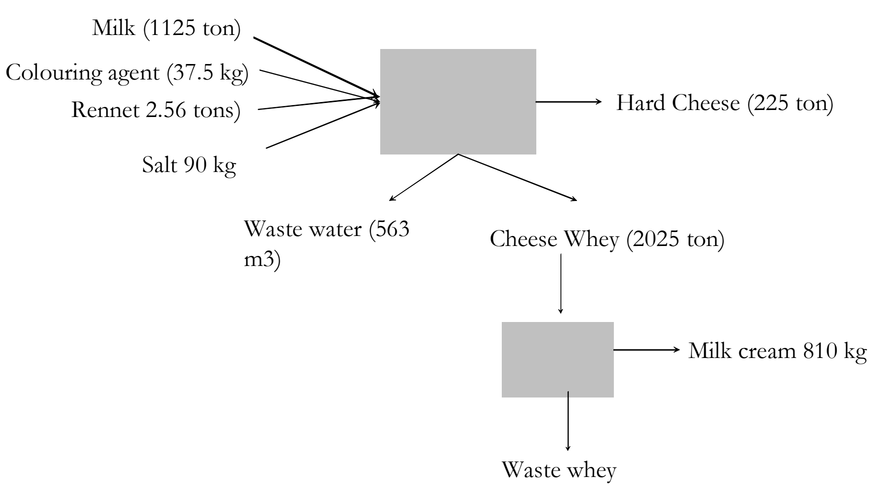
The final product is stored in the refrigeration facility near the factory.

Figure 5: Overall Material Balance for White and Hard Cheese Processing (Basis: summer and winter seasons)

White Cheese



Hard Cheese



The factory does not have the facility to test and monitor the quality of the raw milk and its products. The quality of the raw milk and its fat content is judged by the staff based on their experience. The raw milk usually gets spoilt on its way to the factory, which is judged by the staff returned to the supplier.

A Baume hydrometer is used to check the concentration of salt during the cheese making process. For all the other steps in cheese and milk cream manufacturing process, the different steps are controlled based on judgment.

3.0 Financial profile

Order of capital investment: 5,500,000 LE
Annual turnover: LE 180,000

1US$ = 4.62 LE (Egyptian Pounds)

Critical cost heads	Consumption	Unit costs	Total expenditure
Milk	10 ton/d	1.20 LE	12,000 LE
Salt	800 kg/d	0.17 LE	136 LE
Rennet	22.75 kg (sold in 25 L packs)	3.25 L.E.	81.25 LE
Colouring agent	167 g/d		
LFO	80 L/d	0.4 LE	32 LE
Water[25]	-----		
Electricity			
Salaries	10,000 LE		
Marketing[26]	2,000 LE		
Maintenance of equipment[2]	3,000 LE		
Pollution control[2]	0 LE		
Sampling, measurement and laboratory analyses[2]	0 LE		
Fees to external consultants[2]	0 LE		
Total operating costs	**27,250 LE**		

4.0 Market profile

There is a huge demand for cheese in the local markets, as it forms a major dietary supplement in the region. The products manufactured by the factory (hard, white cheese and milk cream) are sold in the local markets of the town. The market position of cheesy Dairy products has been steady for the last three years. Recently, the factory started targeting markets outside the Foodland Governorate. While the customers of

[25] All the water requirements are met through a bore well within the premises of the enterprise.

[26] This data should be tabulated (under suitable heads such as – consumption, unit costs, total expenditure) if available.

Yumycheez have been generally happy with the product quality and costs, lately competition has increased with many new brands coming in the market and the quality consciousness has increased too.

5.0 Identification and evaluation of environmental issues

The factory is located on the Agriculture road, on the outskirts of the town in the 1950s (see **Figure 1** for the location map of the factory). However, today, it has become a populated suburb. The factory operates on the ground floor of a residential building. It is located in a sparsely populated area of the suburb. The suburb has a Regional Agriculture College, quarters and hostels for the college, a primary health centre and agricultural fields surrounding it. It lacks a green belt. The residents of Regional Agriculture College quarters and the hostels have complained against the foul odour from the canal (due to decomposition of high BOD) whey discharged into it). While no litigations have been filed so far, they cannot be ruled out in the future.

The environmental issues (include safety and health issues) identified in the factory are as given below:

- The disposal of whey produced during cheese production is the major problem in the plant. Whey comprises about 80-90% of the total volume of milk used in the cheese making process and contains more than 50% solids, as that of the whole milk, which includes 20% of the protein and most of lactose. It has a very high organic content, with a BOD of approximately 60,000 mg/l. The factory discharges 8-9 cu. m. / day of cheese whey directly to the nearby canal. The factory is presently not complying with the COD and BOD discharge limits laid down by the regulatory authorities and is liable to face prosecution in the form of penalty and immediate resolution of the problem, or face closure.
- Air emissions generated due to burning of the LFO are discharged into the atmosphere through a 12-meter high stack.
- The chances of contamination of the raw milk and the final product are very high, due to poor house keeping practices and operating procedures. Milk used in making the cheese is heated only to 42°C, which is much lower than the temperature required for milk pasteurisation (minimum 75°C). The cheese is handled manually while cutting on the cheese tables. Thus the product formed may have changes of bacterial contamination, leading to rejection of the entire batch.
- Spillages of milk and LFO during handling also leads to contamination of the shop floor, the spillages are attended only at the end of the day.
- Equipment and clothing used in making cheese are not sterilized.

6.0 Cleaner Production opportunities

The Rapid CPOA indicated that the factory provides several cleaner production opportunities, which should be reassessed during a Comprehensive CPOA. Based on the information collected during the Rapid CPOA the following options were generated. These are summarized below:

No.	Potential CP Opportunity	Relevant process / operations	Potential Benefits of the opportunity	Information gaps
1	Good housekeeping and introduction of 5S principles	Entire production area	Reduced risk of contamination, more efficient operations, safer workplace	None
2	Introduce pre-testing for milk quality and fat content	Raw milk receiving process	Better quality control leading to higher product quality	Parameters of importance and testing equipment know-how
3	Optimising salt addition	Curdling process of milk	Whey generated will contain less salt, and thus can be utilised as a by-product	Exact process sequencing for salt addition
4	Equipment modification (use of specially designed knives for cheese cutting process)	Cheese cutting process to expel whey	Cheese wastage in the whey stream will be reduced	Quantification of the cheese draining out with whey BOD and COD of the whey expelled
5	Equipment for milk pasteurisation, process monitoring and quality assurance	Entire production cycle	Enhanced product quality and low rejections	Information for milk pasteurisation equipment provider
6	Use of natural gas to replace LFO	Heating the raw milk	Less air emissions and no spillages	Quantity of natural gas required and its availability

7.0 Screening level CBA

A screening level CBA is illustrated below to demonstrate the monetary benefits estimated by the installation of cheese cutting knives, in place of the traditional flat handmade tin knives for cutting cheese as a potential cleaner production opportunity.

Yield lost daily		80 kg cheese/day
Yearly losses		24 ton cheese/ year
1 ton hard cheese (whole sale price)		9,000 LE
Yearly saving of recoverable yield losses		24 * 9,000 **216,000 LE**
Cost of curd cutting knives (2 sets)		**12,000 LE**
Pay back period		12,000/ 216,000 *12 = **20 days**

The pay back period for this option will be further studied in detail in the Comprehensive CPOA (see **Annex 5**) , considering the ancillary cost, like training.

8.0 Next steps

While the Rapid CPOA has identified and recommended a number of Cleaner Production options, additional information in certain critical areas is required to implement these options. It is therefore required to conduct a Comprehensive CPOA in the unit. The information gaps identified in the Rapid CPOA should be addressed in the Comprehensive CPOA, so as to enable the analysis of these options in further detail, and check their feasibility in terms of the economic and environmental benefits.

Annex

5

Model Comprehensive CPOA Report

Annex 5: Model Comprehensive CPOA Report

1.0 Preliminary details and background of the industry[27]

Name:	Yumycheez Dairy Products
Address:	Agriculture road, Dairy City.
Governorate:	Foodland
Ownership:	Private, owned by Mr. Renette
Sector / sub-sector:	Dairy / cheese manufacturing
Year of establishment:	1950
Plot area in sq. m. :	100
Date visited:	2nd January, 2003
Time taken:	8.00 a.m.

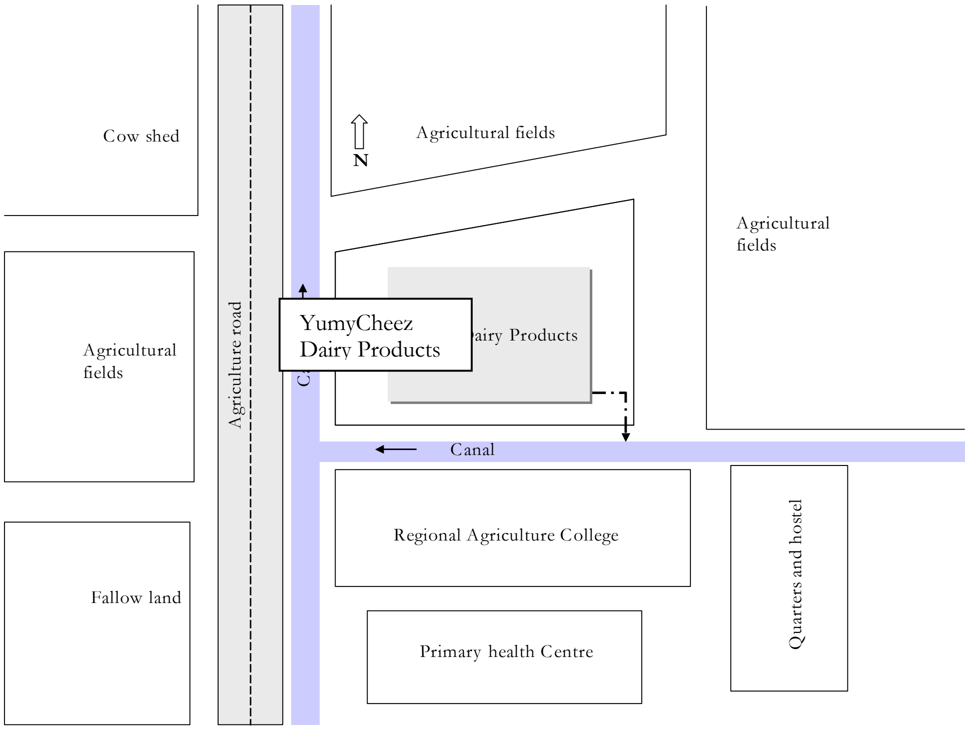
Mr. Renette had an ancestral factory established in 1950. The factory used the traditional technique of cheese making. With the help of his sons, he renovated the factory in 1992, maintaining the same technique of cheese production. The new factory has a total area of 100 sq. m. and a working area of 70 sq. m. It operates 2 shifts a day. Mr. Renette stores the final product in a refrigeration unit, located near his factory.

Recently, Mr. Renette and his sons have started experiencing increasing demands in terms of quality from customers, which their old technology is not able to meet any longer. Also looming over their heads is the threat of non-compliance with the biochemical oxygen demand (BOD) and the chemical oxygen demand (COD) discharge limits laid down by the regulatory authority on all dairy product manufacturers.

The factory is located on the Agriculture road, on the outskirts of the town in the 1950s (see **Figure 1** for the location map of the factory). However, today, it has become a populated suburb. The factory operates on the ground floor of a residential building. It is located in a sparsely populated area of the suburb. The suburb has a Regional Agriculture College, quarters and hostels for the college, a primary health centre and agricultural fields surrounding it. It lacks a green belt. The residents of Regional Agriculture College quarters and the hostels have complained against the foul odour from the canal (due to decomposition of high BOD whey discharged into it). While no litigations have been filed so far, they cannot be ruled out in the future.

[27] Based on the Rapid CPOA report and additional information gathering exercises.

Figure 1: Location map (not to scale)



2.0 Profiles of important aspects

2.1 Production profile

The factory uses 10 tons of fresh milk daily for its cheese production. The production efficiency of the factory is 20% for white cheese and 10 % for hard cheese.

The production rate is a function of the availability and quality of the raw milk. The main products of this factory are:

- **Hard cheese** (Ras) known as "Roumy Cheese" which represents 70% of the total yearly production. Hard cheese is produced for 9 months per year with peaks in the winter, where more quantity of milk is produced with better compositional and microbiological quality. A daily rate of production is averaged as 1 ton cheese requires about 10 tons of milk. This is equivalent to 10% production efficiency.

- **Soft white cheese** known as "Domiaty Cheese", which represents about 30% of the factory yearly production. White cheese is produced for only 3 months per year during the summer season, where the quantity and quality of milk is the lowest. A daily rate of production is about 2 tons requiring 10 tons of milk. This is equivalent to 20% production efficiency.

- **Milk cream** is produced as by-product, where it is separated from the hard cheese whey before discharge to the sewer / canal. About 20 kg milk cream is produced daily from processing 10 tons of milk.

Sr.	Product List	Production
1	During winter White cheese (Domiaty cheese) Hard cheese (Roumy cheese)	 22.5 tons/month 52.5 tons/month
2	During summer White cheese (Domiaty cheese) Hard cheese (Roumy cheese)	 52.5 tons/month 22.5 tons/month
3	Milk cream	0.5 tons/month

The fresh milk is supplied by special milk suppliers who collect the milk from hundreds of farmers. Cow milk with an average fat content of 3.5% represents 95% of the total used milk in the factory, while buffalo milk with an average fat content of 5.5% is used only to adjust the fat content during the production of hard cheese, so that it is not less than 3.6%. Note that the fat content of 5.5% for buffalo milk is low, compared to the average requirement of about 6-7% according to the Egyptian Standard Specifications.

2.2 Financial profile

Order of capital investment: LE 5,500,000
Annual turnover: LE 180,000

1US$ = 5.935 LE (Egyptian Pounds) as of the date of the CCPOA

Critical cost heads	Consumption	Unit costs	Total expenditure
Milk 1 kg of cow milk (3.5 % fat) 1 kg of buffalo milk (5.5 % fat)	10 ton/d	1.20 LE[28] 1.10 LE 1.30 LE	12,000 LE
Salt	800 kg/d	0.17 LE	136 LE
Rennet	22.75 kg (sold in 25 L packs)	3.25 LE	81.25 LE
Colouring agent	167 g/d		
Light furnace oil	120 L/d	0.4 LE	48 LE
Water[29]	23 m^3/d	1 LE	23

[28] Represents the average unit cost.

[29] Total consumption is not recorded as all the water requirements are met through a bore well within the premises of the industry

Critical cost heads	Consumption	Unit costs	Total expenditure
Electricity			
Salaries	10,000 LE		
Marketing[30]	2,000 LE		
Maintenance of equipment[2]	4,000 LE		
Pollution control[2]	1,000 LE		
Sampling, measurement and laboratory analyses[2]	400 LE		
Fees to external consultants[2]	0 LE		
Total operating costs	**29,690 LE**		

2.3 Market profile

The raw materials are sourced from local markets. Milk is brought by the farmers from the neighbouring villages in tin cans to the factory. The other chemical requirements (salt, rennet, detergents etc.) are purchased from the town on a monthly basis. There is a huge demand for cheese in the local markets, as it forms a major dietary supplement in the region. The products manufactured by the factory (hard, white cheese and milk cream) are sold in the local markets of the town. Recently, the factory started targeting markets outside the Foodland Governorate. The market position of cheesy Dairy products has been steady for the last three years. Recently, the factory started targeting markets outside the Foodland Governorate. While the customers of Yumycheez have been generally happy with the product quality and costs, lately competition has increased with many new brands coming in the market and the quality consciousness has increased too.

2.4 Labour profile

The factory employs eight people; they are local residents of Dairy city. The present staff is mostly illiterate and generally unskilled, but working in the factory for the last ten years they have developed necessary skills for cheese processing. The working hours of the factory are 8am to 6 pm. The factory operates for 25 days a month. The workers can avail of sick leave in addition to the other holidays. The workers are not provided with proper clothing, gloves, and caps, they change into old clothing during the working hours, and leave them at the factory after their work. At the end of the day the workers take a wash in an enclosure

[30] This data should be tabulated (under suitable heads such as – consumption, unit costs, total expenditure) if available.

adjoining the factory building. The staff does not undergo any annual medical tests. The working culture of the factory is informal and does not have an organizational structure.

2.5 Equipment and machinery profile

As shown in the layout diagram **Figure 2**, the factory houses the following machinery:

- 2 stainless steel cheese vats or tanks of 1.6 tons capacity each. These vats have water jackets on the sides for heating the vat contents. The water in the jacket is heated by direct heating from burners installed on the external side of the factory wall.
- 14 circular plastic barrels of 220-kg capacity used to curdle the milk during the processing of white cheese.
- 9 wooden cheese-pressing tables with removable sides to drain out the whey.
- One pump for transfer of milk and cheese whey.
- Two skimmers used to separate cream from hard cheese whey.
- 5 press machines of 20-mould capacity each for moulding hard cheese.

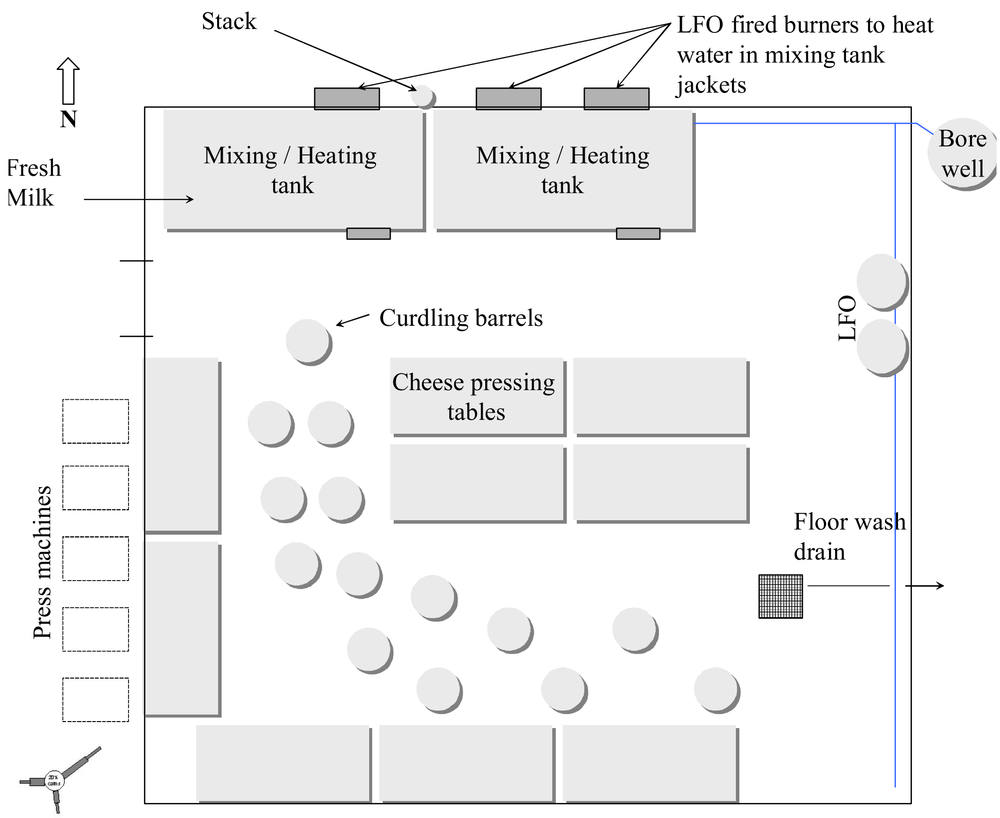


Figure 2: Factory layout (not to scale)

2.6 Utilities

The factory entirely relies on a bore well for all its water needs. The bore well was dug in 1955 and the owner is experiencing water shortage during the summers. Groundwater is used in the water jackets for heating the milk, washing the equipment and other housekeeping purposes. The factory does not have a municipal water connection. The equipment and floors of the factory are cleaned daily at the end of the day. The extracted groundwater is pumped twice to an overhead tank of 4 cu. m. capacity and used with gravity flow. The manufacturing process does not consume water. The quantity of water used in the jackets for heating the milk is about 2 cu. m. Wastewater from washing purposes was found to be about 14 m^3/day, in addition to 8-9 m^3/day of cheese whey.

Water is used in the factory for two purposes:

- Washing equipment and floor washing before and after each batch of cheese making, consumes water of about 4200 m^3/year (about 14 m^3/day).
- Indirect heating of the cheese vat through the water jacket around the vat. Total make up water is estimated to be about 1.6 m^3/day (200 L/vat).

Regarding energy consumption, the factory uses light fuel oil (LFO) for the indirect heating of cheese vats by three fuel burners, which are equipped with a long chimney.

- The daily consumption of LFO is about 120 L (1 L costs about 0.4 L.E). The LFO is purchased on a monthly basis and is stored in drums inside the factory.

The factory has a refrigeration unit of 70 sq. m. area. The refrigerant used is freon gas. This is used to store the final product at a temperature of about 4° C. The refrigeration unit is 3 floors high and the temperature is more or less the same throughout the facility. The cheese can be stored for a period of 6 months (during low demand).

The consumable spares like the lights, pipes etc are purchased as and when required. The other daily consumables, like detergents for cleaning, are purchased on a monthly basis.

2.7 Quality control and testing

The pre-testing of milk is limited to the fat content alone and is accomplished by using the Gerber method in a manual skimmer, where the price is determined based on the fat content. The other parameters for the incoming raw milk (such as acidity, water content, etc.) are assessed by the workers as per their judgement. The milk batch can be rejected in case of a deviation; however this rarely happens. The salt concentration is measured using a Baume hydrometer, while a thermometer is used to measure the temperature in the vat. All the other steps in cheese and milk cream manufacturing process are controlled based on the judgment of the workers.

2.8 Process description

The factory gets about 10 tons fresh milk per day. The milk is first filtered through a fine mesh cloth prior to its manual loading in the 1.6 ton capacity cheese vats. The vats are then heated to a temperature of 42ºC by heating the water jacket using the LFO burners. It takes about 45 minutes to reach this temperature. About 8% (128 kg) of salt is added in the tank during this process. After 45 minutes, the milk is transferred into 220 kg capacity barrels using a small submersible pump. When the pump goes out of order, the transfer operation is done manually.

Later, rennet (0.5 kg per 220 kg of milk) is added to the barrels. The milk is held in the barrels for 2 hours. The rennet acts to coagulate the milk solids into curd.

After 2 hours of retention, the semi-solid cheese is carefully transferred from the barrels to the wooden tables. These tables have perforated bottom and removable sides. Workers use flat tin handmade knives to scoop the cheese, so as to avoid disturbing its consistency. This operation is called as **scalding** and requires skilled workers. However, there is significant cheese wastage in the stream during this process.

Once the whole batch is poured on the table, a wooden plank is placed on the top and weights are placed to exert pressure on the cheese. Water inside the cheese is drained through perforations into the floor drain. This water is called whey. The whey is drained with wash water to the sewer, which has a 6% solids consistency. It was reported that about 375 kg of the whey is reused for packing with the cheese cans.

The process for making the hard cheese is similar to that of white cheese, with the only differences being the use of a colouring agent, and the curing of the cheese, which is done in the sun. In the case of hard cheese manufacture and process, a colouring agent called "Anatto" is added in very small quantities to the cheese vats, so as to provide a yellowish colour to the cheese. The milk is heated to 32°C, followed by the addition of rennet to start the curdling process, which takes 35 minutes.

Note that sterilization is not practiced in the unit at any level of operations.

Simple PFDs describing the stages of production of both white and hard cheese is shown in **Figures 3 and 4**. An overall material balance for the process is also described in **Figure 5.**

Figure 3: PFD for white cheese

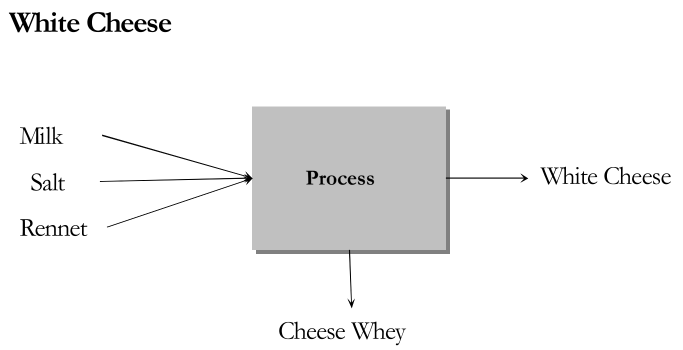
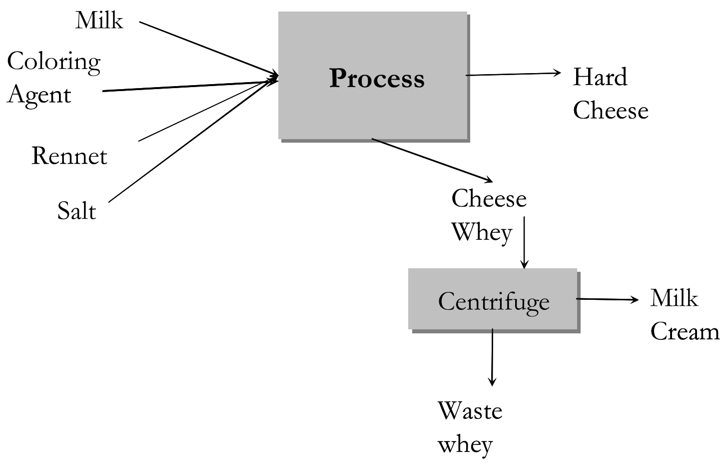


Figure 4: PFD for hard cheese



The formed curd is then cut using metallic knife crisscross to separate whey from curd. This process is followed by gentle stirring with a special wooden stick to break the curd blocks into small pieces. The vat is then heated to 47°C to start the cooking stage. Salt is added after 1.5 hrs of cooking. The contents of the vat are then stirred for an additional 30 minutes.

Then, the whey is drained out and collected in barrels, where it is passed to a skimmer for cream separation prior to being drained to the sewer / canal. The curd is packed in a mould lined with permeable cloth, and pressed for 3 hours to form a cylindrical block of cheese weighing about 12.5-13 kg.

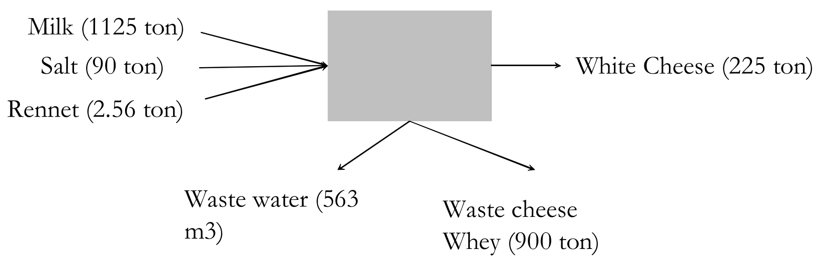
The block is stamped with the manufacturer's name and the date, and air-dried on wooden shelves. During the first two weeks of curing, salt is spread under and above the cheese blocks. Following this, the cheese is aged for at least three months before being sold in the market.

Milk cream is manufactured from the whey formed during the processing of hard cheese. The whey is centrifuged to separate the milk cream.

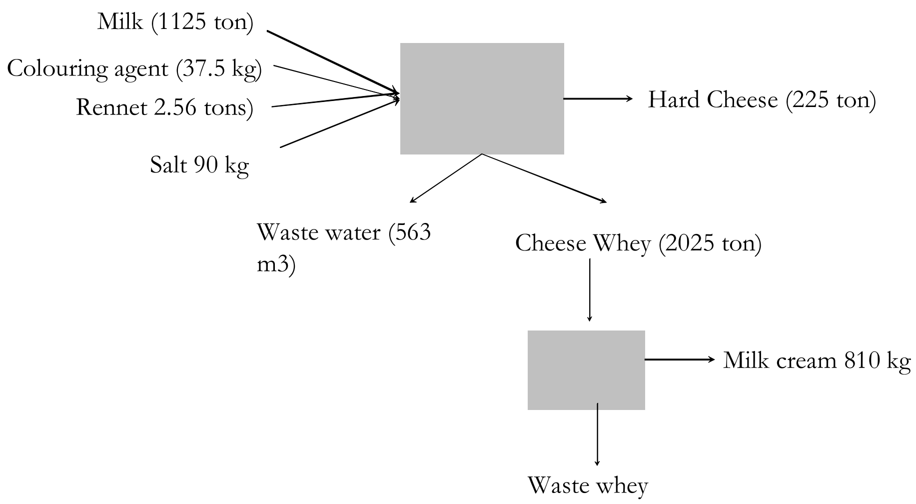
The final product is stored in the refrigeration facility near the factory.

Figure 5: Overall Material Balance for White and Hard Cheese Processing (Basis: Annual)

White Cheese



Hard Cheese



3.0 Identification and evaluation of environmental issues

The environmental issues (include safety and health issues) identified in the factory are as given below:

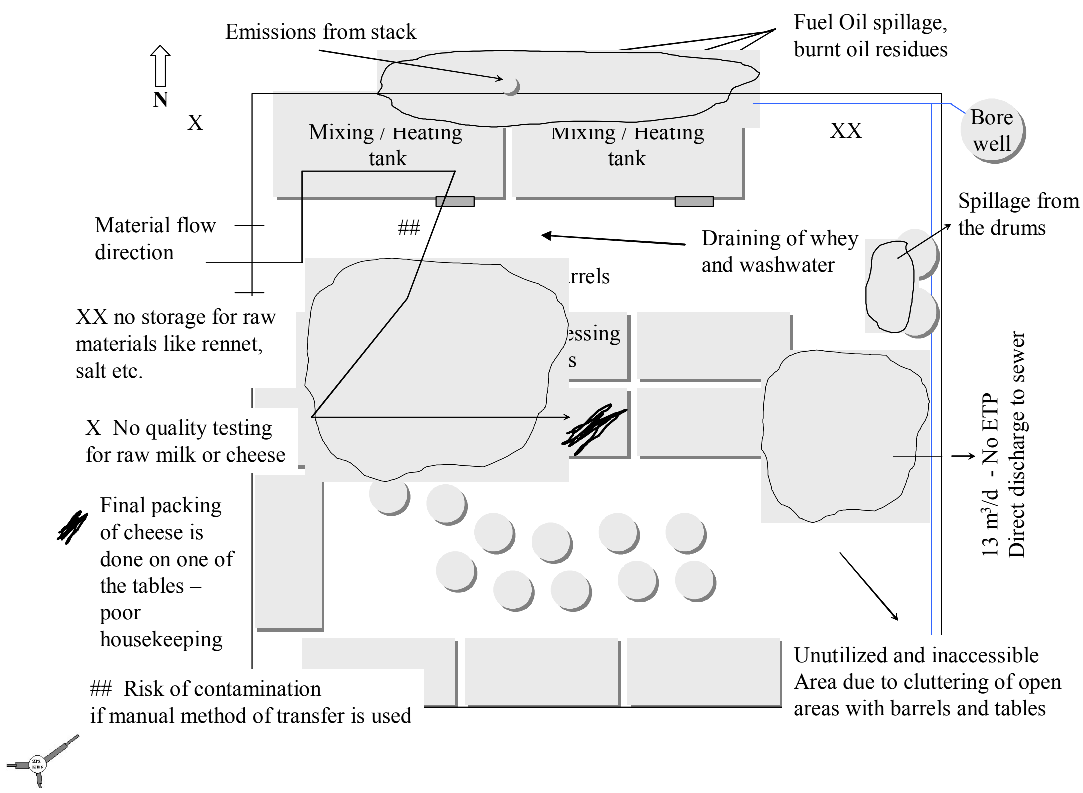
- The disposal of whey produced during cheese production is the major problem in the plant. Whey comprises about 80-90% of the total volume of milk used in the cheese making process and contains more than 50% solids, as that of the whole milk, which includes 20% of the protein and most of lactose. It has a very high organic content, with a BOD of approximately 60,000 mg/l. The factory discharges 8-9 cu. m. / day of cheese whey directly to the nearby canal. The factory is presently not complying with the COD and the COD discharge limits laid down by the regulatory authorities and is liable to face prosecution in the form of penalty and immediate resolution of the problem, or face closure.

- Air emissions generated due to burning of the LFO are discharged into the atmosphere through a 12-meter high stack.

- The chances of contamination of the raw milk and the final product are very high, due to poor house keeping practices and operating procedures. Milk used in making the cheese is heated only to 42°C, which is much lower than the temperature required for milk pasteurisation (minimum 75°C). The cheese is handled manually while cutting on the cheese tables. Thus the product formed may have changes of bacterial contamination, leading to rejection of the entire batch.
- Spillages of milk and LFO during handling also leads to contamination of the shop floor, the spillages are attended only at the end of the day.
- Equipment and clothing used in making cheese are not sterilized.

An illustrative eco-map depicting the pollution issues in the factory is presented in **Figure 6.**

Figure 6: Eco-map (not to scale)



As seen in the previous section, cheese processing in YumyCheez plant seems to be quite simple in terms of operation; however, it needs some modifications in order to improve the productivity of the unit and solve the environmental issues associated with it.

As a beginning, it must be noticed that the plant does not have any problems with the location, as it is situated on the outskirts of the town area. There are hardly any residential buildings in the vicinity, except for the college quarters, hostel, primary health care unit, and the residence of the owner of the unit (who lives in the same building as that of the plant).

On the other hand, all dairy industries producing cheese have been notified by the Egyptian Government (Joint committee from Department of Industry and Health) to ensure pasteurization of raw milk before manufacturing cheese. The environmental authorities are in favour of the plant decreasing its pollution load, in order that it complies with Environmental Law 93/62, decree 44/2000 for discharge to public sewers.

The plant lacks modern technology availability and needs to have updated information about the new techniques used in cheese production.

The most important problems facing YumyCheez plant can be summarized in the following points:

- **Milk collection:** The period between milking and receiving time can exceed 4 hours, which is the limit for handling milk without cooling.
- **Milk pasteurisation:** Milk is heated only to 37ºC in case of white cheese and to 42ºC in case of hard cheese, which is much lower than the temperature required for milk pasteurisation (minimum 63ºC/30 min). Moreover, milk cans have sharp corners, which are difficult to be cleaned and thus, may result in bacterial contamination.
- **Process control (standard operating procedures):** The factory does not have any Standard Operating Procedures (SOP) regarding process activities starting from milk receiving until cheese ripening. Most activities are carried out through the workers' judgement alone.
- **Hygiene:** The plant suffers from unhygienic conditions.
- **Sterilization:** None of the equipment used in making the cheese is sterilized.
- **Cutting the curd (hard cheese):** The curd cutting technique is conducted using traditional flat handmade tin knives for slicing the curd in one direction only. To transform the resulting large cheese slices into small sized curd, additional time for heating, acid development and stirring is required. As a result, whey with high content of fat and protein is produced, which results in a loss of cheese yield and thus, increased pollution (through the discharge of whey) to the environment.
- **Scalding (hard cheese):** Improper scalding process due to prolonged aggressive stirring, which results in great, losses in the cheese yield, as well as an increase in the wasted whey thus leading to increased pollution load in the final effluent.
- **Salting (white and hard cheeses):** The SOP of the unit is such that a higher than required amount of salt is currently added during the processing operation. This leads to certain disadvantages, such as:
  - Usage of excessive amounts of salt and subsequent wastage with the whey.
  - Greater requirements of rennet for curdling.
  - Slow acid development in the scalding process.
  - Greater time requirement to remove the whey from the curd during the scalding process.
- **Protein and fat losses:** During the Comprehensive CPOA, samples of milk and cheese whey were collected and analyzed in the Dairy Labs, Food Science Department, University of Ain-Shams. Fat, protein, and total solids were determined and compared to norms for whey, to determine the abnormal losses in protein and fat at YumyCheez process.

	Fat %	Protein %	Total solids %

Milk	5.7	3.4	14.6
Whey	1.5	1.25	8.1
Standard whey	0.4	0.8	6.55
Abnormal losses			
Losses	1.1*	0.45**	1.55
Ratio %	19.29	13.24	10.62

* Collected from whey by separation to produce milk cream

** Discharged with whey

The results shown in the previous table indicate the following:

- Appreciable loss of protein in hard cheese whey (13.24% of total milk protein), which is not recovered and wasted to the drain.
- Fat losses to whey of about 19.29% as milk cream prior to the discharge of the whey to the drain.
- In addition to the above, lactose representing about 5.5% of whey is also wasted with the whey to the drain.

Effluent Characterization: Recently, the end-of-pipe stream was connected to the general public sewer. The total water consumption mainly used for washing and cleaning reaches about 14 m^3/day, based on consumption for 2 shifts per day. Besides this, the whey from the cheese process is also discharged to the end-of-pipe stream.

Whey from white cheese process	=	8 cu. m. /day
Whey from hard cheese process	=	9 cu. m. /day

Therefore, the total end of pipe wastewater effluent from the plant reaches an average flow of about 21-23 m^3 / day for two shifts of operation.

Samples were collected during the Comprehensive CPOA from the final whey (after cream separation) and from the end-of-pipe effluent. They were sent for analysis to measure parameters like pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Total Suspended Solids (TSS).

Samples were analysed at Water Research and Quality Control Laboratory, Water Technology and Chemical Analysis Unit, Faculty of Engineering, Mansoura University. The results of the chemical analysis indicate the following:

- The BOD level measured for the whey looks unrealistic and should be around 40,000 mg/l.
- Final waste effluent is highly contaminated with organic matter, which is equivalent to high BOD and COD loads. This exceeds the allowable limits as per the Egyptian Law 93/62 decree 44/2000 for discharge to a public sewer.

- Whey, which is discharged directly to the sewer, is responsible for the high organic pollution load of the final effluent. This is confirmed by the chemical analysis which shows that the levels of BOD and COD are almost the same for both whey and final effluent (note that the waste effluent was collected at the time of discharging the whey, and no cleaning or washing activities were practiced at that time). An estimate for the level of contaminants in the equalized waste effluent (whey and effluent from the washing operations) at the end of one shift is given for hard cheese as below:

	Concentration (mg/l)		
	Whey	Equalized Effluent (Estimated)	Limits of Law 93/62, Decree 44/2000
COD	96,670	35,000	1,100
BOD	52,500	2,000	600

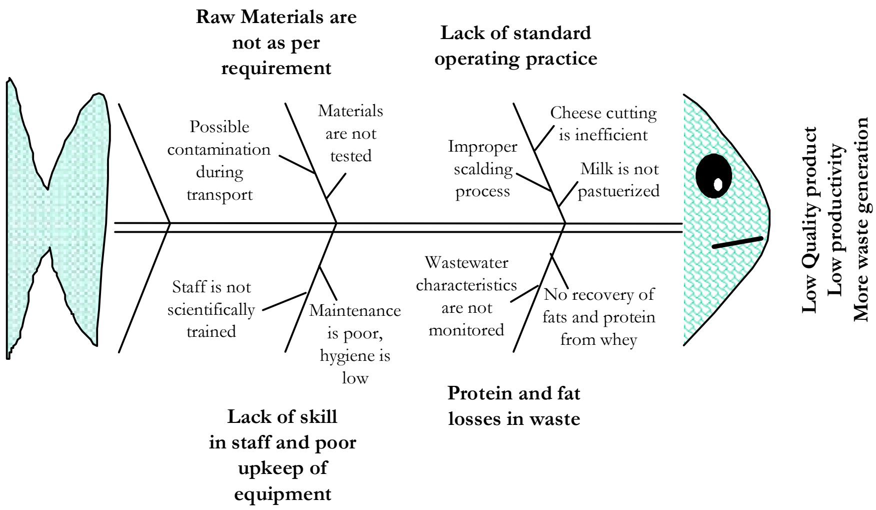
Average total flow $\simeq$ 11 cu. m. / shift

Therefore, the whey has to be segregated from the plant (washing operations) effluent stream and treated separately, so as to recover the valuable protein and lactose. Such an action will reduce the organic pollution load to a large extent.

- **Fuel consumption:** Kerosene burners are used for heating the milk vats. It was noticed that black smoke leaks across the wall cracks near the surface of the vat. Not too clear about the last sentence. This could have an adverse effect on the quality of the produced cheese due to contamination.

Figure 6 presents the fishbone diagram which was developed during problem diagnosis.

Figure 6: Fishbone diagram for problem diagnosis



4.0 Cleaner Production opportunities / options

The following Cleaner Production option categories emerged during the Comprehensive CPOA of the YumyCheez factory.

4.1 Improve operating procedures

It is recommended that operating procedures be standardized, by introducing worker instructions, and practising record keeping for process inputs and outputs. The procedures will cover the main activities - milk receiving, milk filtration, renneting, curd cutting, scalding, whey separation, curd moulding and pressing and cheese ripening (curing).

It is recommended that analytical equipment be provided to improve monitoring of the cheese making operations. This includes measurement and analysis of fat in the raw milk and whey, measurement and analysis of pH, salt content, temperature of renneting and scalding, and microbiological analysis.

Piloting tests should be undertaken to modify the process, so as to reduce the salt content in the cheese and whey, and thus, improve the scalding process, which presently causes product losses due to prolonged stirring.

Advice should be given on equipment needs for pasteurisation, so as to comply with the latest legislation. However, the external / Programme donor will not fund the cost of the equipment (estimated to be 100,000 LE).

4.2 Improve factory hygiene

This will include the following:

- Introduction of hot water systems to improve equipment cleaning.
- Modification of milk vats to have washing drains, and the provision of hoses with spring valve ends for hygienic cleaning.
- Provision of stainless steel covers for the vats (which are presently open) so as to minimize cross contamination.
- Provision of employee training on health and hygiene issues.

4.3 Increase cheese yield from curd-whey separation and reduce pollution

Whey expulsion is an essential part of cheese making and has the objective of reducing the moisture content of the curd from 88% to as low as 40%. Good cutting leads to effective whey expulsion and permits the resulting equal sized smaller curd to be cooked uniformly throughout. Cheese cutter knives will be provided to cut the freshly curdled whey to more effectively separate cheese and whey. It is estimated that cheese losses from the current system for hard cheese is around 90 kg per day.

The cheese whey draining tables will also be modified to include stainless overflow channels to capture the whey and keep it separate from the wastewater effluent.

4.4 Energy savings

Kerosene burners are used for heating three of the milk vats. It is proposed to switch these to gas-fired cylinders, since the latter are a cheaper fuel source. This will also reduce the adverse effects of black smoke from the kerosene on cheese quality.

5.0 CBA of Cleaner Production options

5.1 Curd processing improvements (hard cheese)

A. Opportunities:

- Using of good curd cutting knives specially designed to release the whey from the curd in an easy way.
- Provide monitoring devices to measure the quality of raw milk, intermediate curd, whey, and products.
- Optimise the operating conditions.

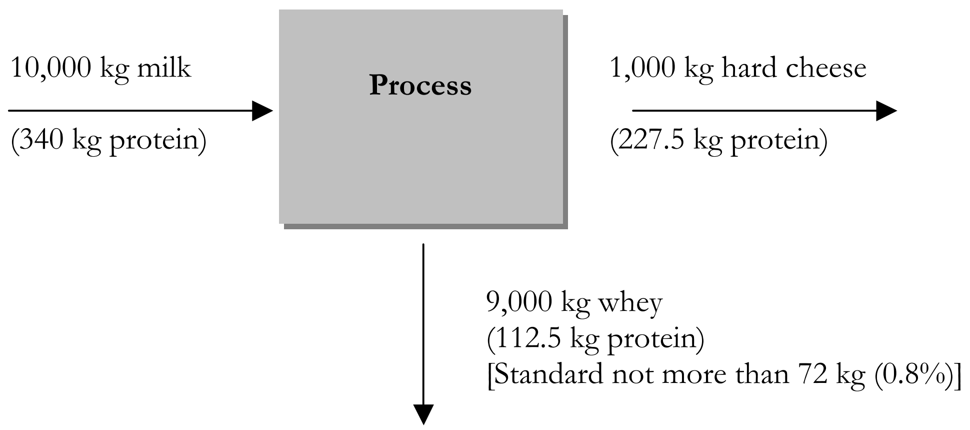
- Provide training to the workers on the Standardized operating procedures (SOP).
- Improve the plant hygienic conditions and develop Sanitation Standard Operation Procedures (SSOP).
- Conduct trials using the upgraded procedures.

These opportunities are expected to result in recovering 18% of the cheese yield losses.

B. Savings:

Conducting protein material balance for hard cheese

Basis: 1 Day



Daily protein losses (whey lost – discharge standard)		40.5 kg/day
Equivalent yield losses		178 kg cheese/day
Yearly losses		53.4 ton cheese/year
1 ton hard cheese (whole sale price)		9,500 LE
Yearly saving for recoverable yield losses		53.4 * 9,500 **507,300 LE**

Taking the percent fat residue in whey after cream separation as 0.5 % (measured during the comprehensive CPOA); we can calculate;

Fat lost in whey	=	9,000 * (0.5/100)= 45 kg/day

Fat represents 70 % of cream, which is equivalent to 64 kg cream/day. Taking the wholesale price of cream as 10 LE,

Value of lost cream with whey (on an annual basis)	=	64 * 10 * 300 = **192,000 LE**
Net yield saving (by deduction of cream value)[31]	=	507,300 – 192,000 = **315,300 LE/year**

C. Costs:

Curd cutting knives (2 sets)	=	12,000 LE
Stainless steel tables with side drains (4 tables)	=	10,000 LE
Monitoring devices	=	3,000 LE
15 person-day training	=	1,000 LE
Conducted trials (Price of about 1.5 ton milk)	=	2,000 LE
Total	**=**	**28,000 LE**

D. Payback period:

Payback period	=	(28,000/315,300) * 12 = **1 month**

5.2 Saving energy

Substitution of liquid kerosene by gas cylinders for heating milk vats involves the following;

Number of cylinders required	=	4 cylinders/day
Current cost of heating	=	48 LE / day

[31] When the standard for permissible protein content in whey is achieved, most of the cream that could have been produced from the 0.5% fat in whey after separating cream would be used up in making the additional cheese (53.4 tons per year)

Cost of using gas only	=	4*11 = 44 LE/day
Daily saving	=	48 – 44 = 4 LE
Yearly saving	=	1,200 LE
Cost of getting 20 cylinders (an inventory of stock for 5 days operations is maintained at all times), taking the price of each cylinder as 200 LE	=	20 * 200 = 4,000 LE
Payback period	=	(4,000/1,200) = **3.5 months**

5.3 Water saving and hygienic washing procedures

Cost of modifying milk vats	=	2,500 LE
Average daily water consumption	=	14 m^3
Daily water cost	=	14 LE
Daily water saving	=	35 % 4.9 m^3
Yearly saving	=	5 * 300 = 1,500 LE
Payback period	=	(2,500/1,500) * 12 = **20 months**

This option also provides an intangible benefit in terms of improved hygiene.

6.0 Implementation plan and recommendations

Based on the findings of the Comprehensive CPOA and the CBA of the cleaner production options, the following actions are recommended for YumyCheez factory:

- An Implementation Project with full financial and technical assistance, not including the funding for the cost of the new equipment,
- Workers' training on implementation for the Cleaner Production options, and
- Holding dissemination workshops for similar dairy factories.