LAKE VICTORIA ENVIRONMENTAL MANAGEMENT PROGRAM II

SUB COMPONENT
2.2: PROMOTION OF CLEANER PRODUCTION TECHNOLOGIES

Resource Efficient and Cleaner Production Guidance Manual for the Dairy Processing Industry

Jointly prepared by KNCPC, UCPC & CPCT

ACRONYMS AND ABBREVIATIONS

BOD:	Biological Oxygen Demand
CIP	Cleaning – In -Place
CO_2	Carbon Dioxide
COD:	Chemical Oxygen Demand
CP:	Cleaner Production
CPA	Cleaner Production Audit
CPCT	Cleaner Production Centre of Tanzania
EE:	Energy Efficiency
GDP:	Gross Domestic Product
Kg	Kilogrammes
Kg/L	Kilogram per litre
KNCPC:	Kenya National Cleaner Production
KWh	Kilowatt Hour
NO_X	Nitrogen Oxides
PHE	Plate Heat Exchanger
RECP:	Resource Efficient and Cleaner Production
RR:	Renewable Resources
RRT:	Renewable Ressources Technologies
SO_2	Sulphur Dioxide
TN:	Total Nitrogen
TP:	Total Phosphorous
UCPC	Uganda Cleaner Production Centre

PREFACE

The purpose of this Resource Efficient and Cleaner Production sector manual guide is to raise awareness of the environmental impacts associated with industrial and manufacturing processes. Also, it serves to highlight the approaches that industry and government can take to avoid or minimize these impacts by adopting Resource Efficient and Cleaner Production approach.

This guide is designed for two principal audiences.

- Environmental consultants, Cleaner Production practitioners, employees of industry bodies, government officers or private consultants that provide advice to the dairy processing industry on environmental issues
- The guide describes Cleaner Production opportunities for improving resource efficiency and preventing the release of contaminants to environment. The Cleaner Production opportunities described in this guide will help improve production as well as environmental performance.

Chapter 1 Country background of the Dairy sub-sector, industry structure and production processes. This chapter is designed to help the user of the manual get a brief and orientation understanding of the contribution of the sub-sector to the respective national GDP. This is envisaged to enable the user contextualize the manual

Chapter 2 describes resource efficiency and cleaner production concept that defines RECP, RECP principles and techniques, RECP versus end-of –pipe approach and its benefits.

Chapter 3 provides an overview of the dairy processing industry including process descriptions, environmental impacts and key environmental indicators for the industry. The processes discussed in most detail are milk, butter, cheese and dried milk production, as well as cleaning and ancillary operations.

Chapter 4 describes Resource Efficiency and Cleaner Production opportunities for each of the unit operations within the process and examples where these have been successfully applied. Quantitative data are provided for the inputs and outputs associated with each unit operation as an indication of the typical levels of resource consumption and waste generation.

Chapter 5 describes the Resource Efficiency and Cleaner Production assessment methodology in detail. This can be used as a reference guide for carrying out a RECP assessment within an organization.

Chapter 6 provides a case study demonstrating the application of Cleaner Production at a dairy processing plant.

Chapter 7 describes barriers to RECP and how to overcome them

Chapter 8 Appendices
Annex 1. contains RECP evaluation questionnaire
Annex 2. Contains a reference and bibliography list
Annex 3. contains a glossary.
Annex 4. contains checklist for assessment

ACKNOWLEDGEMENTS

This manual (self guide) has been jointly developed by the Kenya National Cleaner Production Centre (KNCPC), Uganda Cleaner Production Centre (UCPC) and Cleaner Production Centre of Tanzania (CPCT). This is a step-by-step guide to implementing RECP at a dairy processing plant. It is a tool to help managers and staff think about RECP in a strategic way by assessing the company's current resource use and waste generation, determining whether there is room for improvement, identifying ways to make the improvements, and then progressively implementing the changes.

This manual is an adaptation of the manual on "Cleaner Production Assessment in Dairy Processing" of UNEP and Danish Protection Agency prepared by COWI Consulting Engineers and Planners AS, Denmark.

The method described in this guide is a team-based assessment that involves participation by several staff members in a company. It requires a significant amount of time, resources and commitment from management. Alternatively, the assessment can be undertaken by one or two individuals within an organization, or perhaps by an external consultant. It is a complete assessment, which includes raw material, energy consumption, and waste generation. However, the company has the option of simply focusing on one aspect of RECP such as water or energy use.

EXECUTIVE SUMMARY

This document is a guide to the application of Resource Efficiency and Cleaner Production (RECP) in the dairy industry, with a focus on the processing of milk and milk products at dairy processing plants. Its purpose is to provide a practical step-by-step guide to conducting a Resource Efficiency Cleaner Production Assessment and raise awareness of the environmental impacts of dairy processing, and to highlight approaches that industry and government can take to avoid or minimize these impacts by adopting a Resource Efficiency and Cleaner Production approach.

This manual is especially designed to:

- Be a practical and directly useful to dairy industry and related personnel
- Be a ready reference guide
- Explain the concepts behind such terms as material and energy balances and RECP indicators to underscore their usefulness
- Provide illustrative examples and worksheets.

The life cycle of milk and milk products commences with the production of fresh cow's milk on dairy farms. Milk is then processed to produce pasteurized and homogenized market milk, butter, cheese, yogurt, custard and dairy desserts etc. It may also be preserved for a longer shelf life in the form of long-life (UHT), condensed, evaporated or powdered milk products. The various products are packaged into consumer portions and distributed to retail outlets. For fresh dairy products, refrigerated storage is required throughout the life of the products to maintain eating appeal and prevent microbiological spoilage. Following use by the consumer, packaging is either discarded or recycled.

In this guide, the upstream process of fresh milk production on dairy farms and the downstream processes of distribution and post-consumer packaging management are not covered. Instead the guide focuses on the processing of key dairy products, namely market milk, butter, cheese and evaporated and powdered milk, at dairy processing plants.

The processing of milk to produce dairy products is a significant contributor to the overall environmental load produced over the life cycle of milk production and consumption. Therefore the application of Resource Efficiency and Cleaner Production in this phase of the life cycle is important.

As in many food processing industries, the key environmental issues associated with dairy processing are the high consumption of water, the generation of high-strength effluent streams, the consumption of energy and the generation of by-products. For some sites, noise and odour may also be concerns. The guide contains background information about the industry and its environmental issues, including quantitative data on rates of resource consumption and waste generation, where available. It presents opportunities for improving the environmental performance of dairy processing plants through the application of Resource Efficiency and Cleaner Production. Case studies of successful Cleaner Production opportunities are also presented.

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1. INTRODUCTION
1.0 COUNTRY OVERVIEW OF DAIRY PROCESSING INDUSTRY

1.1 KENYA

1.1.1 Background

The dairy industry is the single largest agricultural sub-sector, larger even than tea; it contributes some 14% of agricultural GDP and 3.5% of total GDP. With a dairy cattle population estimated at nearly 7million, the largest such herd in Africa and more than the rest of the countries in East and Southern Africa combined, Kenya is the third-largest milk producer in Africa, behind Sudan and Egypt.

Kenyans love milk; they consume more of it than almost anyone else in the developing world. In terms of milk consumption per unit of average income, Kenya ranks only behind Mauritania and Mongolia globally among developing countries. On average, each Kenyan drinks, according to the International Livestock Research Institute (ILRI), about 145 litres of milk a year, triple his Ugandan counterpart and four times the average for Sub-Saharan Africa. A 1999 survey found that urban households spent an average of 18 percent of their income on dairy products, second only to their expenditure on cereals such as maize.

In 2006, production in the country had risen 36% over the preceding years – from 2,8 billion litres in 2002 to 3,8 billion in 2006. This milk was being produced by an estimated 3,3 million strong dairy herd. The country has 34 active processors with an installed processing capacity of 2.9 million litres per day. Kenya processed 362 million litres in 2006, making a substantial contribution towards the country's gross domestic product (GDP).

Up to 1992, the dairy industry was under government control with Kenya Co-operative Creameries (KCC) enjoying a protected monopoly in the marketing of the milk and dairy products. Presently, the dairy industry is regulated by the Kenya Dairy Board (KDB) established under Section 4 of the Dairy Industry Act Cap. 336 enacted by Parliament in 1958. The Government of Kenya, in recognition of the role of the private sector in spearheading industrialization, has put in place a policy framework to foster the creation of a conducive environment to enable private sector participation in economic development

1.1.2 Industry structure

By the end of 2000 there were around 1,500 licensed milk traders in the country and KDB, the Authority in the dairy industry categories as follows: Producers, milk bars, mini-dairies and cottages. According to KDB, only 34 processors were operation in 2004 with a daily capacity of 1,000,000 litres. They produce a wide produce a wide range of products, including; Fresh milk, Yoghurt, Mala (Sour milk), Ice Cream, Cheese, Ultra High Temperature (UHT) milk, Powder milk, Butter and ghee among other products. 1.1.2 Production

1.1.3 Milk production & processing

Since milk market liberalization in May 1992, competition in milk processing and marketing has increased significantly in the industry. As a result, the Board has licensed over 40 private and dairy co-operative processors to handle and market milk and its products. The industry has a total daily processing capacity of 2.5 million litres of which KCC handles 1.2 million litres while other processors handle the remaining 1.3 million litres of milk. Processors mainly produce and market fluid, cultured and solid milk products such as yoghurt, cheese, butter, ghee, condensed and evaporated milk, ice cream and frozen desserts.

From the foregoing, it is obvious that diary activities concentrate the consumption of a number of resources that include energy in form of electricity, fossil fuels and wood biomass and water as an input and for cleaning among other inputs. The consumption naturally results into the generation of wastes such as noise, odour, and emissions including Green House Gases, solid waste and effluents. All the above-mentioned wastes if not well managed may negatively impact on the positive ones Cleaner Production Practices and Techniques should be adopted.

1.2 TANZANIA

The Agricultural sector in Tanzania contributes about 47% of the GDP and livestock sector itself contributes about 30% of the agricultural GDP and about 18% of the national GDP (Private Agricultural Support, www. Pass.ac.tz/livestock.html).

The Tanzania dairy industry is at its infancy stage compared to other countries in the EAC. Milk production in Tanzania is mainly from cattle. Out of the 18.8 million cattle found in the country, about 560,000 are dairy cattle consisting of Friesian, Jersey, Ayrshire breeds and their crosses to the East African Zebu. The rest are indigenous cattle raised for dual purpose of meat and milk production. Dairy goats are also gaining popularity as a source of milk, especially in poor families and their milk is normally consumed at household level.

About 70% of the annually produced milk comes from indigenous cows and 30% from dairy cows. The total annual milk production has increased from 585 million litres in 1995/96 to 1.426 billion litres in 2006/2007. Only a small portion (10%) of the marketable surplus of the annual milk production filters through into urban markets and processing plants. This is mainly due to remoteness and poor infrastructure in rural areas which hamper smooth collection and marketing of milk. Thus the milk produced in Tanzania is mostly consumed locally at household level and a significant amount is left for the calves.

There are about 30 milk processors in the country and out of these only 7 are considered as major players. The seven dairy processing plants owned by Tanzania Dairies Ltd (TDL) were privatized in line with the market liberalization policy and new plants have been constructed. The seven plants had a total processing capacity of about 370,000 litres per day. The dairy plants are mostly located in Dar es Salaam, Iringa, Mara and Tanga regions. In 2006, the total milk processing capacity was about 507,000 per day. Currently most of the dairy processing plants are working at about 12% of the installed capacity, resulting in only 60,000 litres being processed per day. The low performance in milk processing makes the dairy industry in Tanzania uncompetitive in the region as shown by the rise in milk imports form 3,459 metric tons in 1997 to 7,111 metric tons in 2004 worth about US $ 10 million. The low performance od milk processing include among others inadequate supply of raw milk, high milk collection and transport costs due to poor infrastructure, high cost of utilities such as electricity and low milk consumption levels.

1.3 UGANDA

1.3.1 Background

In 2010, Uganda adopted the National Development Plan (NDP) (2010/11-2014/15). The NDP is the country's medium term strategic direction, development priorities and implementation strategies with a thrust to accelerate socio-economic transformation to achieve the National Vision of a transformed Ugandan society from a peasant to a modern and prosperous country within 30 years. The Plan categorizes agriculture as one of the 8 primary growth sectors i.e. sectors and sub-sectors that directly produce goods and services. Dairy is one of the sub-sectors that constitute the Agricultural sector.

Agriculture has for a long time been a core sector of Uganda's economy in terms of its contribution to GDP and employment. By 2005 it employed 73 per cent 25 of the labour force (UBOS, 2005)26. In 2008/09, the sector accounted for 23.7 per cent of total GDP. Agricultural exports accounted for 47 per cent of total exports in 2007. Much of the industrial activity in the country is agro-based. Even though its share in total GDP has been declining, agriculture remains important because it provides the basis for growth in other sectors such as manufacturing and services.

From the foregoing, it is evident that Uganda's economic development is natural resource-based. It is against that background that Uganda's development programmes should be able to make use of natural resources gainfully and sustainably to promote competitiveness, independence, self sustenance and a dynamic economy, which is resilient to any external shocks; an economy which supports stability and protection of biological and physical systems.

It is evident that Uganda's natural resources are both a challenge and an opportunity to national development. This is the very reason why they should be jealously guarded and sparingly used in order for the country to achieve its development targets.

1.3.2 Industry structure

Livestock sub-sector contributes 13.6% to agricultural GDP and 5.0% to National GDP. The dairy industry contributes about 50% of total output from livestock sector and plays an important role as a source of food, income and employment. Dairy farming is concentrated in 52 districts found in the cattle corridor which stretches from the south western region through central to north eastern. On average, 60% of the households in the cattle corridor keep livestock.

The national herd size is about 7.7 million cattle of (indigenous, exotic and crosses). The total national milk production has experienced steady growth from an estimated 365 million litres in 1991 to 1.296 billion litres in 2005. The current growth rate of milk production is estimated at 8-10%.

Uganda has five milk sheds though only two are important sources of marketable milk. Thus; South-western region has the highest milk production (36%): Central (34%): Midwestern (15%): Northern (8%): Eastern (7%). Uganda has a total of 98 milk collection centres collecting 445,000 litres of milk per day (i.e. approximately 30% of the milk available for collection).

1.3.3 Production and Processing

Only 10 -20% of the milk produced in Uganda is processed; the rest is handled through the informal market which deals in raw milk. A number of products are made by the different processing companies and include: Ultra High Temperature (UHT) milk (plain & flavored), cheese (hard & soft), cream, ice cream, yoghurt (plain & flavored), cultured milk, butter and ghee.

From the foregoing, it is obvious that diary activities concentrate the consumption of a number of resources that may include energy in form of electricity, fossil fuels and wood biomass and water as an input and for cleaning among other inputs. The consumption naturally results into the generation of wastes such as noise, odour, and emissions including Green House Gases, solid waste and effluents. All the above-mentioned wastes if not well managed may negatively impact on the environment. To mitigate the negative effects while enhancing the positive ones Cleaner Production Practices and Techniques should be adopted.

2.0 What is Resource Efficient and Cleaner Production (RECP)

Over the years, industrialized nations have progressively taken different approaches to dealing with environmental degradation and pollution problems, by:

- Ignoring the problem;
- Diluting or dispersing the pollution so that its effects are less harmful or apparent;
- Controlling pollution using 'end-of-pipe' treatment;
- Preventing pollution and waste at the source through a 'resource efficient and cleaner production' approach

The gradual progression from 'ignore' through to 'prevent' has culminated in the realization that it is possible to achieve economic savings for industry as well as an improved environment for society. This, essentially, is the goal of Resource Efficient and Cleaner Production.

2.1 Definition of Resource Efficient and Cleaner Production (RECP)

Resource Efficient and Cleaner Production (RECP) is defined by UNIDO and UNEP as the continuous application of an integrated preventive environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment.

It specifically works to advance the three dimensions of sustainable development in an integrated manner, by catalyzing:

- Production Efficiency through optimization of the productive use of natural resources (materials, energy and water) by enterprises and other organizations;

- Environmental Management through minimization of the impact on environment and nature, by preventing the generation of waste and emissions and improving the use of chemicals in enterprises and other organizations; and

- Human Development through minimization of risks to people and communities from enterprises and other entities and supporting their own development.

2.2 Resource Efficient and Cleaner Production (RECP) Techniques

Good Housekeeping

Good work practices and techniques such as proper maintenance can produce significant benefits at no or low cost

Process optimization

Resource consumption can be reduced by optimizing existing processes.

Raw material substitution

Environmental problems can be avoided by replacing hazardous materials with more environmentally benign materials.

New Technology

Adopting new technologies can reduce resource consumption and minimize waste generation through improved operating efficiencies. Technological improvements can occur in a number of ways:

- Changing manufacturing processes and technology;
- Changing the nature of process inputs (ingredients, energy sources, recycled water etc.)
- Changing the final product or developing alternative products;
- On-site reuse of wastes and by-products

New product Design

Changing product design can result in benefits throughout the life cycle of the product, including reduced use of hazardous substances reduced waste disposal, reduced energy consumption and more efficient production processes. New product design is a long-term strategy and may require new production equipment and marketing efforts but payback can ultimately be very rewarding

Changing attitudes

It is important to stress that RECP is about attitudinal as well as technological change. In many cases, the most significant RECP benefits can be gained through lateral thinking, without adopting technological solutions. A change in attitude on the part of company directors, managers and employees is crucial to gaining the most from RECP.

2.3 Difference between RECP and Pollution Control

The key difference between pollution control and RECP is one of timing. Pollution control is an after-the-event, 'react and treat' approach, whereas RECP reflects a proactive, 'anticipate and prevent' philosophy. Prevention is always better than cure. This does not mean, however, that 'end-of-pipe' technologies will never be required. By using a RECP philosophy to tackle pollution and waste problems, the dependence on 'end-of-pipe' solutions may be reduced or in some cases, eliminated altogether. RECP can be and has already been applied to raw material extraction, manufacturing, agriculture, fisheries, transportation, tourism, hospitals, energy generation and information systems.

2.4 Why invest in Resource Efficient and Cleaner Production?

Investing in RECP, to prevent pollution and reduce resource consumption is more cost effective than continuing to rely on increasingly expensive 'end-of-pipe'. The initial investment for RECP options and for installing pollution control technologies may be similar, but the ongoing costs of pollution control will generally be greater than for RECP. Furthermore, the RECP options generate savings through reduced costs for raw materials, energy, waste treatment and regulatory compliance.

Greener products

The environmental benefits of RECP can be translated into market opportunities for 'greener' products. Companies that factor environmental considerations into the design stage of a product will be well placed to benefit from the marketing advantages of any future eco-labeling schemes.

Some reasons to invest in Cleaner Production

- Improvements to product and processes;
- Savings on raw materials and energy, thus reducing production costs;
- Increased competitiveness through the use of new and improved technologies;
- Reduced concerns over environmental legislation;
- Reduced liability associated with the treatment, storage and disposal of hazardous wastes;
- Improved health, safety and morale of employees;
- Improved company image;
- Reduced costs of end-of-pipe solutions

2.5 Cleaner Production and Sustainable Development

In the past, companies have often introduced processes without considering their environmental impact. They have argued that a trade-off is required between economic growth and the environment, and that some level of pollution must be accepted if reasonable rates of economic growth are to be achieved. This argument is no longer valid, and the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in June 1992, established new goals for the world community that advocate environmentally sustainable development.

Economy and environment go hand in hand

RECP can contribute to sustainable development, as endorsed by Agenda 21. RECP can reduce or eliminate the need to trade off environmental protection against economic growth, occupational safety against productivity and consumer safety against competition in international markets.

Setting goals across a range of sustainability issues leads to 'win–win' situations that benefit everyone. RECP is such a 'win–win strategy: it protects the environment, the consumer and the worker while also improving industrial efficiency, profitability and competitiveness.

RECP can provide advantages for all countries

RECP can be especially beneficial to developing countries and those undergoing economic transition. It provides industries in these countries with an opportunity to 'leapfrog' those more established industries elsewhere that are saddled with costly pollution control.

2.6 Cleaner Production and Quality and Safety

Food safety and food quality are very important aspects of the food industry. While food safety has always been an important concern for the industry, it has received even greater attention over the past decade due to larger scales of production, more automated production processes and more stringent consumer expectations. A stronger emphasis is also being placed on quality due to the need for companies to be more efficient in an increasingly competitive industry. In relation to food safety, Hazard Analysis Critical Control Point (HACCP) has become a widely use tool for managing food safety throughout the world. It is an approach based on preventing microbiological, chemical and physical hazards in food production processes by anticipating and preventing problems, rather than relying on inspection of the finished product. Similarly, quality systems such as Total Quality Management (TQM) are based on a systematic and holistic approach to production processes and aim to improve product quality while lowering costs. RECP should operate in partnership with quality and safety systems and should never be allowed to compromise them. As well, quality, safety and RECP systems can work synergistically to identify areas for improvement in all three areas.

2.7 RECP and Environmental Management Systems

Environmental issues are complex, numerous and continually evolving, and an *ad hoc* approach to solving environmental problems is no longer appropriate. Companies are therefore adopting a more systematic approach to environmental management, sometimes through a formalized environmental management system (EMS). RECP helps companies to implement EMS effectively and provides a company with a decision-making structure and strategy in managing the day-to-day operations.

3.0 Primary Production and Dairy Processing

The dairy industry is divided into two main production areas:

- The primary production of milk on farms—the keeping of cows (and other animals such as goats, sheep etc.) For the production of milk for human consumption;
- The processing of milk—with the objective of extending its saleable life.

This objective is typically achieved by (a) heat treatment to ensure that milk is safe for human consumption and has an extended keeping quality, and (b) preparing a variety of dairy products in a semi-dehydrated or dehydrated form (butter, hard cheese and milk powders), which can be stored

The general trend towards large processing plants has provided companies with the opportunity to:

- Acquire bigger, more automated and more efficient equipment. This

technological development has, however, tended to increase environmental loadings in some areas due to the requirement for long-

- Distance distribution.

Basic dairy processes have changed little in the past decade. Specialized processes such as ultra-filtration (UF), and modern drying processes, have increased the opportunity for the recovery of milk solids that were formerly discharged. In addition, all processes have become much more energy efficient and the use of electronic control systems has allowed improved processing effectiveness and cost savings

3.1 Process overview

3.1.1 Milk production

The processes taking place at a typical milk plant include

- Receipt and filtration/clarification of the raw milk;
- Separation of all or part of the milk fat (for standardization of market milk, production of cream and butter and other fat-based products, and production of milk powders);
- Pasteurization;
- Homogenization (if required);
- Deodorization (if required);
- Further product-specific processing;
- Packaging and storage, including cold storage for perishable products;
- Distribution of final products

Figure 1 below is a flow diagram outlining the basic steps in the production of whole milk, semi-skimmed milk and skimmed milk, cream, butter and buttermilk. In such plants, yogurts and other cultured products may also be produced from whole milk and skimmed milk.

3.1.2 Butter production

The butter-making process, whether by batch or continuous methods, consists of the following steps:

- Preparation of the cream;
- Destabilization and breakdown of the fat and water emulsion;
- Aggregation and concentration of the fat particles;
- Formation of a stable emulsion;
- Packaging and storage;
- Distribution

Figure 2 below is a flow diagram outlining the basic processing system for a butter-making plant. The initial steps, (filtration/clarification, separation and pasteurization of the milk) are the same as described in the previous section. Milk destined for butter making must not be homogenized, because the cream must remain in a separate phase.

After separation, cream to be used for butter making is heat treated and cooled under conditions that facilitate good whipping and churning. It may then be ripened with a culture that increases the content of diacetyl, the compound responsible for the flavour of butter. Alternatively, culture inoculation may take place during churning. Butter which is flavour enhanced using this process is termed lactic, ripened or cultured butter. This process is very common in continental European countries. Although the product is claimed to have a superior flavor, the storage life is limited. Butter made without the addition of a culture is called sweet cream butter. Most butter made in the English-speaking world is of this nature.

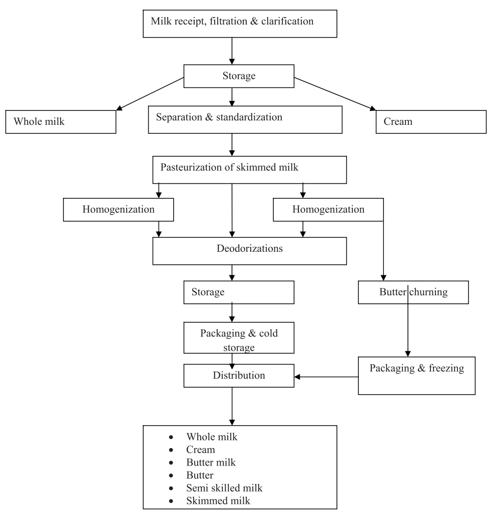


Figure 1 Flow diagram for processes occurring at a typical milk plant

Both cultured and sweet cream butter can be produced with or without the addition of salt. The presence of salt affects both the flavour and the keeping quality.

Butter is usually packaged in bulk quantities (25 kg) for long-term storage and then re-packed into marketable portions (usually 250 g or 500 g, and single-serve packs of 10–15 g). Butter may also be packed in internally lacquered cans, for regional and international markets

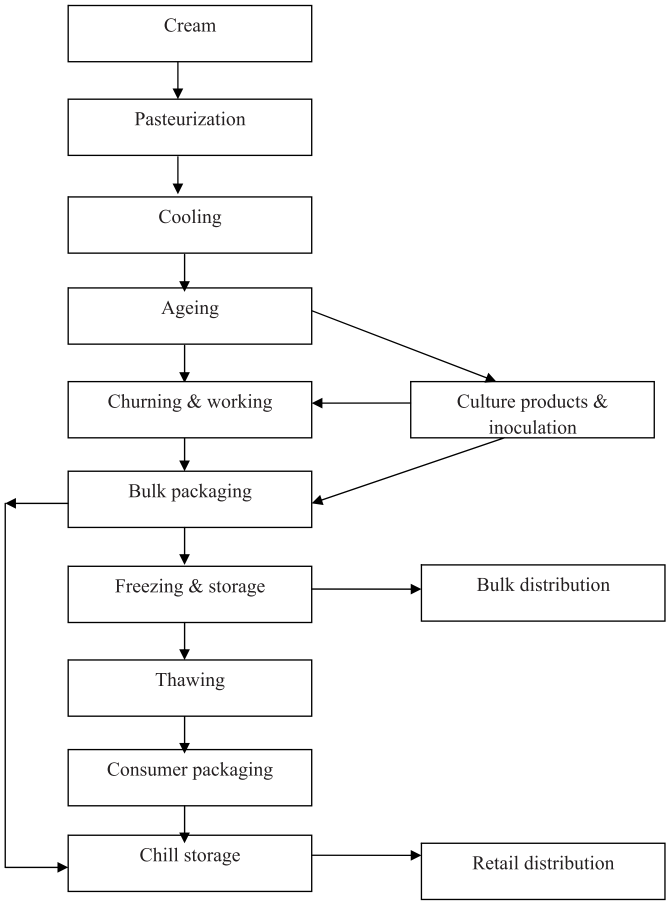


Figure 2 Flow diagram for a typical butter-making plant

3.1.3 Cheese production

Virtually all cheese is made by coagulating milk protein (casein) in a manner that traps milk solids and milk fat into a curd matrix. This curd matrix is then consolidated to express the liquid fraction, cheese whey. Cheese whey contains those milk solids which are not held in the curd mass, in particular most of the milk sugar (lactose) and a number of soluble proteins.
Figure 3 outlines the basic processes in a cheese-making plant. All cheese-making processes involve some or all of these steps.

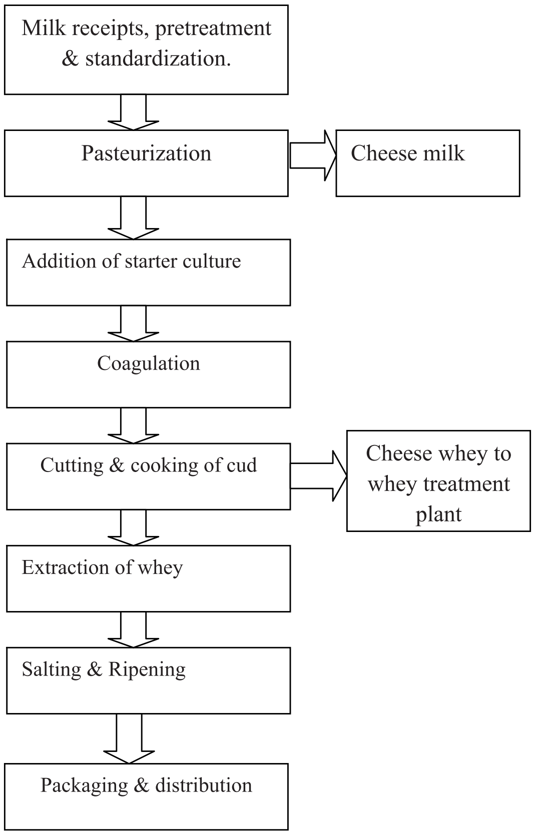


Figure 3   Flow diagrams for a typical cheese plant

3.1.4 Milk powder production

Milk used for making milk powder, whether it is whole or skim milk, is not pasteurized before use. The milk is preheated in tubular heat exchangers before being dried. The preheating temperature depends on the season (which affects the stability of the protein in the milk) and on the characteristics desired for the final powder product.

The preheated milk is fed to an evaporator to increase the concentration of total solids. The solids concentration that can be reached depends on the efficiency of the equipment and the amount of heat that can be applied without unduly degrading the milk protein.
The milk concentrate is then pumped to the atomizer of a drying chamber. In the drying chamber the milk is dispersed as a fine fog-like mist into a rapidly moving hot air stream, which causes the individual mist droplets to instantly evaporate. Milk powder falls to the bottom of the chamber, from where it is removed. Finer milk powder particles are carried out of the chamber along with the hot air stream and collected in cyclone separators.

Milk powders are normally packed and distributed in bulk containers or in 25 kg paper packaging systems. Products sold to the consumer market are normally packaged in cans under nitrogen. This packaging system improves the keeping quality, especially for products with high fat content. Figure 4 outlines the basic processes for the production of milk powder

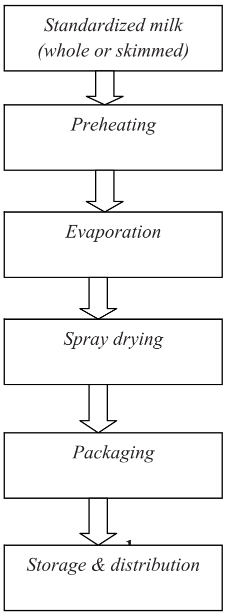


Figure 4 Flow diagrams for a typical milk drying plant3.2

Environmental impacts

This section briefly describes some of the environmental impacts associated with the processing of dairy products. While it is recognized that the primary production of milk has some significant environmental impacts, this document is predominantly concerned with the processing of dairy products.

3.2.1 Impacts of dairy processing

As for many other food processing operations, the main environmental impacts associated with all dairy processing activities are the high consumption of water, the discharge of effluent with high organic loads and the consumption of energy. Noise, odour and solid wastes may also be concerns for some plants

Water Consumption

Dairy processing characteristically requires very large quantities of fresh water. Water is used primarily for cleaning process equipment and work areas to maintain hygiene standards

Effluet Discharge

Environmental problem caused by dairy processing is the discharge of large quantities of effluent. Dairy processing effluents generally exhibit the following properties:-

- High organic load due to the presence of milk components;
- Fluctuations in ph due to the presence of caustic and acidic cleaning agents and other chemicals;
- High levels of nitrogen and phosphorus;
- Fluctuations in temperature

If whey from the cheese-making process is not used as a by-product and discharged along with other wastewaters, the organic load of the resulting effluent is further increased, exacerbating the environmental problems that can result.

In order to understand the environmental impact of dairy processing effluent, it is useful to briefly consider the nature of milk. Milk is a complex biological fluid that consists of water, milk fat, a number of proteins (both in suspension and in solution), milk sugar (lactose) and mineral salts.

Dairy products contain all or some of the milk constituents and, depending on the nature and type of product and the method of manufacturing, may also contain sugar, salts (e.g. sodium chloride), flavours, emulsifiers and stabilizers.

For plants located near urban areas, effluent is often discharged to municipal sewage treatment systems. For some municipalities, the effluent from local dairy processing plants can represent a significant load on sewage treatment plants. In extreme cases, the organic load of waste milk solids entering a sewage system may well exceed that of the township's domestic waste, overloading the system.

In rural areas, dairy processing effluent may also be irrigated to land. If not managed correctly, dissolved salts contained in the effluent can adversely affect soil structure and cause salinity. Contaminants in the effluent can also leach into underlying groundwater and affect its quality.
In some locations, effluent may be discharged directly into water bodies. However this is generally discouraged as it can have a very negative impact on water quality due to the high levels of organic matter and resultant depletion of oxygen levels.

Energy Consumption

Electricity is used for the operation of machinery, refrigeration, ventilation, lighting and the production of compressed air. Like water consumption, the use of energy for cooling and refrigeration is important for ensuring the quality of dairy products and storage temperatures are often specified by regulation. Thermal energy, in the form of steam, is used for heating and cleaning.

Fossil fuel resources are also used in transportation of dairy products while in other instances fossil fuel may be used in generating thermal energy. The use of fossil fuel resources leads to the generation of emissions including greenhouse gas, which have been linked to global warming.

Solid Waste

Dairy products such as milk, cream and yogurt are typically packed in plastic-lined paperboard cartons, plastic bottles and cups, plastic bags or reusable glass bottles. Other products, such as butter and cheese, are wrapped in foil, plastic film or small plastic containers. Milk powders are commonly packaged in multi-layer Kraft paper sacs or tinned steel cans, and some other products, such as condensed milks, are commonly packed in cans.

Breakages and packaging mistakes cannot be totally avoided. Improperly packaged dairy product can often be returned for reprocessing; however the packaging material is generally discarded, hence leading to generation of solid waste.

Emissions to Air

Emissions to air from dairy processing plants are caused by the high levels of energy consumption necessary for production. Steam, which is used for heat treatment processes (pasteurization, sterilization, drying etc.), is generally produced in on-site boilers, and electricity used for cooling and equipment operation is purchased from the grid. Air pollutants, including oxides of nitrogen and sulphur and suspended particulate matter, are formed from the combustion of fossil fuels. In addition, discharges of milk powder from the exhausts of spray drying equipment can be deposited on surrounding surfaces. When wet these deposits become acidic and can, in extreme cases, cause corrosion.

Refrigerants

For operations that use refrigeration systems based on chlorofluorocarbons (CFCs), the fugitive loss of these gases to the atmosphere is of environmental concern, since CFCs are recognized to cause ozone depletion in the atmosphere. For such operations, the replacement of CFC-based systems with non- or reduced-CFC systems is thus an important issue.

Noise

Some processes, such as the production of dried casein, require the use of hammer mills to grind the product. The constant noise generated by this equipment has been known to be a nuisance in surrounding residential areas. The use of steam injection for heat treatment of milk and for the creation of reduced pressure in evaporation processes also causes high noise levels.

A substantial traffic load in the immediate vicinity of a dairy plant is generally unavoidable due to the regular delivery of milk (which may be on a 24-hour basis), deliveries of packaging and the regular shipment of products. Noise problems, therefore, should be taken into consideration when determining plant location.

Hazardous Wastes

Hazardous wastes consist of oily sludge from gearboxes of moving machines, laboratory waste, cooling agents, oily paper filters, batteries, paint cans, etc. These need to be addressed using Best Available Cleaner Production Practices.

3.3 Environmental indicators

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

3.3.1 Water consumption

As with most food processing operations, water is used extensively for cleaning and sanitizing plant and equipment to maintain food hygiene standards. Table 1 shows the areas of water consumption within a dairy processing plant, and gives an indication of the extent to which each area contributes to overall water use.

At modern dairy processing plants, a water consumption rate of 1.3–2.5 litres water/kg of milk intake is typical; however 0.8–1.0 litres water/kg of milk intake is possible (Bylund, 1995). To achieve such low consumption requires not only advanced equipment, but also very good housekeeping and awareness among both employees and management.

Table 1 Areas of water consumption at dairy processing plants [1]

Area of use	Consumption (L/kg product)	Percentage of total
Locker room	0.01–1.45	2%
Staff use	0.02–0.44	2%
Boiler	0.03–0.78	2%
Cold storage	0.03–0.78	2%
Receipt area	0.11–0.92	3%
Filling room	0.11–0.41	3%
Crate washer	0.18–0.75	4%
Cooling tower	0.20–1.8	5%
Cleaning	0.32–1.76	8%
Cheese room	0.06–20.89	13%
Utilities	0.56–4.39	16%
Incorporated into Products	1.52–9.44	40%

TOTAL	**2.21–9.44**	**100%**

Danish EPA, 1991

3.3.2 Effluent discharge

Dairy processing effluent contains predominantly milk and milk products which have been lost from the process, as well as detergents and acidic and caustic cleaning agents. The constituents present in dairy effluent are milk fat, protein, lactose and lactic acid, as well as sodium, potassium, calcium and chloride. Milk loss to the effluent stream can amount to 0.5–2.5% of the incoming milk, but can be as high as 3–4%.

A major contributing factor to a dairy plant's effluent load is the cumulative effect of minor and, on occasions, major losses of milk. These losses can occur, for example, when pipe work is uncoupled during tank transfers or equipment is being rinsed. Table 2 provides a list of the sources of milk losses to the effluent stream.

The organic pollutant content of dairy effluent is commonly expressed as the 5-day biochemical oxygen demand (BOD_5) or as chemical oxygen demand (COD). One litre of whole milk is equivalent to approximately 110,000 mg BOD5 or 210,000 mg COD.
Concentrations of COD in dairy processing effluents vary widely, from 180 to 23,000 mg/L. Low values are associated with milk receipt operations and high values reflect the presence of whey from the production of cheese. A typical COD concentration for effluent from a dairy plant is about 4000 mg/L. This implies that 4% of the milk solids received into the plant is lost to the effluent stream, given that the COD of whole milk is 210,000 mg/L and that effluent COD loads have been estimated to be approximately 8.4 kg/m^3 milk intake (*Marshall and Harper, 1984).*

Table 2 Sources of milk losses to the effluent stream[1]

Process area	Source of milk loss
Milk receipt and storage	• Poor drainage of tankers • Spills and leaks from hoses and pipes • Spills from storage tanks • Foaming • Cleaning operations
Pasteurisation and ultra	• Leaks

heat treatment	• Recovery of downgraded product • Cleaning operations • Foaming • Deposits on surfaces of equipment
Homogenisation	• Leaks • Cleaning operations
Separation and clarification	• Foaming • Cleaning operations • Pipe leaks
Market milk production	• Leaks and foaming • Product washing • Cleaning operations • Overfilling • Poor drainage • Sludge removal from separators/clarifiers • Damaged milk packages • Cleaning of filling machinery
Cheese making	• Overfilling vats • Incomplete separation of whey from • Curds • Use of salt in cheese making • Spills and leaks • Cleaning operations
Butter making	• Vacreation and use of salt • Cleaning operations
Milk powder production	• Spills during powder handling • Start-up and shut-down processes • Plant malfunction • Stack losses • Cleaning of evaporators and driers • Bagging losses

[1] EPA Victoria 1997.

Due to the traditional payment system for raw milk (which is based on the mass or volume delivered (plus a separate price or premium for the weight of milk fat in some countries), the dairy processing industry has always tried to minimize loss of milk fat. In many countries the payment system now recognizes the value of the non-fat milk components. Systems that control the loss of both fat and protein are now common in the industrialized world, but less so in the developing world. The disposal of whey produced during cheese production has always been a major problem in the dairy industry. Whey is the liquid remaining after the recovery of the curds formed by the action of enzymes on milk. It comprises 80–90% of the total volume of milk used in the cheese making process and contains more than half the solids from the original whole milk, including 20% of the protein and most of the lactose. It has a very high organic content, with a COD of approximately 60,000 mg/L (Morr, 1992). Only in the past two decades have technological advances made it economically possible to recover soluble proteins from cheese whey and, to some extent, to recover value from the lactose.

Most dairies are aware that fat and protein losses increase the organic load of the effluent stream and, even in the developing world, the use of grease traps has been common for some decades. Many companies, however, do not take any action to reduce the organic pollution from other milk components. It is becoming more common for dairy companies to be forced by legal or economic pressures to reduce the amount and concentration of pollutants in their effluent streams.

Therefore, at most sites, wastewater treatment or at least pretreatment is necessary to reduce the organic loading to a level that causes minimal environmental damage and does not constitute a health risk. The minimum pretreatment is usually neutralization of pH, solids sedimentation and fat removal.

3.3.3 Energy consumption

Energy is used at dairy processing plants for running electric motors on process equipment, for heating, evaporating and drying, for cooling and refrigeration, and for the generation of compressed air.

Approximately 80% of a plant's energy needs is met by the combustion of fossil fuel to generate steam and hot water for evaporative and heating processes. The remaining 20% or so is met by electricity for running electric motors, refrigeration and lighting.

The energy consumed depends on the range of products being produced. Processes which involve the concentration and drying of milk, whey or buttermilk for example, are very energy intensive. The production of market milk at the other extreme involves only some heat treatment and packaging, and therefore requires considerably less energy. Table 10 provides some indicative figures of specific energy consumption of different dairy products

Table 10 Specific energy consumption for various dairy products [1]

Product	Electricity consumption	Fuel consumption
	(GJ/tonne product)	(GJ/tonne product)
Market milk	0.20	0.46
Cheese	0.76	4.34
Milk powder	1.43	20.60
Butter	0.71	3.53

1 *Joyce and Burgi, 1993. (based on a survey of Australian dairy processors in 1981–82)*

Energy consumption will also depend on the age and scale of a plant as well as the level of automation. Plants producing powdered milk exhibit a wide range of energy efficiencies, depending on the type of evaporation and drying processes that are used. Energy consumption depends on the number of evaporation effects (the number of evaporation units that are used in series) and the efficiency of the powder dryer.

Substantial increases in electricity use have resulted from the trend towards automated plant with associated pumping costs and larger evaporators as well as an increase in refrigeration requirements. High consumption of electricity can also be due to the use of old motors, excessive lighting or possibly a lack of power factor correction.

4.0 RESOURCE EFFICIENT AND CLEANER PRODUCTION OPPORTUNITIES

Dairy processing typically consumes large quantities of water and energy and discharges significant loads of organic matter in the effluent stream. For this reason, Resource efficient and Cleaner Production opportunities described in this guide focus on reducing the consumption of resources (water and energy), increasing production yields and reducing the volume and organic load of effluent discharges.

At the larger production scales, dairy processing has become an extremely automated process and resource efficient relies, to a large extent, on the efficiency of plant and equipment, the control systems that are used to operate them and the technologies used to recover resources. As a result many Resource efficient and Cleaner Production opportunities lie in the selection, design and efficient operation of process equipment. Operator practices also have an impact on plant performance, for example in the areas of milk delivery, plant maintenance and cleaning operations. Therefore there are also opportunities in the areas of housekeeping, work procedures, maintenance regimes and resource handling.

Section 4.1 provides examples of general Resource efficient and Cleaner Production opportunities that apply across the entire process, whereas Sections 4.2 to 4.7 present opportunities that relate specifically to individual unit operations within the process. For each unit operation, a detailed process description is provided along with Cleaner Production opportunities specific to that activity. Where available, quantitative data applicable to each unit operation is also provided.

4.1 General Information

Many food processors that undertake Cleaner Production projects find that significant environmental improvement and cost savings can be derived from simple modification to housekeeping procedures and maintenance programs. Table 6 is a checklist of some of these ways. They are generic ideas that apply to the dairy manufacturing process as a whole.

Table 6 Checklist of general housekeeping idea

- Keep work areas tidy and uncluttered to avoid accidents.
- Maintain good inventory control to avoid waste of raw ingredients.
- 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 breakdowns.
- Optimize 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.
- Improve start-up and shut-down procedures.
- Segregate waste for reuse and recycling.
- Install drip pans or trays to collect drips and spills.

UNEP Cleaner Production Working Group for the Food Industry, 1999

4.1.1 Water

Water is used extensively in dairy processing, so water saving measures is very common resource efficiency opportunities in this industry. The first step is to analyze water use patterns carefully, by installing water meters and regularly recording water consumption. Water consumption data should be collected during production hours, especially during periods of cleaning. Some data should also be collected outside normal working hours to identify leaks and other areas of unnecessary wastage.

The next step is to undertake a survey of all process area and ancillary operations to identify wasteful practices. Examples might be hoses left running when not in use, CIP cleaning processes using more water than necessary, etc. Installing automatic shut-off equipment and restrictors could prevent such wasteful practices. Automatic control of water use is preferable to relying on operators to manually turn water off.

Once wasteful practices have been addressed, water use for essential process functions can be investigated. It can be difficult to establish the minimum consumption rate necessary to maintain process operations and food hygiene standards. The optimum rate can be determined only by investigating each process in detail and undertaking trials. Such investigations should be carried out collaboratively by production managers, food quality and safety representatives and operations staff. When an optimum usage rate has been agreed upon, measures should be taken to set the supply at the specified rate and remove manual control.

Once water use for essential operations has been optimized, water reuse can be considered. Wastewaters that are only slightly contaminated could be used in other areas. For example, final rinse waters could be used as the initial rinses for subsequent cleaning activities, or evaporator condensate could be reused as cooling water or as boiler feed water. Wastewater reuse should not compromise product quality and hygiene, and reuse systems should be carefully installed so that reused wastewater lines cannot be mistaken for fresh water lines, and each case should be approved by the food safety officer.

Table 7 Checklist of water saving ideas [1]

Use continuous rather than batch processes to reduce the frequency of cleaning;

- o Use automated cleaning-in-place (CIP) systems for cleaning to control and optimize water use;
- o Install fixtures that restrict or control the flow of water for manual cleaning processes;
- o Use high pressure rather than high volume for cleaning surfaces;
- o Reuse relatively clean wastewaters (such as those from final rinses) for other cleaning steps or in non-critical applications;
- o Recalculate water used in non-critical applications;
- o Install meters on high-use equipment to monitor consumption;
- o Pre-soak floors and equipment to loosen dirt before the final clean;
- o Use compressed air instead of water where appropriate;
- o Report and fix leaks promptly.

[1] *UNEP Cleaner Production Working Group for the Food Industry, 1999*

4.1.2 Effluent

Resource Efficient and Cleaner Production efforts in relation to effluent generation should focus on reducing the pollutant load of the effluent. The volume of effluent generated is also an important issue. However this aspect is linked closely to water consumption, therefore efforts to reduce water consumption will also result in reduced effluent generation. Opportunities for reducing water consumption are discussed in Section 4.1.1 Table 7 contains a checklist of common water saving ideas.

Opportunities for reducing the pollutant load of dairy plant effluent focus on avoiding the loss of raw materials and products to the effluent stream. This means avoiding spills, capturing materials before they enter drains and limiting the extent to which water comes into contact with product residues. Improvements to cleaning practices are therefore an area where the most gains can be made. Table 8 contains a checklist of common ideas for reducing effluent loads.

Table 8 Checklist of ideas for reducing pollutant loads in effluent [1]

- Ensure that vessels and pipes are drained completely and using pigs and plugs to remove product residues before cleaning;
- Use level controls and automatic shut-off systems to avoid spills from vessels and tanker emptying;
- Collect spills of solid materials (cheese curd and powders) for reprocessing or use as stock feed;
- Fit drains with screens and/or traps to prevent solid materials entering the effluent system;
- Install in-line optical sensors and diverters to distinguish between product and water and minimize losses of both;
- Install and maintain level controls and automatic shut-off systems on tanks to avoid overfilling;
- Use dry cleaning techniques where possible, by scraping vessels before cleaning or pre-cleaning with air guns;
- Use starch plugs or pigs to recover product from pipes before internally cleaning tanks.

UNEP Cleaner Production Working Group for the Food Industry, 1999

4.1.3 Energy

Energy is an area where substantial savings can be made almost immediately with no capital investment, through simple housekeeping and plant optimization efforts.

Substantial saving are possible through improved housekeeping and the fine tuning of existing processes and additional savings are possible through the use of more energy-efficient equipment and heat recovery systems.

In addition to reducing a plant's demand for energy, there are opportunities for using more environmentally benign sources of energy. Opportunities include replacing fuel oil or coal with cleaner fuels, such as natural gas, purchasing electricity produced from renewable sources, or co-generation of electricity and heat on site. For some plants it may also be feasible to recover methane from the anaerobic digestion of high-strength effluent streams to supplement fuel supplies

Table 9 Checklist of energy saving ideas [1]

- Implement switch-off programs and installing sensors to turn off or power down lights and equipment when not in use;
- Improve insulation on heating or cooling systems and pipe work;
- Favour more energy-efficient equipment;
- Improve maintenance to optimize energy efficiency of equipment;
- Maintain optimal combustion efficiencies on steam and hot water boilers;
- Eliminate steam leaks;
- Capture low-grade energy for use elsewhere in the operation.

[1] *UNEP Cleaner Production Working Group for the Food Industry, 1999*

4.2. Milk production

4.2.1 Receipt and storage of milk

Process description

Raw milk is generally received at the processing plants in milk tankers some smaller plants may also receive milk in 25–50 L aluminium or steel on the structure and traditions of the primary production sector, milk may be collected directly from the farms or from central collection facilities.

Farmers producing only small amounts of milk normally deliver the milk to central collection facilities. At the central collection facilities, operators measure the quantity of milk and the water content. Milk is the filtered and/or clarified using centrifuges to remove dirt particles as well as udder and blood cells. The milk is then cooled using a plate cooler and pumped to insulated or chilled storage vessels, where it is stored until required for production. Figure 5 is a flow diagram showing the inputs and outputs for this process

Inputs and outputs

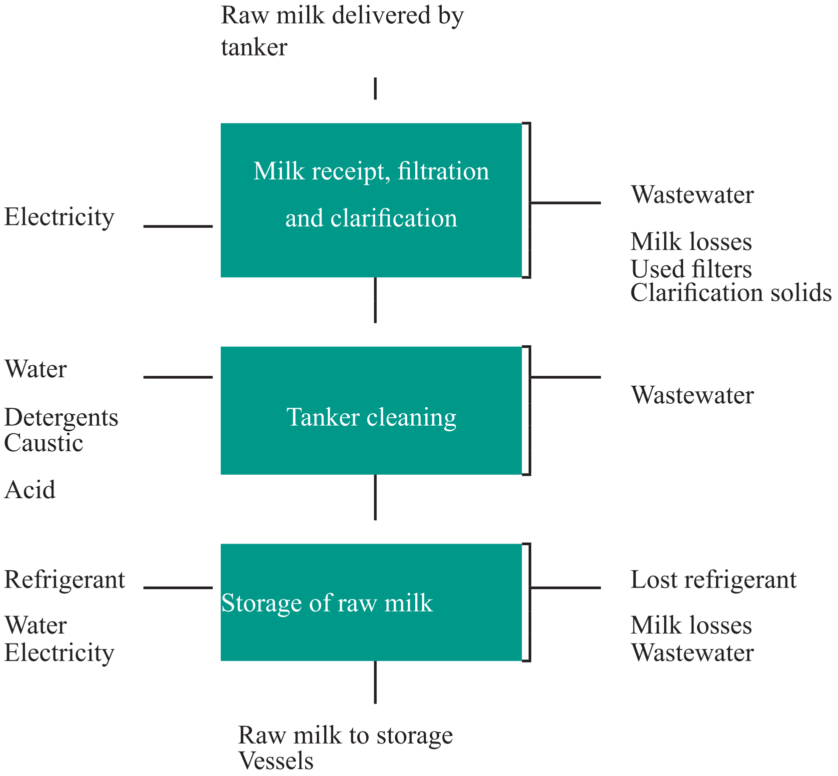


Figure 5 Inputs and outputs from milk receipt and storage

Environmental issues

Water is consumed for rinsing the tanker, cleaning and sanitizing the transfer lines and storage vessels. The resulting effluent from rinsing and cleaning can contain milk split when tanker hoses are disconnected. This would contribute to the organic load of the effluent stream Solid waste is generated from milk clarification and consists mostly of dirt, cells from the cows' udders, blood corpuscles and bacteria. If this is discharged into the effluent stream, high organic loads and associated downstream problems can result.

Resource Efficient and Cleaner Production opportunities

Cleaner Production opportunities in this area focus on reducing the amount of milk that is lost to the effluent stream and reducing the amount of water used for cleaning. Ways of achieving this include:

- Avoiding milk spillage when disconnecting pipes and hoses; Ensuring that vessels and hoses are drained before disconnection;

- Providing appropriate facilities to collect spills;
- Identifying and marking all pipeline to avoid wrong connections that would result in unwanted mixing of products;
- Installing pipes with a slight gradient to make them self-draining;
- Equipping tanks with level controls to prevent overflow;
- Making certain that solid discharges from the centrifugal separator are collected for proper disposal and not discharged to the sewer;
- Using 'clean-in-place' (CIP) systems for internal cleaning of tankers and milk storage vessels, thus improving the effectiveness of cleaning and sterilization and reducing detergent consumption; Improving cleaning regimes and training staff;
- Installing trigger nozzles on hoses for cleaning;
- Reusing final rinse waters for the initial rinses in CIP operations;
- Collecting wastewaters from initial rinses and returning them to the dairy farm for watering cattle.

4.2.2 Separation and standardization

Process description

Dairies that produce cream and/or butter separate fat from the raw milk. Separation takes place in a centrifuge which divides the milk into cream with about 40% fat and skimmed milk with only about 0.5% fat.

The skimmed milk and cream are stored and pasteurized separately. Most dairies standardize all milk, to ensure that their products have a consistent composition. In some cases, products may need to meet certain product specifications in relation to fat content.

These specifications vary from one country to the next. However in general, whole milk must contain around 3.5–4.2% fat, semi-skimmed milk around 1.3–1.5% and skimmed milk around 0.5% (*Varnam and Sutherland, 1994*). Standardization is achieved by the controlled remixing of cream with skimmed milk, and is common both in cheese plants and in the production of milk powders.

Environmental issues

As in other aspects of dairy processing, water is consumed for rinsing and cleaning of process equipment, resulting in the generation of wastewaters containing milk solids and cleaning agents.

The centrifugal separators generate a sludge material, which consists of udder and blood cells and bacteria contained in the raw milk. For standard separators the sludge is removed manually during the cleaning phase, while in the case of self-cleaning centrifuges it is discharged automatically. If the sludge is discharged to the sewer along with the effluent stream, it greatly increases the organic load of the effluent.

Resource Efficient and Cleaner Production opportunities

Cleaner Production opportunities specific to this area are related to reducing the generation of separator sludge and optimizing its collection and disposal. Ways of achieving this include:

- Reducing the frequency with which centrifugal separators are cleaned, by improving milk filtration at the receiving stage or by clarification of the raw milk;
- Collecting the sludge and disposing of it along with other waste solids.

Also of importance is the optimization of cleaning processes, to make them water and energy efficient.

4.2.3 Pasteurization and homogenization

Process description

In large plants, milk is pasteurized in continuous flow pasteurizers, whereas some smaller dairies may use batch-type pasteurizers. In batch pasteurization processes, milk is typically heated to 62.8–65.6°C for 30 minutes, whereas in continuous pasteurization processes it is heated to 71.7–78.1°C for at least 15 seconds. The time–temperature relationship is usually prescribed by law, as are certain safeguards to ensure that all milk attains the minimum treatment. For both batch and continuous processes, the milk is cooled to below 10°C immediately after heating.

For some products milk is homogenized using a pressure pump, which breaks up the butterfat globules to a size that keeps them in suspension. In continuous pasteurization processes homogenization is usually undertaken in conjunction with pasteurization, since its efficiency is improved if the milk is warm.

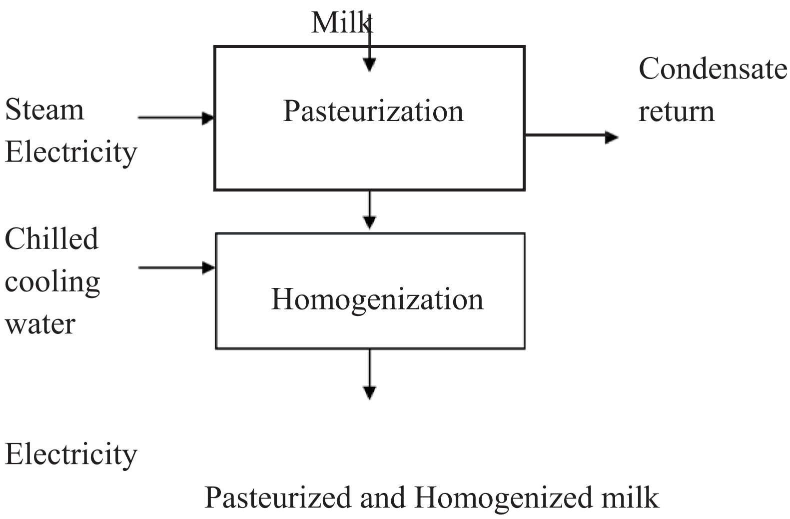


Figure 6   Inputs and outputs for the pasteurization and homogenization of whole milk

Environmental issues

The main environmental issue associated with pasteurization and homogenization is the high levels of energy consumed for the heating and cooling of milk. In addition, water is consumed for rinsing and cleaning of process equipment, resulting in the generation of wastewaters containing milk solids and cleaning agents. In batch pasteurization, small batches necessitate frequent cleaning; therefore losses of milk and the organic loads in wastewater streams are increased.

Resource Efficient and Cleaner Production opportunities

Resource Efficient and Cleaner Production opportunities in this area focus on improving energy efficiency. Ways of achieving this include:

- Replacing batch pasteurizers with continuous process incorporating plate heat exchanger (PHE) pasteurizers, where feasible. PHE pasteurizers are more energy efficient than batch pasteurizers because the heat from the pasteurized milk can be used to preheat the incoming cold milk (regenerative counter-current flow);
- installing new manufacturing equipment, which will result in less waste of milk products than the equipment currently used in many dairies;
- Avoiding stops in continuous processes. The more constant the production, the less milk will be lost, since most waste comes from cleaning of batch process equipment. In the event of upgrades to process equipment, high-volume pasteurizing units should be considered;
- Reducing the frequency of cleaning of the pasteurizer. Particularly for small dairies, optimizing the size of balance tanks before and after the pasteurizer will allow continuous operation of the pasteurizer and reduce cleaning frequency;
- planning production schedules so that product change-over's coincide with cleaning regimes;
- Collecting and recovering the milky wastewater generated at start-up of pasteurization and supplying it to farmers as animal feed.

Also of importance is optimization of cleaning processes, to make them water and energy efficient. To make possible the reprocessing of excess milk returned from the market, dairy plants may wish to consider developing policies which allow for the reprocessing of milk without affecting the quality of the freshly pasteurized product.

The introduction of poorer quality milk into the pasteurization process can result in milk scale and coagulation problems due to higher acidity. This may cause higher milk losses in the pasteurizer due to the need for more frequent cleaning in order to remove milk scale. These issues should be weighed against the benefits of reprocessing returned milk.

The controlled return and reprocessing of milk from the market may require training of sales representatives. Alternatively, penalties could be applied for inappropriate ordering, or bonuses paid for extended periods of no market returns.

4.2.4 Deodorization

Process description

Many dairies remove unwanted taints and odors from milk in deodorization units. In these systems, the odorous substances are drawn-off by injecting steam into the system under vacuum. In situations where the taints and odors are only mild, a vacuum alone may be used. Figure 7 is a flow diagram showing the inputs and outputs for this process

Inputs and outputs

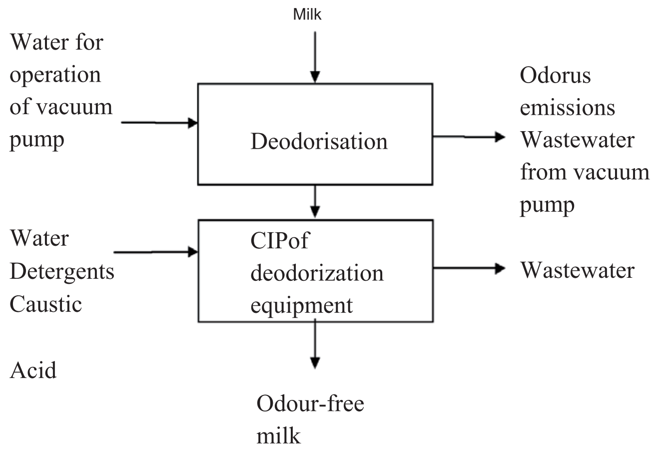


Figure 7 Inputs and outputs for the deodorization of milk

Environmental issues

An environmental issue specific to the deodorization process is the large volume of water used to operate water seals on the vacuum pump.

Resource Efficient and Cleaner Production opportunities

Water used for the vacuum pump can be recalculated to reduce or eliminate the necessity to discharge it

4.2.5 Storage and packaging

Process description

Due to the large range of products produced at many dairies (e.g. different fat contents or heat treatment regimes), the bulk storage of these products can involve very extensive storage systems, with associated vessels, piping and valves.

Milk is packaged or bottled in a number of types of containers, including glass bottles, paper cartons, plastic bottles and plastic pouches. In most cases, filling of containers is highly automated. After filling, the packaged milk products are usually stored and transported in wire or plastic crates.

Finished products are held in refrigerated storage until dispatched to retail outlets. The storage temperature depends on the product, but for milk and fresh dairy products, the optimum temperature is usually $<4^0$C. Refrigerated storage chambers are usually cooled using forced draft evaporators chilled by a primary refrigerant. A secondary refrigerant such as ice water, brine or glycol recirculated in a closed circuit cooling system is also sometimes used. Door openings are usually sealed with rubber swing doors and/or air curtains when open.

Environmental Issues

The main environmental issues associated with the storage and packaging operations are the loss of milk products from spills and packaging mistakes, generation of wastewater from cleaning processes and energy consumed for refrigerated storage. However the choice of packaging materials is becoming an increasingly important issue.

Milk products can be lost to the wastewater stream during start-up and shut-down, from residues remaining in storage vessels and from the initial cold water rinses of packaging and storage equipment. Milk products may also be lost due to breakage of packaging material. Generally, incorrectly filled packages are emptied and the milk is returned to the milk receival area.

Considerable work has been undertaken to determine the most suitable form of packaging in terms of overall environmental impacts. Although glass bottles can be cleaned and recycled (thereby creating minimal solid waste), cleaning them consumes water and energy. Glass recycling systems require large capital investments and involve high running costs since the bottles must be collected, then transported and cleaned. Glass bottles can also be inconvenient for consumers because they are heavier and more fragile than cartons.

Cartons, on the other hand, create solid waste that must be transported and disposed of. Solid waste can be disposed of in a landfill, incinerated, or composted. All of these disposal alternatives have environmental impacts, including the generation of leachate from landfills and air pollution from incineration.

Resource Efficient and Cleaner Production opportunities

Resource Efficient and Cleaner Production opportunities in this area focus on improving the energy efficiency of refrigeration systems and optimizing CIP processes to reduce both water use and the organic load discharged into the effluent stream. Ways of achieving this include:

- clearing milk residues from the pipes using compressed air before the first rinse;
- collecting the more highly concentrated milk wastewater at start-up and shut-down for use as animal feed;
- Optimizing the accuracy of filling operations. This will not only result in improved efficiency, but will also reduced potential for waste and spillage. Minor variations in filling performance can have significant cumulative effects particularly for small unit fill quantities;
- improving procedures for recovering milk from wrongly filled containers;
- emptying and collecting product from wrongly filled containers for use as animal feed;
- reducing energy consumption through improved insulation, closing of doors to cold areas, goodmaintenance of room coolers and regular defrosting;
- using direct ammonia-based cooling systems instead of CFC-based systems

4.3 Butter production

The primary objective of butter making is to conserve the fatty portion of the milk in a form that can be used at a later date. It is essentially a dehydration process, in which the majority of the aqueous phase is removed and the remainder is emulsified into the fat. Milk is an emulsion of milk fat in water, whereas butter is an emulsion of water in milk fat. Butter production involves the conversion from one state to the other.
The evolution of the butter-making process has progressed from the use of skins and gourds for churning, through to the use of wooden-barreled butter churns, which have since been exchanged for stainless steel churns. Although the development of the continuous process in the 1950s led to the replacement of the batch process in most industrial plants, the batch or churn process may still be used in smaller dairies.

In batch processes, prepared cream is agitated in a specially designed vessel (butter churn) until phase inversion occurs and the fat ‘breaks’ from the cream in the form of butter grains. The surrounding liquid—the buttermilk—is then decanted off. The butter grains are washed in fresh chilled water, salted (if required) and worked by a shearing process to produce a homogeneous mass with a controlled moisture content.

In the more common continuous process, phase inversion of the cream, working of the butter, the addition of salt and moisture control take place in cylindrical, rotating chambers which progressively lead the butter mass to blending augers and final extrusion. The continuous process reduces the amount of waste generated by the process by eliminating the butter grain washing step and also by making use of an internal mechanical system for continuous recovery of butter 'fines'.

4.3.1 Cream treatment: ripened cream process

Process description

Pasteurization of the cream for making cultured butter is normally carried out at temperatures of up to 110°C. The cream may be subjected to vacuum treatment during cooling in order to improve its spread ability.

In the production of ripened butter, the cream is cooled, inoculated with a culture and ripened. After a ripening period of 12–18 hours at 20°C, the cream is cooled to below 10°C.

The cream treatment process has received considerable attention over many years because it affects the quality of the final product. The quality of the fat before it is churned affects product losses from the process.

The optimum temperature for ageing the cream (allowing all fat to become solid) is generally lower than the temperature required for efficient churning. Cream that is too cold is therefore susceptible to damage, and may result in blocked pipeline and excessive loss.

The most effective churning temperature for cream can be achieved by using heat exchangers with a low pressure drop and a minimum temperature differential between the cream and the water. This avoids localized overheating. Figure 8 is a flow diagram showing the inputs and outputs for this process.

Inputs and outputs

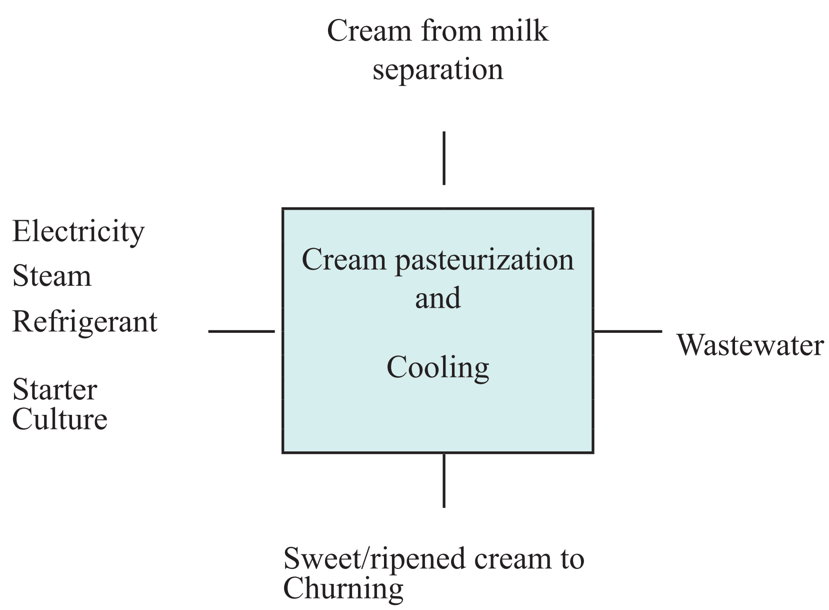


Fig 8 Inputs and Outputs for Cream Processes

Environmental issues

The main environmental issue associated with this process is the high organic load in wastewaters generated from rinsing and cleaning the pasteurizer. This can be further exacerbated by the requirement for frequent cleaning, which results in a greater loss of milk solids.

Resource Efficient and Cleaner Production opportunities

Cleaner Production opportunities in this area focus on reducing water use and loss of product. Ways of achieving this include:

- Minimizing the number of times the pasteurizer is cleaned. Particularly in small butter dairies, optimizing the size of balance tanks before and after the pasteurizer will allow it to operate continuously, resulting in less need for cleaning;
- Installing modern pasteurizing equipment. This will reduce waste of cream in many dairies, because improvements in plate design now give a more gentle and constant heat treatment. This decreases the build-up of overheated solids on heating surfaces. In the event of upgrades to process equipment, high-volume pasteurizing units should be considered;
- collecting the more highly concentrated milk wastewater generated when starting up the pasteurizer, for use as animal fee

4.3.2 Butter churning

Process description

The cream enters the butter maker and the fat globules are disrupted under controlled conditions to destabilize the emulsion and agglomerate the milk fat. This is achieved in the first churning cylinder, which is fitted with a beater driven by a variable-speed motor. The beater speed is adjusted to give the desired butter grain size with minimum fat loss in the buttermilk.

To maintain steady butter-making conditions, it is essential that the cream feed rate be constant. This can be achieved by using a balance tank between the ageing silo and the pump.

The mixture of butter grains and buttermilk falls from the first cylinder into the back section of a second cylinder, where the grains are consolidated. This second cylinder is a larger, perforated, slowly rotating drum which causes the grains to travel along an inclined rotating screen with a tumbling action, thus assisting their aggregation at the same time as they are drained of buttermilk. The buttermilk is pumped away from below the cylinder.

From the second cylinder, the moist grains of butter fall into the worker compartment which uses contra-rotating augers to compact the grains into a heterogeneous mass, expelling more buttermilk from the grains as they are squeezed together. Compacted butter grains are fed from the auger through a series of alternating perforated plates and impeller blades. These apply shear forces that further consolidate the butter grains and break up the droplets of buttermilk now remaining in the fat matrix. This forms a dispersed aqueous phase of what is now a water-in-oil emulsion. A second worker compartment, operating under vacuum, may be incorporated to obtain a denser, finer-textured product. A second set of augers removes the butter and forces it through a final set of orifice plates and blades which complete the emulsification before the product is discharged from the butter maker. Figure 9 is a flow diagram showing the inputs and outputs for this process

Inputs and output

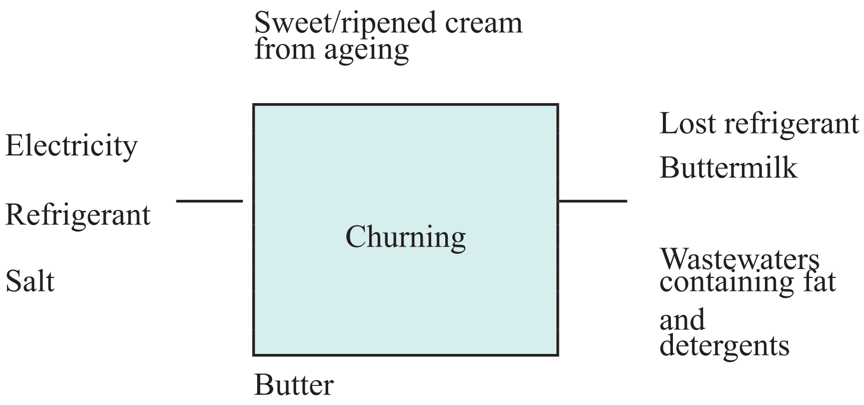


Figure 9 Inputs and outputs of the churning process

Environmental issue

Unless the buttermilk is used as a product or as an ingredient in other products, the quantities of buttermilk produced (about 50% of the original cream volume) represents a potential environmental loading. Pollutant discharge is greatest when a continuous butter maker is closed down, due to the loss of the fat remaining in the machine.

Resource Efficient and Cleaner Production Opportunities

Cleaner Production opportunities in this area focus on reducing loss of product. Ways of achieving this include:

- ensuring that the buttermilk is collected separately and hygienically so that it can be used in other processes, such as a base for low-fat spreads;
- collecting all first rinses, and separating the residual fat for use in other processes;
- preventing the build-up of milk scale deposits;
- maintaining butter makers on a regular basis;
- Avoiding spills by ensuring that the buttermilk collection facilities are large enough to hold all the liquid.

4.3.3 Butter packaging

Butter may be discharged from the butter maker directly into the feed hopper of a bulk butter packer. However, it is more commonly discharged to a butter silo fitted with a pump, thus avoiding any discontinuities in production. From the silo, butter is pumped to the packing machines through pressure compensators, which control the shear forces.

Butter can be packed initially into 25 kg cases, and subsequently repacked into consumer portions. Alternatively, consumer portions can be packed directly from the continuous butter maker. Most consumer portions are packed in a film wrap (either vegetable parchment or a parchment-lined aluminium foil) or in plastic tubs, which are becoming increasingly popular.

Repackaging of bulk butter into consumer portions requires that the frozen butter first be allowed to reach an optimum temperature of 6–8^{0}C, under controlled humidity conditions to avoid excessive condensation. Heat for this process can be provided by carrying out the first stage of thawing in a packed butter store, or low-grade heat from recovery processes.

After temperature adjustment and before repackaging, the butter is re-blended to break down the matrix of fat crystals and to re-introduce plasticity. At this stage, there is the opportunity to adjust salt and moisture content to the maximum permitted by local regulation. For repackaging in large quantities, continuous butter blenders are available which incorporate all functions of chopping and blending and prod for in-line addition of salt, water and culture. Their construction is similar to that of a continuous butter maker. Figure 10 is a flow diagram showing the inputs and outputs for this process.

Inputs and outputs

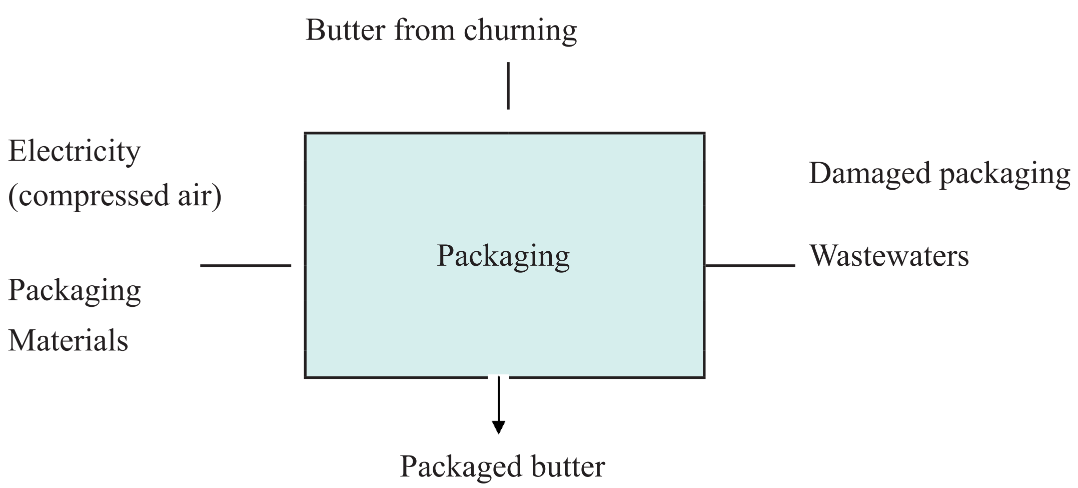


Figure 10 Inputs and outputs of the butter packaging process

Environmental issues

The main environmental issues associated with this process are the high organic loads in the wastewaters generated from rinsing and cleaning the equipment. The greatest potential for environmental loading occurs when machines, such as a continuous butter blender or packing machines, are closed down, because of the residual fat they contain. In addition, product loss may occur when packaged products containing product residues are discarded.

Resource Efficient and Cleaner Production opportunities

Resource Efficient and Cleaner Production opportunities in this area focus on reducing water use and loss of product. Ways of achieving this include:

- collecting first rinses while still warm and separating the milk fat residues for use in other processes;
- Reducing the disposal of packaging material by having personnel constantly optimizing operation of the packaging machines.

4.3.4 Butter storage

Bulk-packed butter is a relatively stable commodity at low temperatures. Commercial freezing stores operate at temperatures down to –30^{0}C, at which temperature the butter should remain in satisfactory condition for more than one year. If storage periods of more than one year are necessary, or if low-temperature refrigerated storage cannot be guaranteed throughout the entire storage life of the butter, the butter can dehydrate below the optimum moisture content.

Factors affecting the ability of butter to withstand long-term storage include:

- the cleanliness and hygiene of butter-making operations at all stages;
- the prevention of post-pasteurization contamination during the addition of salt, moisture etc., and in particular the absence of micro-organisms that grow at low temperatures in the water used for these purposes;
- the degree to which salt (if added) is dispersed to the aqueous phase;
- the overall quality of the butter in terms of its homogeneity, texture and moisture distribution;
- The type of butter.

Process description

In order to standardize its consistency and appearance, butter for immediate consumption is placed in cold storage at 5^{0}C for 24–48 hours. This ensures that fat crystallization is complete and individual packs are firm enough to withstand subsequent transportation to the market.

For long-term storage, butter freezing facilities must operate at below –15^0 C, and temperatures down to –30^{0}C are not uncommon. Sufficient space should be allowed between cases and pallets to allow air circulation, which encourages even chilling.

Refrigeration is usually, but not always, provided by direct expansion ammonia evaporators. Chambers are normally equipped with fork-lift truck access doors protected with automatic door or curtain openers. Figure 11 is a flow diagram showing the inputs and outputs for this process

Inputs and outputs

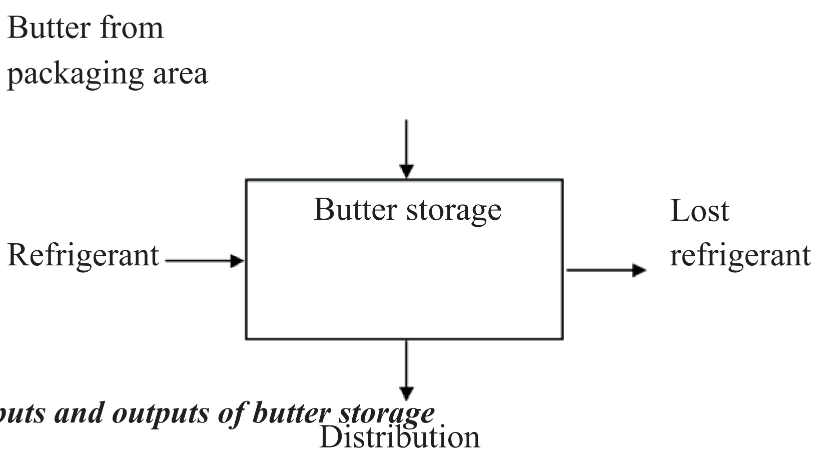


Figure 11 Inputs and outputs of butter storage

Environmental issues

The main environmental issue associated with the storage of butter is the energy consumed for refrigeration and the potential loss of refrigerant to the atmosphere.

Resource Efficient and Cleaner Production opportunities

Resource Efficient and Cleaner Production opportunities in this area focus on improving the energy efficiency of refrigerated storage. Ways of achieving this include:

- Installing the insulation;
- Keeping doors closed in cold areas;
- Undertaking regular defrosting of cold rooms and regular maintenance of refrigeration systems;
- Avoiding refrigerants that contain cfcs. Refrigeration systems based on ammonia cooling are preferred.

4. 4 Cheese production

Modern cheese technology was founded in the nineteenth century when Joseph Harding perceived a need to adopt strict hygiene and control over methods of making cheddar cheese. This represented a step forward in the scientific approach to cheese making.

Cheeses can be categorized according to the following attributes:

- Fat content (high-fat, semi-fat and low-fat cheeses);
- Consistency (soft cheeses have a moisture content of 45–50% and semi-hard cheese below 40%);
- Method of preparation and production (soft cheeses retain whey in the curd matrix and have coagulation temperatures of 20–400c; semi-hard cheeses receive more draining and the curd is heated to 42–480c; hard ‘cooked-curd’ cheeses are well drained and heated to 52–550c).

Some other types of cheese include:

- Fresh cheese that can be consumed just after manufacturing and salting (e.g. Quark);
- Acid-curd cheeses that are coagulated at a higher temperature (e.g. Ricotta);
- Lactic-curd cheeses which are kneaded or spun (e.g. Mozzarella);
- Soft cheeses that ripen for only a short time;
- Cheeses that develop different tastes due to enzyme action of surface bacteria;
- Blue cheeses of many flavours and types;
- Semi-hard, mild-tasting, pressed cheeses with holes (e.g. Gouda, havarti and titlist);
- Very hard, dry cheeses which are used for grating (e.g. Parmesan).

The process description that follows is for the production of cheddar cheese. Cheddar cheese has been used as an example because it is the most widely manufactured and consumed cheese in the world and its industrial manufacturing has been largely automated. The manufacture of cheddar cheese demonstrates most of the principles of the industrial processing of cheese and provides a good example for discussing the pertinent environmental issues of cheese making.

4.4.1 Cheddar cheese production

Process description

Whole or standardized milk is usually pasteurized at 70^{o}C for 15 seconds and then cooled to the inoculation temperature of 30^{o}C before being poured into a cheese vat fitted with internal agitators. If milk is received on one day and held overnight before being used for cheese production, it will be cooled to 4^{o}C after pasteurization, and warmed up to inoculation temperature for cheese making.

The starter culture is prepared the day before by the laboratory and may be a single-strain or mixed-strain culture, depending on the flavour required and on the cheese makers' experience. It is important that the mother cultures from which the daily starter is produced be kept under extremely hygienic conditions in order to avoid contamination especially from bacteriophages. These are viruses that kill bacteria and can stop cheese-making operations without warning. Each is specific to a bacterial strain, and for this Season the type of starter used is 'rotated' frequently.

Generally, starter is added at the rate of 1–1.5% of the volume of cheese milk. The quantity, however, is determined on a case-by-case basis, depending on starter activity and the subsequent rate of acid development in the cheese milk. When the acidity has reached the required level, usually after 45–60 minutes, rennet is added and dispersed evenly throughout the milk, after which curd formation begins. Rennet acts to coagulate the milk solids into curd. When the curd is firm enough it is carefully cut into cubes the size of large peas. Cutting is done using multiple knives mounted on a frame, which is driven through the curd in two planes.

The mixture of curd pieces and whey is then gradually heated through the walls of the cheese vat to a temperature of 39 ^{O}C, with slow and careful agitation. Heating assists the process of syneresis, whereby the protein structure shrinks slightly due to the action of the heat, thus expressing whey and creating a firmer curd. During the process of syneresis it is important that the curd pieces not be damaged by the agitators; this could result in a cloudy whey and high losses of fat

When cooking is complete (determined by acidity development and curd structure) the curd pieces are allowed to settle and the whey is drained off. The curd is now one cohesive mass. Although the process described applies to cheddar cheese, it is similar to that used for other pressed cheese processes. The primary objective is to force whey out of the curd through the action of acidity development, heat and pressure.

The curd mass is divided with a knife into blocks. These blocks are turned over and rotated regularly and stacked two or three high. They become thinner as a result of the pressing action. The blocks are kept together as much as possible to maintain warmth. This process continues until the curd texture and the acidity of the whey draining out are at optimum levels. The curd blocks are Then milled into pieces about the size of large potato chips.

Dry salt is added to the milled pieces and thoroughly mixed, after which the curd pieces are filled into moulds and pressed overnight. The whey that is expelled from the press station is salt whey and is often white. The molded blocks of cheese are removed from the moulds and allowed to dry. They are then wrapped in an impervious materia—usually a plastic shrink-wrap—and transferred to a ripening room where they remain for about two months, under controlled temperature and humidity, before sale.

Due to the airtight wrapping, maturation during storage is minimal. As a result the majority of cheddar cheeses are mild and bland in flavour and since no rind is formed, all of the cheese can be consumed. So-called 'farmhouse' cheddar cheese is formed and wrapped in a cheesecloth gauze instead of plastic film and is matured for up to six months. This allows the cheese to mature properly and gas to escape slowly, resulting in a product that has fuller flavour, buttery texture and thin rind. Figure 12 is a flow diagram showing the inputs and outputs for this process.

Inputs and outputs

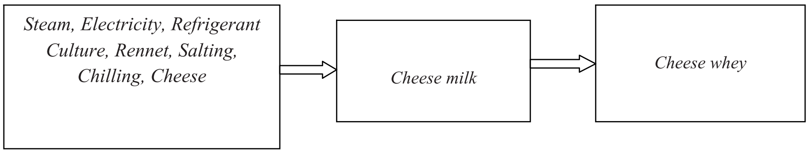


Figure 12 Inputs and outputs for Cheddar cheese production

Environmental issues

The major environmental issue associated with the cheese-making process is the disposal of whey. There are generally three types of whey:

- ***Sweet whey,*** which is generated when enzymes, principally rennet, are used to coagulate the milk. Sweet whey typically contains 0.6–0.9% soluble protein, up to 0.3% fat and large quantities of lactose (up to 5%). The pH value of sweet whey from cheddar cheese manufacturing is generally 5.1–5.3;
- ***Acid whey***, which is generated when acid, is used to coagulate the milk, for example in the production of cottage cheese. Acid whey typically contains the same proportion of soluble proteins as sweet whey, but less fat and somewhat less lactose (4.5%), since some of the lactose is converted to lactic acid. It has a low pH value, between 4.5 and 4.7;
- ***Salt whey***, which is the product expressed during the pressing of salted cheese curd, such as in the manufacturing of cheddar cheese. This whey should be collected separately from other types of whey.

Whey produced from natural cheese-making operations contains approximately 6% solids. In the past, whey was perceived merely as an insurmountable problem for the dairy industry because of the high costs of disposal using traditional effluent treatment processes. All too often dairies have taken the easy way out by simply dumping it on land, into rivers or down boreholes. Because of its lactose and protein content, untreated whey has a very high concentration of organic matter which can lead to pollution of rivers and streams and can create bad odors.

Resource Efficient and Cleaner Production opportunities

A number of opportunities exist for the recovery of the valuable high-grade protein from sweet whey. However it has only been in recent years that they have become technically and economically viable. The method used is ultra filtration (UF), followed by spray drying of the protein. This process is costly, so is only worthwhile when large quantities of fresh whey are available. Spray-dried whey powder contains between 25% and 80% protein and is used in food products, where it performs a similar function to egg proteins. Whey powder is highly soluble, even at high acidity, and is capable of forming stable foams and gels when heated. Whey protein powder is therefore used in the manufacturing of bakery and meat products, where its gelatinous properties are particularly useful.

Other options available for whey utilization are:

- *Evaporation followed by spray drying to produce whey powder*
  One of the problems associated with this solution is that the lactose tends to caramelize, making any heating process difficult. Unless special precautions are taken, the resulting product is very hygroscopic due to the high concentrations of lactose (70–75%). Whey powder in this form is not suitable for use as a food ingredient because it is very sticky and absorbs moisture during storage, forming hard lumps.

- Non-hygroscopic whey powder can be produced by precrystallising the lactose before drying. In this way, most of the lactose is present in the alpha-crystalline form, which is non-hygroscopic. Higher-quality whey powder can be produced by incorporating a secondary crystallization step after spray drying.

- Powder is removed from the drying chamber at 8–14% moisture. The moisture remaining in the powder permits almost complete crystallization of the lactose and the residual moisture can then be removed in a secondary drying system (e.g. a fluid bed) before the powder is cooled and packaged.

Feeding it to animals

In most countries where this is practiced, the whey is normally fed to pigs or cows. This is a low-cost solution but the price obtained for whey, after transport costs are considered, is often only a very small fraction of the cost of the original milk. The advantages are that there are no capital costs and no effluent charges

Demineralization or reduction of the mineral content of whey

This increases the range of opportunities for its use as a food ingredient. Ion exchange treatment or electro dialysis is used in the demineralization process, and dematerialized whey is spray-dried in the same way as whey powder. The main use of dematerialized whey powder is in the manufacture of infant milk formulations, where it is used in combination with skimmed milk powder to give a similar composition to that of human milk. Another use of dematerialized whey powder is in the manufacture of chocolate. Electro dialysis, or ion exchange technology, is comparatively expensive but it does give an end product with a higher value.

Anaerobic digestion and fermentation

Whey can be anaerobically digested to produce methane gas, which can be captured and used as a supplementary fuel on site. Whey can also be fermented to produce alcohol.

In addition, there are a number of Cleaner Production opportunities for reducing the loss of product from the process, which include:

- Preventing the loss of curds by not overfilling cheese vats;
- Completely removing whey and curds from the vats before rinsing;
- Segregating all whey drained from the cheese;
- Sweeping up pressings instead of washing them to drain;
- Screening all liquid streams to collect fines

4.4.2 Cheese packaging

Process description

After maturation cheeses are packed, either as entire cheeses (in the case of small varieties), or in consumer portions for larger cheeses such as cheddar. Packaging usually involves a combination of manual and automated processes. Packaging materials include natural wax, laminated paper/foil, shrink-wrap plastic, cartons and pre-formed plastic boxes.

In some cases it is necessary to clean the surface of the cheese and dry it before packaging. This is most common with cheeses that Cleaning, together with stripping of the cheesecloth bandage, is often a manual process. The process of dividing larger cheeses into smaller portions and then shrink-wrapping them is often a semi-manual operation. Wrapping and boxing of small varieties is normally fully automated. Farmhouse cheddar cheeses, edam, gouda and a few other varieties are often dipped in wax to protect and seal the natural rind. Figure 3–11 is a flow diagram showing the inputs and outputs for this process require a longer maturing time, during which there may be considerable mould growth on the surface. These growths are harmless but not aesthetically pleasing to the consumer.

Inputs and outputs

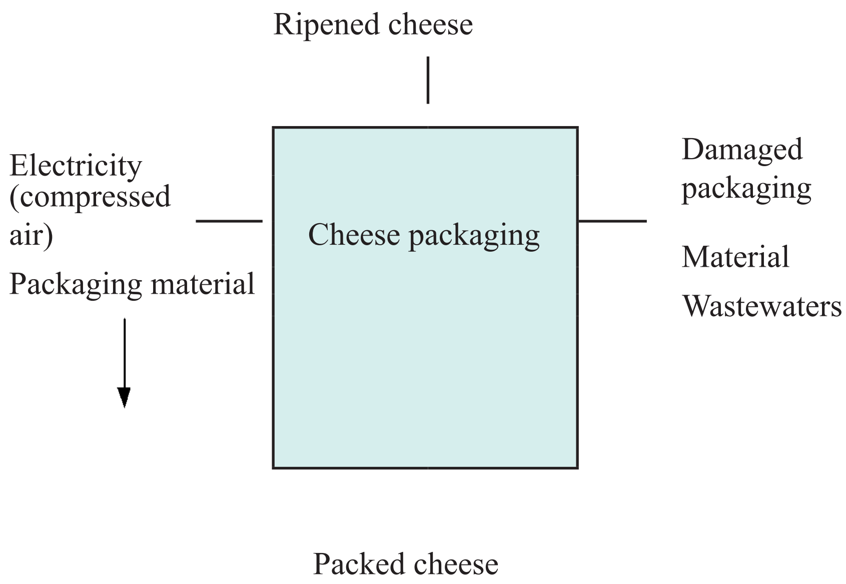


Figure 3–11 Inputs and outputs for cheese packaging

Environmental issues

The major wastes from the cheese packing area are solid wastes, including discarded cuts and small pieces of cheese and damaged packaging material. In addition there are liquid discharges from the cleaning of packaging machines, work surfaces and conveyors.

Cleaner Production opportunities

All cheese scraps should be collected separately from other waste and either used as raw material for processed cheese manufacturing (where possible) or sold as animal feed. Liquid wastes should be treated, together with other effluent streams.

4.4.3 Cheese storage

Process description

Cheese storage at the processing plant is limited mainly to the ripening period, as cheeses are normally dispatched for sale immediately after final preparation and packing The temperature of storage varies for different types of cheese. Quick- ripening soft cheeses require a low temperature of 4.5ºC whereas the harder cheeses, requiring longer ripening periods, are normally stored at up to 18ºC. The most important aspect of cheese storage during the ripening stage is humidity control. Humidity may vary from 75% to 85% for hard, dry-rind cheeses (such as farmhouse cheddar) to over 90% for soft, rindless cheese or surface-ripened soft cheeses. Figure 13 is a flow diagram showing the inputs and outputs from this process.

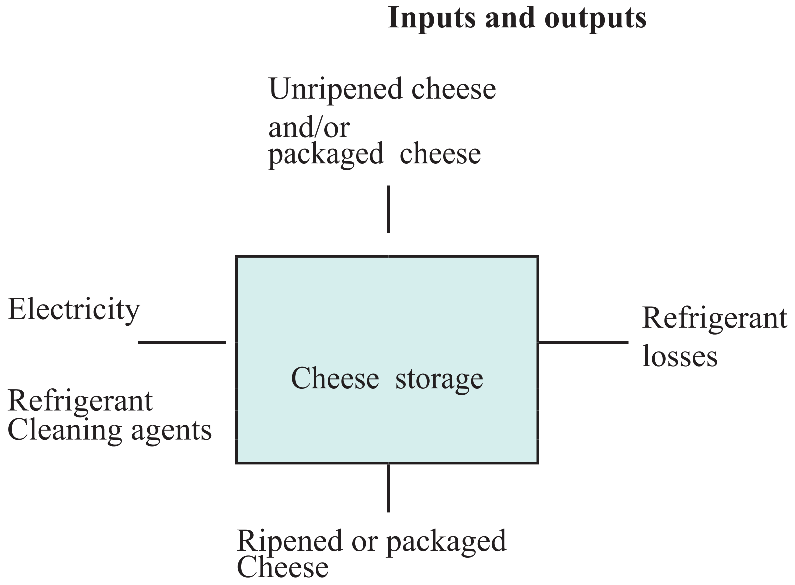


Figure 13 Inputs and outputs for cheese storage

Environmental issues

The main environmental issues associated with cheese storage are energy and refrigerants consumed in refrigerated cold stores.

Resource Efficient and Cleaner Production opportunities

Methods for reducing energy consumption and minimizing the impacts of refrigerant use are"

- Installing good insulation;
- Keeping doors to cold rooms closed;
- Undertaking regular defrosting and maintenance of refrigeration systems;
- Avoiding refrigerants that contain CFCs. Refrigeration systems based on ammonia cooling are preferred

4.5 Evaporated and dried milk production

For many centuries, the only known way to conserve the valuable solids of milk was to manufacture butter and cheese. In the mid-1800s, however, it was found that milk could be preserved by boiling it with sugar to form a thick conserve (sweetened condensed milk) which was protected from spoilage by its high sugar content. This discovery was followed at the end of the century by the development of unsweetened condensed milk. Commonly known as 'evaporated milk', this product was sterilized in the can, using a revolving retort.

The manufacturing of condensed milk products grew steadily until about 1950, but has since declined. The last major markets for these products are in South-east Asia and South America, which are now mainly being supplied by companies that reconstitute skimmed milk powder.

The period of development of the milk conserves coincided with a major development of private and co-operative dairies in the United States, in which butter and cheese were made on a large scale. The skimmed milk resulting from the separation of cream for butter making was, at best, returned to farmers for cattle feed, but was often dumped in rivers and lakes. This practice continued up until the 1930s, at which time it became possible to dry skimmed milk.

Drying of milk was introduced at the beginning of the 20th century on a very small scale, but many years went by before equipment and processes were developed for extensive commercial use in the 1930s. At this time spray drying processes were introduced in parallel with the earlier roller-drying process.

Further development did not take place to any major extent, however, until after the Second World War. During the past 30 years in particular, milk drying has become recognised as an essential link between the dairy farmer and the consuming public. This is because it allows milk to be stored for long periods in times of surplus, and for the powder to be reconstituted or recombined in times of shortage. Extensive research and practical experience in the techniques of recombining have led to the development of a wide range of dairy products. The availability of milk powders has allowed the developed world to help counter the increasing shortage of proteins in many countries. Milk powder is one of the food products most widely used in relief programs.

In the drying process the removal of water takes place in two stages. In the first stage, the milk is concentrated by vacuum evaporation to remove up to 90% of the water, and the second drying stage removes much of the remaining moisture. The reason for this two-stage approach is that the energy required per kilogram of water evaporated in the drying process is up to twenty times as much as that required in the evaporation process.

In order to maximise the effectiveness of the two stages of the process, multiple-effect evaporators with up to six effects and mechanical vapour re-compression, as well as double-stage dryers with energy-saving devices, have been developed. There has been considerable progress in energy efficiency since the major increase in price of fossil fuels that resulted from the energy crisis of 1973.

4.5.1 Evaporation

Process description

Falling film evaporators are the most commonly used evaporators in the dairy industry.They are long, tubular structures made from stainless steel. Milk is introduced at the top of the evaporator and flows as a thin film, down the outside surface of heated tubes or plates, which are packed into the evaporator. The surfaces within the evaporator are heated by steam, which is injected into the top of the evaporator.

In most dairies, multiple-effect evaporation is used, in which a number of evaporators are operated in series. The vapour generated from milk evaporated in the first evaporator is used as the steam input in the next evaporator and so on. Up to seven effects can be operated in series, but three to five is more common. Operating evaporators in this way provides for greater steam efficiency and therefore reduced energy consumption.

In order to attain further steam efficiency, the vapour exiting each evaporator can be recompressed to increase its energy before it is used as the heating medium the subsequent evaporator. Traditionally, thermal recompression, also referred to as thermal vapour recompression (TVR), was the most common recompression system in use. It involved the mixing of high pressure steam with the vapour to compress the mixture to a higher pressure. A single evaporator with a thermo compressor is as efficient as a two-effect unit without one. Therefore thermo compression is often used together with multiple-effect evaporation systems.

The effect on energy efficiency of multiple-effect evaporation and thermal recompression is shown in Table 10. TVR evaporators are inexpensive, have no moving parts and provide considerable savings in steam consumption.

Table 10 Steam consumption for different evaporation systems [1]

Type of falling film evaporator	Specific steam consumption (kg steam/kg water evaporated)	
	Without TVR	With TVR
Two–effect evaporator	0.60	0.25
Five–effect evaporator	0.40	0.20
Seven–effect evaporator	-	0.08

[1] *Bylund, 1995*

Another form of vapour recompression is mechanical vapour recompression (MVR). MVR evaporators were developed in Switzerland during the Second World War when there was a lack of fuel for raising steam. The pressure increase of the vapour is accomplished by the mechanical energy that drives the compressor.

The advantage of the MVR evaporator is that all of the vapour is recompressed, rather than just a portion of it, as is the case with TVR evaporators. This makes for a high degree of heat recovery. In addition, MVR systems are driven by electricity rather than steam, which mean that operating costs are considerably lower. The operating cost of a three-effect MVR evaporator are approximately half that of a conventional seven-effect TVR plant. As a result, it is reasonable to expect that older TVR plants will be replaced with MVR technology.

A disadvantage of MVR systems is that it is not possible to attain high temperatures and thus a steam-heated 'finisher' is required. Furthermore, cleaning of the compressor is difficult, although these problems have been alleviated by the recent introduction of high-volume fans instead of compressors. It is important to note that another option has become available for pre-concentration of the liquid to be dried. Reverse osmosis (RO), which is a hyper-filtration concentration process, can remove some of the water from the milk mechanically without the application of heat. Electrical power is used to drive pumps, which causes liquid migration through a semi-permeable membrane. However it is only possible to increase the solids concentration to a certain extent. A two fold concentration for milk and whey is common.

Environmental issues

The main environmental issue associated with the evaporative concentration of milk is the very high level of energy consumption. For example, milk powder is a highly energy-intensive product.

TVR evaporators generate noise and have high energy consumption, especially if the condensate is not reused. The condensate from an evaporator will normally be sufficiently pure to allow direct disposal. However, it is often used for cleaning instead of hot water and thus the environmental loading is, in theory, very limited.

Contamination of the condensate by milk, through improper adjustments, carryover and backflows, can result in losses of milk solids and pollution of the considerable quantities of water produced during the evaporation process.

Cleaning of MVR compressors is difficult and produces liquid wastes. So, to some extent, does the cleaning of the high-volume fans that have begun to replace mechanical compressors. MVR evaporators use large amounts of electrical energy, which can create a secondary environmental loading.

Resource Efficient and Cleaner Production opportunities

Resource Efficient and Cleaner Production opportunities in this area focus on ensuring the efficient operation of the evaporators, including:

- Maintaining a liquid level low enough to prevent product boil-over;
- Using entrainment separators to avoid carry-over of milk droplets during condensation of evaporated water;
- Recirculating low concentration milk and other feedstock's until a required concentration is reached;
- Prior to scheduled shut-downs, processing rinse waters with solids content greater than 7% or

evaporating them during the next run rather than discharging them to the effluent stream;
- Draining equipment thoroughly before starting rinsing and washing;
- Collecting the first rinse water for animal feed;
- Reducing the frequency of cleaning operations as much as possible;
- Reusing condensate as cooling water after circulation through a cooling tower, or as feed water to the boiler

4.5.2 The drying process

Although roller dryers may still be found in the dairy industry and are sometimes useful for specialised products, the use of spray dryers is now almost universal. The trend towards fewer yet larger dairies, coupled with technical advances in drying techniques since the Second World War, and the need for major economies in the use of energy over the past two decades, have made spray dryers the more practical choice. Roller dryers will thus not be discussed other than to say that they have always had severe environmental problems. They generate fine milk flakes in the vapours that are exhausted through a hood and stack placed immediately over the heated rollers and led outside the building. This has necessitated the use of external vapour cleaners.

Process description

After concentration, the milk to be dried is atomized into a frog-like mist which increases the overall surface area of the milk. The atomized mist is created in a chamber through which high- volume; hot air is being pumped or drawn in a spiral pattern from the entry to exit.

The milk spray thus evaporates instantly to powder particles. These particles either Separate out on the walls and bottom of the chamber due to the cyclonic action or, if they are to fine to react to the centrifugal force, are carried out in the co-current air flow and subsequently collected in smaller Cyclones and/or in final fabric filters high ambient temperatures. This is particularly necessary when powders containing high levels of fat are being dried, to avoid lumping and deterioration of the fat. Cleaning of the spray tower is normally a dry operation. Wet cleaning should be restricted to a minimum to reduce the risk of bacterial contamination, as moisture is a growth requirement for most bacteria. Spray drying creates a fire and explosion hazard due to the presence of hot, dry air and a fine, flammable dust. All modern dryers have explosion release mechanisms and fire prevention systems built in. Figure 14 is a flow diagram showing the inputs and outputs for this process.

Inputs and outputs

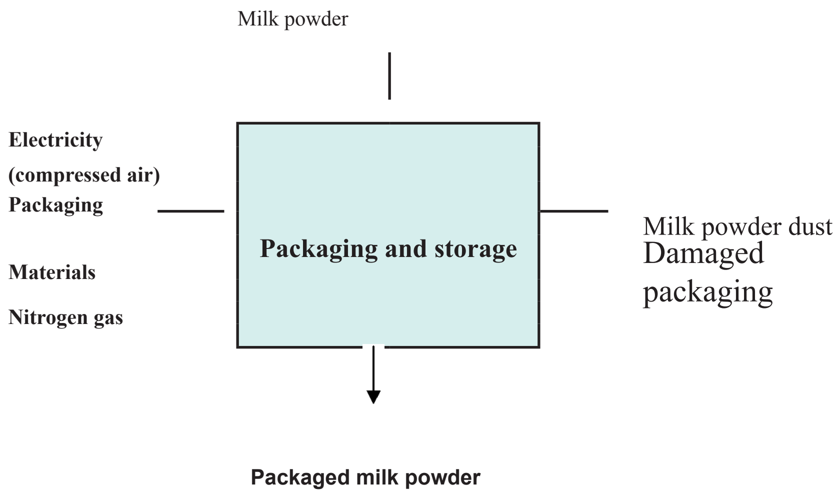


Figure 14 Inputs and outputs for packaging and storage of milk powder

Environmental issues

Dust from the exterior surfaces of sacks and/or from sacks that are leaking or not closed properly can deposit on surrounding surfaces. When wet, these deposits become acidic and can cause corrosion.

Resource Efficient and Cleaner Production opportunities

The Resource Efficient and Cleaner Production opportunities in this area focus on the prevention of emissions of milk powder dust, including:

- Ensuring the proper management of storage operations
- Installing exhaust ventilation to minimize dust in the work place

4.6 Cleaning

Areas and equipment that are in contact with milk and dairy products must be cleaned regularly to maintain hygiene standards. Furthermore, sanitizing must be carried out frequently. The relevant regulatory authority normally defines specific cleaning requirements.

Process description

Production equipment is typically cleaned by pumping rinse water and cleaning solution through all the equipment components. Some equipment has built-in cleaning nozzles that improve the utilization of the cleaning solution. The cleaning solution that leaves the vessel can be either discharged or pumped to another vessel. With the use of cleaning-in-place (CIP) equipment, however, it is possible to use less clean solution and to recirculate cleaning waters to a significant extent. This allows for savings in both detergent and water.

The design of CIP equipment can vary greatly, from simple systems where a batch of cleaning solutions is prepared and pumped through equipment and then drained, to fully automated plants with tanks for water and cleaning solutions.

Modern CIP systems often involve the use of three tanks: one for hot water rinsing, one for alkaline cleaning solution (caustic soda) and one for acidic rinses (nitric acid). Steam is often used to heat the cleaning solutions. The items of equipment to be cleaned are isolated from product flows and the prepared cleaning solutions are pumped through the vessels and pipes. Simpler CIP systems can consist of only one tank and a pump.

Cleaning cycles are often automated according to set sequences and cleaning times, and usually consist of the following steps

- Rinse with cold water (discharged to sewer)
- Addition of detergents and/or caustic soda;
- Circulation of cleaning solution through the equipment with turbulent flow to loosen and suspend soils (discharged to sewer);
- Rinse with water (discharged to sewer);
- Nitric acid rinse to prevent build-up of milk scale (discharged to sewer);
- Rinse with water (discharged to sewer).

Environmental issues

Cleaning is one of the most water-consuming operations, typically accounting for 25-40% of the total water consumption in a diary.

The pollution load of cleaning wastewater is considerable due to the presence of milk fats and proteins as well as detergents and disinfectants.

Resource Efficient and Cleaner Production Opportunities

For dairies without CIP systems consideration should be given to their installation. CIP systems make the recovery and reuse of cleaning solutions possible ad systems equipped with in-line monitoring can control the quality of cleaning solutions, thereby maximizing water use. For dairies with CIP equipment, it is important to determine and maintain optimum operational settings to reduce the consumption of both water and detergents.

Further water reductions can be achieved by providing facilities for the collection of final rinse waters so that they can be reused as the initial rinse water in the next CIP cycle.

Detergents and disinfectants can be significant sources of pollution if too much is used. It is very important, therefore, to monitor their consumption. An optimum detergent concentration for cleaning should be determined.

Operators should ensure that tanks, pipes and hoses are as completely empty as possible before they are cleaned. Empty pipelines can be blown with compressed air before cleaning in order to reduce any milk film that may have adhered to the walls of vessels and pipelines.

Cleaning of floors and equipment often consumes large quantities of water, due to the traditional cleaning method in which the operator directs a jet of water from a hose onto equipment and floors until the milk and solids float down the drain. Solid wastes, such as curd particles in the cheese making process, can be collected using a brush or broom rather than being rinsed down the drain.

The use of pigging systems to remove product residues from the internal surfaces of pipeline prior to cleaning can help to reduce the pollutant load of cleaning wastewaters and also allow for product recovery.

Table 11 Abrasion wear index for nozzle materials [1]

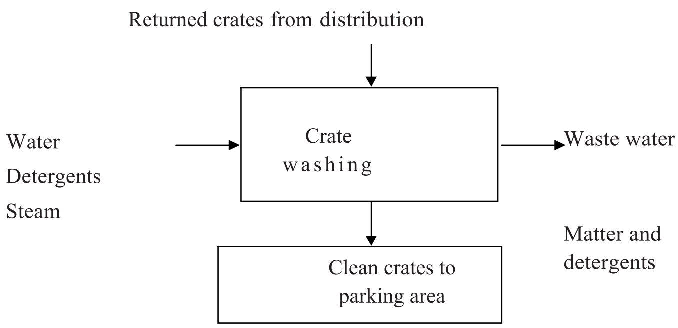
Material	Abrasion wear index
Brass	1 (poor)
Stainless steel	4-6 (good)
Hard plastic	4-6 (good)
Ceramic	90-200 (excellent)

[1] McNeil and Husband, 1995

Regular monitoring of spray nozzle wear should be incorporated into maintenance programs. Nozzles in service can be compared with new nozzles to determine the extent of wear, and the flow rate of a nozzle can be determined by measuring the time taken to fill a container of known volume.

Inputs and Outputs

Figure 15 is a material flow diagram showing the inputs and outputs for crate washing



Environmental issues

The crate washer uses large amounts of water and detergents. This causes the discharge of large quantities of water as well as dirt and some organic matter from milk. Leaks often go undetected as the area is generally wet.

Resource Efficient and Cleaner Production opportunities

In this area therefore focus on reducing the consumption of water. Ways of achieving this include:

- Optimizing water consumption by monitoring the water pressure and the condition of the water spray nozzles;
- Installation of spray nozzles of the optimum dimensions;
- Fixing leaks promptly;
- Turning off the crate washer when not in use;
- Recirculating wash water through a holding tank.

4.7 Ancillary operations

4.7.1 Compressed air supply

Air is compressed in an air compressor and distributed throughout the plant in pressurized pipes. Normally, the compressor is driven by electricity and cooled with water or air. Figure 16 is a flow diagram showing the inputs and outputs for this process.

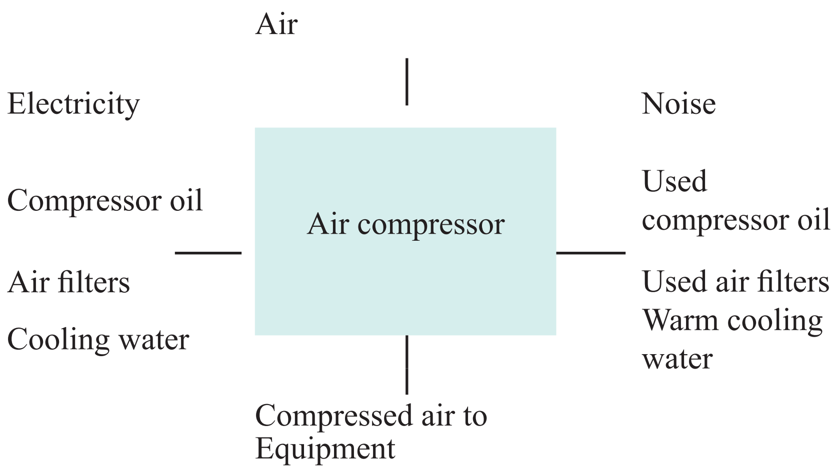


Figure 16 Inputs and outputs for production of compressed air

Environmental issues

With just a few small holes in the compressed air system (pipes, valves etc.), a large amount of compressed air is continuously lost. This results in a waste of electricity because the compressor has to run more than is necessary. Table 12 lists unnecessary electricity consumption that can be caused by leaks in the compressed air system.

Table 12 Electricity loss from compressed air leaks [1]

Hole size (mm)	Air losses (L/s)	kW.h/day	MW.h/year
1	1	6	3
3	19	74	27
5	27	199	73

[1] UNEP, 1996

Air compressors are usually very noisy, causing serious risk of hearing damage to the workers in the area. If the air compressor is water cooled, water consumption can be quite high.

Resource Efficient and Cleaner Production opportunities

It is very important to check the compressed air system frequently. The best method is to listen for leaks during periods when there is no production.

It is very important to check the compressed air system frequently. The best method is to listen for leaks during periods when there is no production. Maintenance (e.g. change of compressor oil) and the keeping of accurate log-books will often help identify the onset of system leaks.
A great deal of energy can be saved through these simple measures. It pays to implement procedures that ensure the compressed air system is leak free and well maintained.

The consumption of cooling water should be regulated by a temperature-sensitive valve, ensuring the optimum cooling temperature and minimum use of water. Furthermore, the cooling water can be recirculated via a cooling tower. Alternatively, the cooling water can be reused for other purposes such as cleaning, where the hygiene requirements are low.

4.7.2 Steam supply

Process description

Steam is produced in a boiler and distributed throughout the plant by insulated pipes. Condensate is returned to a condensate tank, from where it is recirculated as boiler feed water, unless it is used for heating in the production process. Figure 17 is a flow diagram showing the inputs and outputs for this process.

Inputs and outputs

▼

Boiler feed water

Condensate return (90^0C)

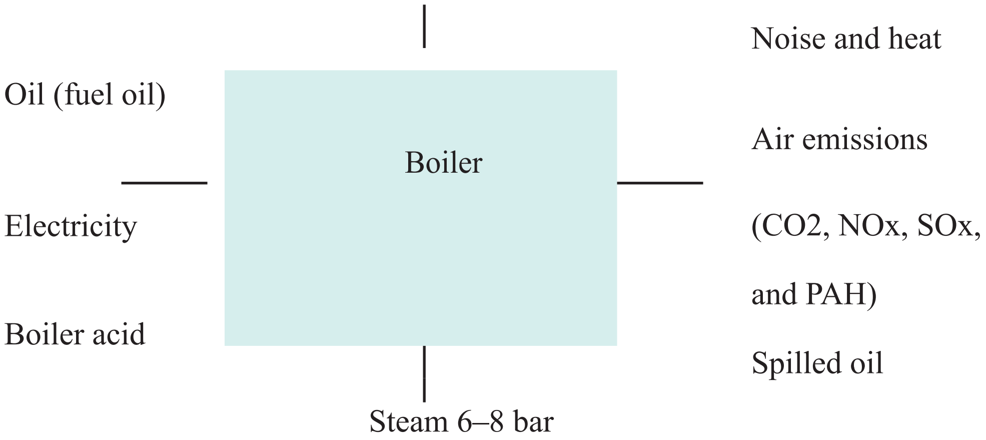


Figure 17 Inputs and outputs for supply of steam

Environmental issues

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

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

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

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

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

Table 13 shows the emissions produced from the combustion of various fuels to produce steam.

Table 13 Emissions from the combustion of fuel oil

Input		Outputs	
Fuel oil (1% sulphur)	1 kg	Energy content	11.5 kW.h
		Carbon dioxide (CO_2)	3.5 kg
		Nitrogen oxides (NOx)	0.01 kg

	Sulphur dioxide (SO_2)	0.02 kg

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

1 kW.h = 3.6 MJ

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

Resource Efficient and Cleaner Production opportunities

Instead of using fuel oil with a high sulphur content, it is advantageous to change to a fuel oil with a low sulphur content (less than 1%). This increases the efficiency of the boiler and reduces sulphur dioxide emissions.

There is no investment costs involved, but the running costs will be higher because fuel oil with a lower sulphur content is more expensive.

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

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

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

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

The following equipment is often not insulated:

- Valves and flanges;
- scalding vats/tanks;
- autoclaves;
- cooking vats;
- Pipe connections to machinery

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

If steam condensate from some areas is not returned to the boiler, both energy and water are wasted. Piping systems for returning condensate to the boiler should be installed to reduce energy losses. The payback period is short, because 1 m^3 of lost condensate represents 8.7 kg of oil at a condensate temperature of 100 C.

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

4.7.3 Water supply

Process description

High-quality domestic water supplies may not need any treatment before use in the plant. However if the available water is of poor quality it may be necessary to treat it to meet hygiene requirements. Treatment normally consists of aeration and filtration through gravel or sand and chlorination may also be necessary.

Environmental issues

Water is a valuable resource, so its use should be minimized wherever possible. Since electricity is needed for pumping water, energy consumption also increases with increasing water consumption. The losses that occur due to holes in water pipes and running taps can be considerable.

Refrigeration and cooling

Process description

In refrigeration and cooling systems a refrigerant, typically ammonia or a chlorofluorocarbon (CFC)-based substance, is compressed, and its subsequent expansion is used to chill a closed circuit cooling system. The refrigerant itself can act as a primary coolant, re-circulated directly through the cooling system, or alternatively, it can be used to chill a secondary coolant, typically brine or glycol.

CFCs were once extensively used in refrigeration systems, but they are now prohibited in most countries, and their use is being phased out as a result of the Montreal Protocol on ozone-depleting substances. All cooling systems should be closed circuit systems and free of leaks. However, due to wear and tear and inadequate maintenance, leaks may occur.

Figure 18 is a flow diagram showing the inputs and outputs from this process

Inputs and outputs

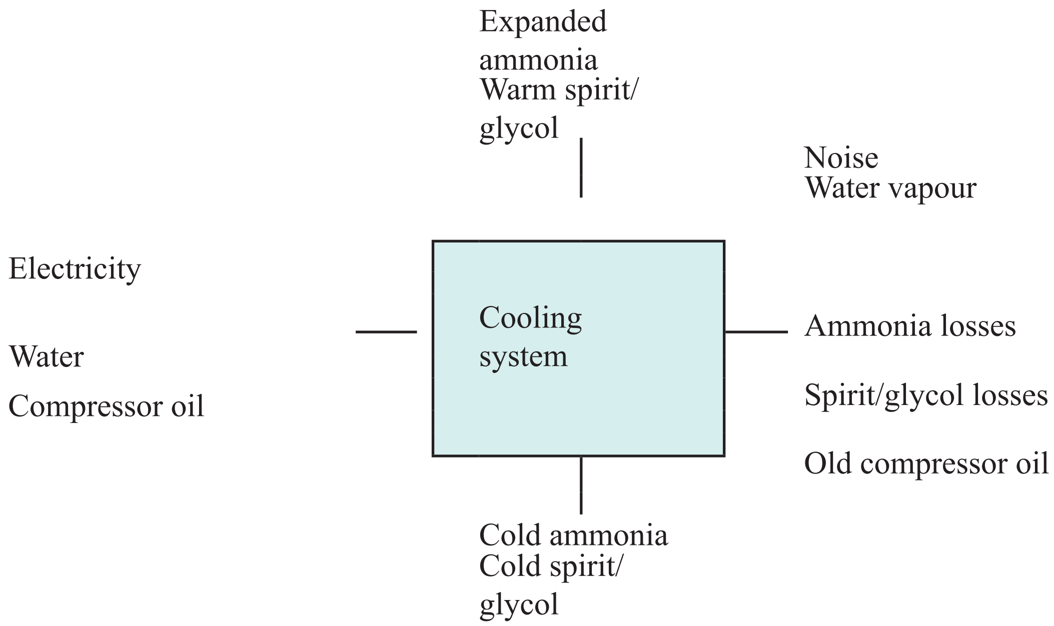


Figure 18 Inputs and outputs for cooling system

Environmental issues

The consumption of electricity and of water can be quite high. If CFC-based refrigerants are used there is a risk that refrigerant gases will be emitted to the atmosphere contributing to the depletion of the ozone layer. There is also a risk of ammonia and glycol leaks, which can be occupational, health and safety problem for workers, but can also result in environmental problems.

Resource Efficient and Cleaner Production Opportunities

CFC based refrigerants should be placed by the less hazardous hydrogenated chlorofluorocarbons (HCFCs) or, preferably, by ammonia. In the long run both CFCs should be replaced by other refrigerants according to the Montreal protocol. Replacing CFCs can be Expensive, as it may require the installation of new cooling equipment.

Minimizing the ingress of heat into refrigerated areas can reduce energy consumption This can be accomplished by insulating cold rooms and pipes that contain refrigerant, by closing doors and windows to cold areas, or by installing self-closing doors.

5. RESOURCE EFFICIENT AND CLEANER PRODUCTION ASSESSMENT

A cleaner Production Assessment is a methodology for identifying areas of inefficient use of resources and poor management of wastes, by focusing on the environmental aspects and thus the impacts of industrial processes. Many organizations have produced manuals describing Cleaner Production assessment methodologies at varying levels of detail. However, the underlying strategies are much the same. The basic concept centers on a review of a company and its production processes in order to identify areas where resource consumption, hazardous materials and waste generation can be reduced. Table 14 lists some of the steps described in the more well-known methodologies.

Table 14 Methodologies for undertaking a Cleaner Production assessment

Organization	Document	Methodology
UNEP, 1996	*Guidance materials for UNIDO/UNEP National Cleaner Production Centers*	1. Planning and Organization 2. Pre-assessment 3. Assessment 4. Evaluation and feasibility study 5. Implementation and continuation
UNEP, 1991	Audit and reduction manual for industrial emissions and waste Technical report series NO. 7	1. Pre-assessment 2. Material balance 3. Synthesis
Dutch Ministry of Economic Affairs, 1991	*Prepare Manual for the Prevention of Waste and Emissions*	1. Planning and Organization 2. Assessment 3. Feasibility 4. Implementation
USEPA, 1992	*Facility Pollution Prevention Guide*	1. Development of pollution prevention 2. Programme 3. Preliminary assessment

The rest of this chapter describes the steps within a Resource Efficiency and Cleaner Production assessment as outlined in the UNEP/UNIDO document, Guidance Materials for UNIDO/UNEP National

Cleaner Production Centers. (UNEP, 1995).

The steps from this methodology are detailed further Figure 20

Phase I: Planning and organization

- Obtain management commitment
- Establish a project team
- Develop policy, objectives and targets
- Plan the Cleaner Production assessment

⇩

Phase II: Pre-assessment (qualitative review)

- Company description and flow chart
- Walk-through inspection
- Establish a focus

⇩

Phase III: Assessment (quantitative review)

- Collection of quantitative data
- Material balance
- Identify Cleaner Production opportunities
- Record and sort options

⇩

Phase IV: Evaluation and feasibility study

- Preliminary evaluation
- Technical evaluation
- Economic evaluation
- Environmental evaluation
- Select viable options

⇩

Phase V: Implementation and continuation

- Prepare an implementation plan
- Implement selected options
- Monitor performance
- Sustain Cleaner Production activities

Fig 19 Overview of the Cleaner Production assessment methodology

5.1 Planning and Organization

The objective of this phase is to obtain commitment to the project, initiate systems, allocate resources and plan the details of the work to come. A project has more chance of success if this groundwork is done well.

5.1.1 Obtain management commitment

Experience from companies throughout the world shows that Cleaner Production results in both environmental improvements and better economic performance. However, this message has to reach the management of the company. Without management commitment the Cleaner Production assessment may be only a short-term environmental management tool.

5.1.2 Establish a project team

It is best to establish a project team as early in the process as possible. The project team is responsible for progressing the assessment and will normally undertake the following tasks:

- Analysis and review of present practices (knowledge);
- Development and evaluation of proposed Cleaner Production initiatives (creativity).

- Implementation and maintenance of agreed changes (authority).

5.1.3 Develop environmental policy, objectives and targets

The environmental policy outlines the guiding principles for the assessment. It acts to focus efforts in a way considered most important by management. The environmental policy can be refined as the project team gains more insight into the Cleaner Production possibilities within the company.

The policy contains the company's mission and vision for continuous environmental improvement and compliance with legislation. Objectives describe how the company will do this. For example, objectives could include reducing consumption of materials and minimizing the generation of waste. Targets are measurable and scheduled, and are used to monitor if the company is proceeding as planned. An example of a target might be a 20% reduction in electricity consumption within 2 years. In general, objectives and targets should be

- Acceptable to those who work to achieve them.
- Flexible and adaptable to changing requirements.
- Measurable over time (targets only).
- Motivational.
- In line with the overall policy statement.

5.1.4 Plan the Cleaner Production assessment

The project team should draw up a detailed work plan and a time schedule for activities within the Cleaner Production assessment. Responsibilities should be allocated for each task so that staffs involved in the project understand clearly what they have to do. It is also wise to anticipate any problems or delays that may arise and plan for them accordingly. Lengthy delays and problems arising out of poor planning erode motivation at both the worker and management level.

5.2 Pre-assessment

The objective of the pre-assessment is to obtain an overview of the company's production and environmental aspects. Production processes are best represented by a flow chart showing inputs, outputs and environmental problem areas.

5.2.1 Company description and flow chart

A description of the company's processes should answer the following questions:

- What does the company produce?
- What is the history of the company?
- How is the company organized?
- What are the main processes?
- What are the most important inputs and outputs?

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

- Cleaning;
- Materials storage and handling;
- Ancillary operations (cooling, steam and compressed air production);
- Equipment maintenance and repair;
- Materials that are not easily recognizable in output streams (catalysts, lubricants etc.);
- By-products released to the environment as fugitive emissions.

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

5.2.2 Walk-through inspection

Much of the information needed to fill out the input/output sheets, described above, may be obtained during a walk-through inspection of the company.

The walk-through inspection should, if possible, follow the process from the start to the finish, focusing on areas where products, wastes and emissions are generated. During the walk-through, it is important to talk to the operators, since they often have ideas or information that can be useful in identifying sources of waste and Cleaner Production opportunities. The text box over page provides examples of the types of questions that may be asked to prompt the investigation.

During the walk-through problems encountered along the way should be listed, and if there are obvious solutions to these they should also be noted. Special attention should be paid to no-cost and low-cost solutions. These should be implemented immediately, without waiting for a detailed feasibility analysis.

5.2.3 Establish a focus

The last step of the pre-assessment phase is to establish a focus for further work. In an ideal world, all processes and unit operations should be assessed. However time and resource constraints may make it necessary to select the most important aspect or process area. It is common for Cleaner Production assessments to focus on those processes that:

- Generate a large quantity of waste and emissions;
- Use or produce hazardous chemicals and materials;
- Entail a high financial loss;
- Have numerous obvious Cleaner Production benefits;
- Are considered to be a problem by everyone involved.

All the information collected during the pre-assessment phase should be well organized so that it is easily accessed and updated.

Some of the Questions to be answered during a walk-through inspection include:

- Are there signs of poor housekeeping (untidy or obstructed work areas etc.)?
- Are there noticeable spills or leaks? Is there any evidence of past spills, such as discoloration or corrosion on walls, work surfaces, ceilings and walls, or pipes?
- Are water taps dripping or left running?
- Are there any signs of smoke, dirt or fumes to indicate material losses?
- Are there any strange odours or emissions that cause irritation to eyes, nose or throat?
- Is the noise level high?
- Are there open containers, stacked drums, or other indicators of poor storage procedures?
- Are all containers labeled with their contents and hazards?
- Have you noticed any waste and emissions being generated from process equipment (dripping water, steam, evaporation)?
- Do employees have any comments about the sources of waste and emissions in the company?
- Is emergency equipment (fire extinguishers etc.) available and visible to ensure rapid response to a fire, spill or other incident?

5.3 Assessment

The aim of the assessment phase is to collect data and evaluate the environmental performance and production efficiency of the company. Data collected about management activities can be used to monitor and control overall process efficiency, set targets and calculate monthly or yearly indicators. Data collation activities can be used to evaluate the performance of a specific process.

5.3.1 Collection of quantitative data

It is important to collect data on the quantities of resources consumed and wastes and emissions generated. Data should be represented based on the scale of production: for example: water consumption per tonne of made product. Collection and evaluation of data will most likely reveal losses. For instance, high electricity consumption outside production time may indicate leaking compressors or malfunctioning cooling systems.

In determining what data to collect, use the input/output worksheets, described previously, as a guide. Most data will already be available within the company recording systems, e.g. stock records, accounts, purchase receipts, waste disposal receipts and the production data. Where information is not available, estimates or direct measurements will be required.

5.3.2 Material balance

The purpose of undertaking a material balance is to account for the consumption of raw materials and services that are consumed by the process, and the losses, wastes and emissions resulting from the

process. A material balance is based on the principle of ‘what comes into a plant or process must equal what comes out’. Ideally inputs should equal outputs, but in practice this is rarely the case, and some judgment is required to determine what level of accuracy is acceptable.
A material balance makes it possible to identify and quantify previously unknown losses, wastes or emissions, and provide an indication of their sources and causes. Material balances are easier, more meaningful and more accurate when they are undertaken for individual unit operation. An overall company-wide material balance can then be constructed with these.

The material balance can also be used to identify the costs associated with inputs, outputs and identified losses. It is often found that presenting these costs to management can result in a speedy implementation of Cleaner Production options.

While it is not possible to lay down a precise and complete methodology for undertaking a material balance, the following guidelines may be useful

- Prepare a process flow chart for the entire process, showing as many inputs and outputs as possible.
- Sub-divide the total process into unit operations. (Sub-division of unit operations should occur in such a way that there is the smallest possible number of streams entering and leaving the process).
- Do not spend a lot of time and rescues trying to achieve a perfect material balance; even a preliminary material balance can reveal plenty of Cleaner Production opportunities

Environmental performance indicators for the process can be developed from the material balance data. This is achieved by dividing the quantity of a material input or waste stream by the production over the same period. Performance indicators may be used to identify over-consumption of resources or excessive waste generation by comparing them with those of other companies or figures quoted in the literature. They also help the company track its performance towards its environmental targets.

5.3.3. Identify Cleaner Production opportunities

Identifying Cleaner Production opportunities depends on the knowledge and creativity of the project team members and company staff, much of which comes from their experience. Many Cleaner Production solutions are arrived at by carefully analyzing the cause of a problem.
Another way of identifying Cleaner Production opportunities is to hold a ‘brainstorming’ session, where people from different parts of the organization meet to discuss solutions to specific problems in an open and non-threatening environment.

Some other sources of help from outside the organization could be:
- This guide;
- External industry personnel or consultants;
- Trade associations;

- Universities, innovation centers, research institutions, government agencies;
- Equipment suppliers;
- Information centers, such as unep or unido;
- Literature and electronic databases

5.3.4 Record and sort options

Once a number of Cleaner Production opportunities have been suggested and recorded, they should be sorted into those that can be implemented directly and those that require further investigation.

It is helpful to follow the following steps:

- Organize the options according to unit operations or process areas, or according to inputs/outputs categories (e.g. problems that cause high water consumption).
- Identify any mutually interfering options, since implementation of one option may affect the other
- Opportunities that are cost free or low cost, that do not require an extensive feasibility study, or those are relatively easy to implement, should be implemented immediately.
- Opportunities that are obviously unfeasible, or cannot be implemented should be eliminated from the list of options for further study.

Problem type	Problem description	Cleaner Production Options
Examples: Resource Consumption Energy consumption air pollution solid waste Wastewater Hazardous waste occupational health and safety	Examples: • Name of process and • Department • Short background of Problem • Amount of materials • Lost or concentration • Of pollutants • Money lost due to • Lost resources	Examples: • How the problem can be solved • Short-term solution Long-term solution • Estimated reductions in resource • consumption and Waste generation

5.4 Evaluation and feasibility study

The objective of the evaluation and feasibility study phase is to evaluate the proposed Cleaner Production opportunities and to select those suitable for implementation.

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

5.4.1 Preliminary evaluation

The quickest and easiest method of evaluating the different options is to form a group, consisting of the project team and management personnel, and discuss the possible solutions one by one. This process should give a good indication of which projects are feasible and what further information is required.

5.4.2 Technical evaluation

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

5.4.3 Economic evaluation

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

When performing the economic evaluation, costs of the change are weighed against the savings that may result. Costs can be broken into capital investments and operating costs. Standard measures used to evaluate the economic feasibility of a project are payback period, net present value (NPV), or internal rate of return (IRR).

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

5.4.4 Environmental evaluation

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

For a good environmental evaluation, the following information is needed: changes in amount and toxicity of wastes or emissions;

- Changes in energy consumption;
- Changes in material consumption;

- Changes in degradability of the wastes or emissions;
- Changes in the extent to which renewable raw materials are used;
- Changes in the reusability of waste streams and emissions;
- Changes in the environmental impacts of the product.

In many cases it will be impossible to collect all the data necessary for a good environmental evaluation. In such cases a qualified assessment will have to be made, on the basis of the existing information. Given the wide range of environmental issues, it will probably be necessary to prioritize those issues of greatest concern. In line with the national environmental policy of the country, some issues may have a higher priority than others.

Aspects to be considered in the evaluation are:

i) Preliminary evaluation

Is the Cleaner Production option available?

- Can a supplier be found to provide the necessary equipment or input material?
- Are consultants available to help develop an alternative?
- Has this Cleaner Production opportunity been applied elsewhere? If so, what have been the results and experience?
- Does the option fit in with the way the company is run?

ii) Technical evaluation

- Will the option compromise the company's product?
- What are the consequences for internal logistics, processing time and production planning?
- Will adjustments need to be made in other parts of the company?
- Does the change require additional training of staff and employees?

iii) Economic evaluation

- What are the expected costs and benefits?
- Can an estimate of required capital investment be made?
- Can an estimate of the financial savings be made, such as reductions in environmental costs, waste treatment costs, material costs or improvements to the quality of the product?

iv) Environmental evaluation

- What is the expected environmental effect of the option?
- How significant is the estimated reduction in wastes or emissions?
- Will the option affect public or operator health (positive or negative)? If so, what is the magnitude of these effects in terms of toxicity and exposure?

5.4.5 Select options

The most promising options must be selected in close collaboration with management. A comparative ranking analysis may be used to prioritize opportunities for implementation. An option can be assigned scores, say from 1 to 10, based on its performance against a set of evaluation criteria. By multiplying each score by a relative weight assigned to each criterion, a final score can be arrived at. The options with the highest scores will probably be best suited for implementation. However, the results of this analysis should not be blindly accepted. Instead, they should form a starting point for discussion. All simple, cost-free and low-cost opportunities should of course be implemented as soon as possible.

5.5 Implementation and continuation

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

5.5.1 Prepare an implementation plan

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

- Activities to be carried out;
- The way in which the activities are to carried out;
- Resource requirements (finance and manpower);
- The persons responsible for undertaking those activities;
- A time frame for completion with intermediate milestones.

5.5.2. Implement selected options

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

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

5.5.3 Monitor performance

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

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

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

5.5.4 Sustain Cleaner Production activities

If Cleaner Production is to take root and progress in an organization, it is imperative that the project team does not lose momentum after it has implemented a few Cleaner Production options. Sustained

Cleaner Production is best achieved when it becomes part of the management culture through a formal company environmental management system or a total environmental quality management approach.

An environmental management system provides a decision-making structure and action plan to support continuous environmental improvements, such as the implementation of Cleaner Production.
If a company has already established an environmental management system, the Cleaner Production assessment can be an effective tool for focusing attention on specific environmental problems. If, on the other hand, the company establishes a Cleaner Production assessment first, this can provide the foundations of an environmental management system.

Regardless of which approach is undertaken, Cleaner Production assessment and environmental management systems are compatible. While Cleaner Production projects have a technical orientation, an environmental management system focuses on setting a management framework, but it needs a technical focus as well.

To assist industry in understanding and implementing environmental management systems, UNEP, together with the International Chamber of Commerce (ICC) and the International Federation of Engineers (FIDIC), has published an Environmental Management System Training Resource Kit. This kit is compatible with the ISO 14001 standard.

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

6.0 CLEANER PRODUCTION CASE STUDY

This chapter contains a case study of a Cleaner Production assessment carried out at a dairy in Kenya. The case study provides an example of how to carry out a Cleaner Production assessment at a dairy as well as some specific Cleaner Production opportunities that have proved successful.

6.1 Dairy factory X

The Cleaner Production assessment for Dairy factory X was carried out and identified five Cleaner Production opportunities:

- Better emptying of production tanks;
- Elimination of rinsing between yogurt batches;
- Reduced rinsing at product change-over;
- Optimization of cleaning operations;
- Recovery of low-grade heat.

This case study demonstrates that even when considerable effort has already been made to improve the environmental performance of a company; it may still be possible to identify additional Cleaner Production opportunities through a formal Cleaner Production assessment process.

6.1.1 Company description

Factory X employs 170 people, who work in two shifts. The company produces a wide range of milk, custard and yogurt products. In total l05 million litres of milk is processed per year; 92 million litres for market milk and 13 million litres for other dairy products.

6.1.2 Process description

The milk is delivered to the plant in milk tankers, after which it is separated. Depending on the required end product, the milk may then be mixed with non-separated milk to obtain the correct fat content. The milk is pasteurised and homogenised, and packed into cardboard or glass packaging. A proportion of the milk is processed further into yogurt, custard and buttermilk.

During the production process, product clings to the internal surfaces of pipes and equipment, which can lead to reduced product quality. To avoid this, the entire process is cleaned and sanitized after each production day, and specific pieces of equipment may also be cleaned throughout a production day. Cleaning agents containing, among other things, sodium hydroxide, hydrogen peroxide and peracetic acid are commonly used

Environmental aspects

Liquid effluent

Like all dairy processing plants, the company generates a warm, liquid effluent stream containing milk constituents and cleaning and sanitizing agents. The quantity of effluent discharged per year is 130,000 L. The organic loading of this wastewater averages about 1240 mg COD/L, which is equivalent to 3600 pollution units (pu), where 1 pu equals the organic pollution load generated by one person. The company is not connected to a wastewater treatment plant and therefore discharges treated effluent directly to surface water. The cost for discharging amounts to US$120,000 per year.

Emissions to air

Emissions to air principally result from the combustion of fossil fuels in the boiler for steam generation. Pollutants emitted include NOx, CO, CO2and PAHs, but the quantities have not been measured. The company has three chemical waste streams: ink, solvents and laboratory waste. About 10 litres per year of each of these wastes are generated. This is taken away to the small municipal chemical waste depot.

Solid wastes

By far the largest proportion of the company's solid waste stream is of packaging materials, particularly the cardboard containers used to package milk. Approximately 125,000 containers are lost as waste per year, which represents approximately 0.25% of the total number of cartons consumed. The value of this waste stream has been estimated to be about US$6000. Paper wastes are reused off site.

Energy

The company generates its own steam in an on-site boiler for heating and processing, and other energy needs are met using electricity.

6.1.4 The Cleaner Production assessment

Based on previous studies of product losses undertaken by the company, it was possible to identify areas where relatively large amounts of waste and emissions were being produced. The primary sources of pollution load are product loss to the effluent stream and the use of cleaning agents. This is caused by, among other things, batch production processes, which lead to the need for frequent cleaning and subsequent losses during start-up and shut-down.

Another area of concern was the high energy consumption for heating and cooling. To reduce the pollution load fourteen preventative measures were drawn up. Since then, eight of them have been implemented.

Three options still have to be looked at more closely and three have been found to be impracticable for various reasons.

The result has been as follows:

- A reduction in product loss by 24,000 litres (3.4% reduction);
- A 23% saving in consumption of chemicals;
- A reduction in pollution load by 198 pu./yr (a 5.5% reduction);
- A 138,000 m^3/yr saving in natural gas consumption.

Total savings have amounted to US$68,000 per year, and possibly an additional US$26,000 in reduced effluent charges. This was achieved by a single investment of US$32,000.

Table 16   Identified Cleaner Production options

	Projects implemented	Projects still to be implemented	Feasibility study Required
Loss of product	Improvements to Procedures Improvements to tank emptying Practices	Replacement of cooling installation	
Cleaning operations	No rinsing Between yogurt Batches Optimisation of cleansing process Reduced rinsing		Substitution of cleansing agents Reuse of sour Products
Energy	Pre-heating milk for buttermilk Custard heating	Pre-heating milk For yogurt production	

6.1.5 Better emptying of the production tanks

The filling of packaging containers with product at the plant is a batch process. At the end of each batch, residual product remains in processing vessel. Previous to the Cleaner Production project, this residual product was discharged to sewer with the effluent stream. Now the residual product remaining in the processing vessel is collected and returned to the production process or taken away as cattle feed.
This measure has reduced the amount of product lost to the wastewater stream by 11,500 litres, which represents a 1.6% reduction in the total product loss, and a decrease in the discharge of organic matter of 31 pu/yr.

Implementing this measure was a simple matter. A milk can is positioned below the drain point of the processing vessel. After collecting residual product, the can is emptied into one of the production vessels or into the cattle feed tank, depending on the type of product.
The value of the product recovered is US$4850 and reduction in effluent discharge came to about US$1150. The total annual savings have been US$6000 per year and there was no initial capital cost.

6.1.6 Avoidance of rinsing between yogurt batches

Rinsing traditionally took place between different batches of yogurt to prevent the mixing of different products. Each rinsing incurred a product loss of 110 litres. Most of the rinse water was used as animal feed, with the residual discharged to sewer. The total product loss per year amounted to 22,880 litres, and the total volume of rinse water used was 2,500 m^3 per year.
The new procedure employed for product changeover was to let the processing vessel drain of yogurt and then allow the next batch of yogurt into the system. The resulting mixed zone is collected and used as animal feed. As a result, it is no longer necessary to rinse between the two batches.

Investigations undertaken as part of the Cleaner Production project showed that product loss is reduced by 60 litres per batch, or a total of 12,500 litres per year. The new procedure has also led to a 2,500 m^3 per year reduction in water consumption, because rinsing between batches is no longer undertaken. In addition, the time required to empty the filling machine and collect the mixed zone takes one hour less than the previous rinsing procedure. The emptying of the filling machine demands extra attention from the operators and so written work instructions were prepared.
The annual savings resulting from the change have been US$4600 in product costs, US$2100 in effluent discharge costs and US$7400 in water consumption.

6.1.7 Reduced rinsing at product change-over

Rinsing of process equipment is undertaken between batches of sweet and sour products and between dark and light coloured products. This is done by passing 2000 litres of water through the system eight times in succession. Instead of using eight successive rinses to remove residual product, six rinses were found to be sufficient. This measure has reduced water consumption by 4 m^3 per rinse, which amount to 3120 m^3 per year.

No capital expenditure was required and there were no technical complications and savings amounted to US$2450 per year.

6.1.8 Optimization of cleansing operations

Analysis of the custard preparation and filling operations showed that the cleaning of pipelines and equipment was an area of significant product loss.

A trial was undertaken as part of the project demonstrated that cleaning procedures were far from optimal. Measuring devices were installed in the feed and return lines of the cleansing circuit to measure the temperature and conductivity of the rinse waters. The consumption of detergents and sanitizing agents before and after the trial were also measured. Based on the findings of the trial the following changes were made to the cleaning cycle:

- Level controllers were installed on the mixing vessel to control the volume of cleaning water supplied to the vessel;
- Lowered to reduce the temperature of cleaning water;
- A software program was installed to better control the cleaning program;
- The cleaning time was reduced by 20 minutes.

As a result of the changes, the consumption of detergents and sanitising agents reduced by 23% and the organic load of the wastewater discharged from the cleaning process reduced by 110 pu.

The annual savings resulting from the change have been US$28,500 in detergent costs and US$4200 in effluent discharge costs and US$7400 in water consumption. The only capital cost incurred was for the installation of the measuring equipment, which was US$3150. Therefore the payback on the project has been approximately one month.

6.1.9 Recovery of low-grade heat

One of the steps in the production process requires the heating of product to 90°C. The company previously used steam from the on-site, natural gas boiler. The company changed their process to utilize low-grade heat from the cooling water system.

Heat recovered from the return leg of the cooling water system was used to the heat the product up to 30°C. Steam from the boiler was then used to heat the product the rest of the way, up to 90°C. As a result, 54,000 m^3 less natural gas was used.

The capital investment required for the process changes was US$15,800 and the resulting savings in natural gas costs came to US$7900 per year. Therefore the payback period for the project was 2 years.

7.0 BARRIERS TO RESOURCE EFFICIENT AND CLEANER PRODUCTION AND HOW TO OVERCOME THEM

The foregoing chapters have established that CP is a proactive approach to improve profitability, internal working environment and pollution and waste and emission reduction in the fish industry. Often times however, several types of barriers can block or slow the progress of a RECP programme.

Discussed here below are major barriers to be overcome for smoother RECP implementation.

1. Attitudinal barriers
2. Systemic barriers
3. Organizational barriers
4. Technical barriers
5. Economic barriers
6. Government barriers

The numbering of the barriers does not in any way suggest order of importance just as the categorization may not be reflective of prevailing circumstances in all dairy processing plants. The actual combination of barriers prevailing in each dairy processing plant as well as their importance may differ widely from one plant to another even though they may be operating in the same locality.

This would then mean that enabling measures will be individual plant specific and no generalized solution would be suggested to fit all players.

7.1Attitudinal barriers

There is misconception that implementation of RECP is costly. However, in actual fact this has been found to be not always true as in each enterprise there are RECP opportunities which can be adopted at very minimal cost. But this mind set tends to act as an attitudinal barrier to RECP implementation. RECP audits or other studies often reveal that various obstacles formulated in financial or technical terms are in fact attitudinal.

Attitudinal barriers can be classified as:

- Indifference towards housekeeping and environmental affairs
- Resistance to change

Indifference towards housekeeping and environmental affairs

Good housekeeping is more a matter of culture than technique. Many small scale enterprises are set up and run by family members and lack housekeeping culture because in most cases they have no professional management systems. This ignorance and systemic failure allows continued environmental degradation by dairy processing enterprises in the context of short term profit making business strategies.

Resistance to change

Plant employees generally resist change that demands adoption of RECP out of fear of failure of the unknown. Many operators lack formal training and resist experimentation, fearing that any deviation from standard practice would cause them to lose control of the processes and reduce productive output. Experimentation with RECP measures is often resisted. Such reluctance to try out new practices is breeding ground for the "not me first" syndrome where people are only willing to try out an idea if it has already been successfully implemented elsewhere.

Attitudinal barriers can be overcome by ***enabling factors*** including the following:

- Early success
- Employee involvement
- Encouraging experimentation
- Publicizing early RECP successes

Early success: Since early success might encourage management as well as staff to continue experimentation with RECP, plant audits should first identify obvious no cost or low cost options. Such options often entail eliminating lapses in housekeeping, maintenance and process control have clear financial pay offs and are easily identified in the first joint on site visit of experts to the company.

Employee involvement: Involving company employees in the process of RECP options generation from an early stage increases chances of success as this helps to change their attitudes towards RECP.

Encouraging experimentation, especially with no and low cost options. Fear of the unknown or failure might be eliminated by specific, on the spot guidance and instructions for experimentation, e.g. modifying working procedures or choosing alternative raw or auxiliary materials. To minimize risks, experimentation should start with no and low cost practices such as improved housekeeping and process optimization, and gradually be extended on the basis of lessons learned and experience gained.

Publicizing early RECP success: Mills should emphasize both the financial and the environmental benefits of early RECP successes in order to create awareness among the entire workforce and to sustain commitment and involvement from key decision makers.

7.2 Systemic barriers

Production monitoring data and routine procedures for analysis of such data are essential to avoiding subjective and tendentious discussions in RECPA process. Data collection and the development of information systems within the company are prerequisites for establishing a basis of accuracy and reliability in RECP and other operations.

The immediate financial benefits of not keeping production records might, however, often appear to outweigh the advantages of appropriate data collection and evaluation for production process optimization. Although collection of baseline data is an important starting condition for RECP activities, it is most often not necessary to do until obvious lapses in housekeeping and equipment maintenance have been eliminated.

Systemic barriers can be identified as follows:

- Lack of professional management skills
- Low quality production records
- Inadequate and ineffective management systems

Lack of professional management skills

Professional management skills can be lacking in the following areas:

Leadership: Small scale enterprises are run as family affairs generally. The owners and decision makers are seldom fully qualified professional managers and often fail to provide the leadership and guidance required to develop the business. Consequently, the outlook of employees is also limited to the day to day details of work with no future targets in mind.

Supervision: Supervisors in SSE's are often persons who have been promoted because of good performance and are not necessarily trained to perform as supervisors to instruct control and guide other workers. Operators thus view the supervisor as one of their senior colleagues instead of as a shop floor manager with direction and foresight to whom they are accountable.

***Job security*:**

In SSEs, job security is often more dependent on the whims of the employer than on the performance of employees, who are therefore concerned about retaining their jobs by doing what pleases the employer and would generally prefer not to risk failure in a new activity. Even in larger units, professional managers often decline to try new things for fear of failure.

Low quality production records

Dairy plants often fail to maintain proper records of water, energy or material consumption, inventories of chemicals, fuels and raw materials, daily floor level log sheets of inputs, output, downtime etc. or environmental records of the quality and quality of liquid, solid and air emissions. In the absence of record keeping practices, data analysis and evaluation skills do not develop a deficiency which hampers the systematic identification of options.

Inadequate and ineffective management systems

In the absence of a well defined management system, the lines of authority, reporting, responsibility and accountability are often unclear. Ambiguity about performance criteria encourages employees to avoid non routine work such as RECP related measures.

Flaws in management systems are particularly evident in the following areas:

Professional upgrading of employees: Systematic training to upgrade employee job skills is inadequate or nonexistent at many companies, where employees are thus not exposed to new industrial concepts such as RECP.

Production Planning: Production schedules are usually prepared on a day to day basis which hampers systematic long term work such as baseline data collection or assessment of impact of implemented measures.

Enabling measures

The following enabling measures are proposed to deal with Systemic constraints:

- Proper documentation and plant layout
- In house RECP maintenance provisions
- Training a plant level RECP team
- Developing simple management indicators
- Conducting a top down housekeeping drive
- Disseminating success stories

Proper documentation and plant layout

Plants can improve their plant site drawings and documentation inclusive of the most recent revamping and capacity expansion projects. Such documentation serves as an excellent basis for collecting and evaluating the data needed for RECPAs

In-house RECP maintenance provisions

Generally companies with in house maintenance are a step a head of companies that rely on outside contractors for equipment maintenance and revamping.

Training a plant level RECP team:

Conducting a training session with plant level RECP team at the start of a CPA is highly recommended. Such training should clarify the objective of RECP to reduce environmental impacts by improving productive efficiency and illustrate the benefits of planned production and the need for collecting and evaluating realistic production records. Attention should also be given to illustrating problem solving approaches preferably with examples from within the company such as lapses in housekeeping or maintenance. For best results, key decision makers including the proprietor as well as shop floor supervisor should participate.

Developing simple management indicators

In the absence of professional management skills simple indicators should be developed to enable management and supervisors to gain control over the production processes and to minimize wastage of materials, water and energy. Indicators as simple as input material and water and energy consumption per unit of productive output might be sufficient to illustrate the benefits of improved housekeeping and initiate ongoing efforts in this field.

Conducting a top down housekeeping drive

Housekeeping improves once key decision makers take the lead. Top management can routinely pin point lapses in housekeeping such as leaking equipment and pipes and material spills and follow up on their elimination.

Disseminating success stories

RECP success stories can help to create and raise RECP awareness. Such accounts should be well documented with before and after financial as well as environmental data in order to pinpoint the crucial role of accurate information systems in achieving RECP. Sectoral as well as generic manuals and workshops can contribute to the dissemination of such success stories.

7.3 Organizational barriers

A company's organizational structure could hamper the introduction of proactive environmental management practices. It is therefore essential to assess how the tasks and responsibilities related to production management and environmental issues are divided in the company, and to suggest changes favorable to RECP. Shop floor supervisors and technical staff members should be involved in the project team, which in turn should cooperate with outside consultants.

Organizational barriers can be categorized in three separate but interrelated characteristics of industries (particularly SSIs):

- Concentration of decision-making powers
- Over-emphasis on production
- Non-involvement of employees

Concentration of decision making powers

Generally the owner is chief executive who makes all decisions, even for low cost measure. Such leaders tend to be unaware of the positive impact of motivational tools such as public recognition and awards or systems of incentives and rewards. Denied a share of decision-making responsibility, employees lack the initiative to take up new and challenging assignments such as RECP, and if a RECP team is formed, its members might not feel they have a real stake in the process.

Over-emphasis on production

An owner's stress on production can relegate low priority on the time and effort required to conduct a CPA. In some companies, such emphasis is sustained by the fact that payment of employees is on a production basis, by which the higher the output, the higher the payment. In such a system, there is a built-in tendency to overlook RECP and housekeeping standards to boost output.

Non-involvement of employees

Production personnel do not participate in RECP activities unless ordered to do so by the chief executive. Technical staffs often face excessive workloads and poor remuneration, especially at the junior level, which causes a high turnover rate. This condition hampers RECP efforts, as the expertise of a RECP team member often disappears when he or she departs.

Enabling Measure

- Mechanisms to cope with organizational barriers include:
- Sharing of information
- Organizing a capable project team
- Recognizing and rewarding RECP efforts
- Assigning cost to production and waste generation

Sharing Information

Sharing cost data between managers and operators encourage operators to work more carefully with high-cost materials. Sharing information on perceived courses of equipment failure or off-specification products, among operators, and between supervisors and technical staff, facilitates problem- solving approaches to eliminate waste-generation causes.

Organizing a capable project team

A capable well organized RECP team is key to developing the CPA and eliminating barriers to RECP. It might be difficult to establish and effective team, however, given the widespread lack of recognition and low prioritization of RECP, the low rate of employee involvement, and the concentration of decision-making powers. A balance must be found between the preferred situation of a properly functioning project team able to develop and implement RECP on its own, and the prevalent situation, in which the organization structure inhibits the delegation of decision-making power and blocks creative problem solving. The team should also include one or several of the most concerned supervisors and operators (shop floor workers).

Recognizing and awarding RECP efforts.

Once the team has identified and evaluated RECP opportunities, motivational schemes to encourage the team should set up, such as public recognition programmes, rewards, and publicizing early successes.

Assigning cost to production and waste generation

To expend the scope f management beyond production output to more comprehensive control over the efficiency of production, it is necessary to assign costs to the different production factors and waste streams. Normally managers can be incited to action by simple calculation of the monetary value of the raw materials, chemicals and products lost with particular waste stream.

7.4 Technical barriers

RECP often requires technical changes to installations, tools, input materials, auxiliaries, process and equipment. Given that RECP implementation depends upon technology, technical factors often emerge as barriers to it. The technical barriers in small and medium sized industries or enterprises (SMEs) can be categorized as follows:

- Limited technical capabilities
- Limited access to technical information
- Technology limitations

Limited technical capabilities

For most MEs, production ability is limited to the experience of workers, most of whom lack technical capabilities to monitor, control and improve production technology. Limitation in technical skills may take the form of:

`*Limited or non-availability of trained manpower*: lacking in-house or locally available technical personnel, many companies must depend on external expertise to perform CPA

Lack of monitoring facilities: Lacking in-house monitoring facilities for conducting the CPA, many companies must depend on external agencies which are scant, expensive and often based long distance away. Without adequate monitoring facilities, basic data collection suffers

*Limited maintenance facilitie*s: The maintenance department at SMEs are normally equipped with just enough facilities and personnel for routine maintenance, which unfortunately can not be safeguarded in the event of equipment failure.. At such companies major maintenance jobs, such as machine overhaul, motor rewinding, and boiler cleaning, must be entrusted to external firms whose time-intensive work is an expense that represents a burden to SMEs and hinder their undertaking RECP.

Limited access to technical information

Generally, SMEs have limited access to technical information and success stories on low resource consumption and low waste technique. Moreover there is an almost total absence of pertinent technical literature. The information available from abroad is not directly relevant or tailor made to the technical status and size of SME operations

Technology limitations

Technical gaps exist at SMEs in spite of modernization efforts, because most of the old conventional technology has been modified by a trial and error process without analyzing the system's basic chemistry and engineering. Such oversight has resulted in efficient, suboptimal equipment utilization and consequently, higher waste generation.

Enabling measures

Dairies which have an edge in overcoming technical barriers are those with staff trained in the appropriate technical skills and those which do not rely on outside sources for their fabrication Barriers to appropriate technology can be surmounted by the following measures:

- Technically skilled staff
- In-house fabrication facilities
- Disseminating success stories about RECP techniques and technologies
- Need-based support for environment driven research and development

Technically skilled staff

Companies with technically skilled staff members have less trouble getting started with RECP. This staffs members easily absorb the RECP concept and can transfer the general working method to the specific circumstances in their company,

In-house fabrication facilities

SMEs have a tradition of resourcefulness, modifying old, discarded equipment to function in often new and improved ways and accumulating expertise in finding smart but simple technical fixes. The companies that operate in-house fabrication facilities (mechanical, electrical, or civil workshops) are especially well endowed with such expertise, which they can employ to identify appropriate RECP solutions or to translate improvements suggested by outside experts in such solutions.

Disseminating success stories about RECP techniques and technologies

Disseminating success stories of RECP techniques and technologies could do a great deal to abate existing technical constraints. The publication of RECP technical manuals and the organization of work shops and seminars are useful media for disseminating such stories. To standardize the practice of successful RECP techniques and technologies within the industry, they should be dispensed to companies by intermediary organizations, such as small industries service institute, professional organizations, industry associations, and even equipment suppliers.

Need-based support for environment driven research and development

Research and development would help to eliminate those areas in which state-of-the-art technology is not yet able to prevent environmental problems at production scales typical for SMEs.

7.5 Economic Barriers

Major economic barriers to RECP are:

- Prevalence of fiscal incentives that favour production quantum over production costs
- Low prices and easy availability of raw materials
- *Ad hoc* investment policy
- High cost and low availability of capital

Prevalence of fiscal incentives that favour production quantum over production costs

The prevailing fiscal incentives, such as concessions in excise duty, sales tax etc are mostly related to quantum of production with little or no relevance to cost of production. Entrepreneurs therefore tend to concentrate on maximizing production to derive maximum financial benefit, relegating cost-reduction exercises such as RECP to secondary levels of importance.

Low prices and easy availability of raw materials

The impetus to identify and implement RECP measure is too often dampened by the prevailing low prices and abundant availability in many areas of natural resources such as agro residues, water and fuel. Resource scarcity, however, has become a major concern for entrepreneurs in heavily industrialized areas.

***Ad hoc* investment policy**

The ad hoc nature of investment practices in the dairy industry is detrimental to RECP in several interrelated ways:

Limiting economic analysis to obvious direct costs and benefits: The economics of all investments, including RECP measure, are computed mainly on the basis of direct financial returns and short term financial gains. Therefore, only increases in production capacity, reductions in the consumption of raw materials and fuels, and reductions in obvious production costs, such as the workforce, are typically accounted for. The benefits accruing form reduced electricity or pollution control costs are such savings have not been incurred. Savings derived from environmental measure are often a major part of the economic benefit of RECP measures. Failure to include such criteria in economic analysis is therefore unfavorable to the acceptance of RECP.

Ad hoc investment criteria: Small entrepreneurs, who are generally short of capital, tend to overlook the most attractive measures because of their higher expense, selecting instead those that are the least capital-intensive.

Inadequate investment planning: Investments, including those for RECP, are often made without proper planning, which may result in partial implementation. Expected results are thus not achieved causing decision makers to lose faith in the programme.

High cost and low availability of capital

Most financial institutions are not willing to finance cost incentive RECP measure with longer (over one year) pay-back period. In countries where financing is available, interest rates are high, in the range of 15-20 per cent, making major RECP investment a challenge.

Enabling measures

Mills with sound financial basis, and those which do not hesitate to implement no – and low-cost options improve their chances to overcome economic barriers. Companies can make use of the following enabling measure for overcoming economic barriers:

- Financial soundness
- Implementing financially attractive options
- Proper cost allocation and planned investment
- Long term industrial policies
- Financial incentives

Financial soundness

Since financially sound companies are less vulnerable to economic barriers, the perceived financial soundness of a company should be used as a criterion in its selection as a demonstration of RECP investment.

Implementing financially attractive options

Implementing cost-effective low- and no-cost RECP options can pave the way for implementing selected higher-cost options in the near future. Demonstrating the financial viability of such measure could enable a company to qualify for increasing amounts of financial assistance.

Proper cost allocation and planned investment

Awareness of costs due to waste is a crucial starting point for any RECP programme. To illustrate the potential for savings from RECP, the company must prepare an estimate of the costs of the various components in a waste stream e.g. energy, raw materials, water, and product. Once it has allocated the costs of these components, the company can assign cost to a waste stream and estimate the savings that arise from minimizing or eliminating it. Such an exercise also identifies how much is lost through the drain.

Long term industrial policies

Governments should avoid making frequent changes in industrial policies, a pattern which sustains short-sighted investment planning in the private sector. Long-term industrial policies would help industries merge RECP in to their investment planning and encourage them to become more competitive without artificial fiscal protection

Financial incentives

To foster the implementation of high-cost RECP options, financial schemes that give priority to RECP proposals over end-of-pipe proposals could be developed by government or donor agencies. Such schemes, made easily accessible and procedurally simple, could have a huge impact on the capital cost and availability of RECP investments for SMEs. Governments could also institute fiscal incentives for RECP, such as a 100 per cent depreciation allowance on private RECP investments, a government purchasing policy favorable to companies committed to RECP and a concessional corporate tax for companies that perform automatic capacity enhancements.

7.6 Government Barriers

Government policies affect company decision-making and can thus either hamper or encourage companies to adopt RECP. Governments barriers to RECP include industrial policies that discourage RECP undertakings and environmental policies that promote end-of-pipe instead of preventive solutions.

Industrial policies

As discussed above on the economic barriers, frequently changing industrial policy is not conducive to RECP efforts. Incentive schemes, as discussed in the same section are not yet available for RECP

Environmental policies

Regulatory authorities tend to enforce a limited set of environmental discharge standards that do not include guidelines for reducing waste generation. Entrepreneurs therefore prefer to use conventional end-of-pipe control practices that satisfy the regulatory authorities, rather than adopt RECP practices which are not necessarily recognized by these authorities

Enabling measures

Governments can adopt the following measure to foster RECP:

- Financial incentives
- Are-wide volunteer RECP groups
- Enforcement of environmental legislation

Financial Incentives

Government could develop financial schemes that give priority to RECP proposals over end-of-pipe proposals. Such schemes, made easily accessible and procedurally simple, could have a huge impact on the capital cost and availability of RECP investments for SMEs. Governments could also institute fiscal incentives for RECP such as 100 percent depreciation allowance on private RECP investments, a government purchasing policy favorable to companies committed to RECP and concessional corporate tax for companies that perform automatic capacity enhancements.

Area-wide volunteer RECP groups

The government could set the stage for area-wide volunteer RECP groups and create conditions o exploit their achievements.

Enforcement for environmental legislation

If environmental laws are not enforced, entrepreneurs will not necessarily perceive the need to include environmental c concerns in their business activities.

Company profile:

Type of activity:

Worksheet 1: Data collection

Essential information	Available	Not available	Team nominated to collect information
Process flow diagrams			
Production schedule-total tonnage or volume produced per year			
Operating hours			
Major raw materials Inventory			
Product inventories			
Water supply invoices for previous years. Also consider pre-treatment costs and sources (e.g. mains, surface water, ground water)			

Energy supplies invoices for previous year (e.g. electricity, LPG, natural gas or fuel oil)			
Chemicals – costs and usage for previous year (e.g. detergents , sanitizers, wastewater treatment chemicals, oils and lubricants)			
Waste water discharge invoices for previous year — volume, quality, treatment and disposal costs			
Solid waste disposal invoices for previous year — include non-recyclables and recyclables (e.g. cardboard, plastics, glass)			
Useful additional information			
Site plan			
Factory layout			
Environmental audit reports			
Waste water and waste water licenses			

Worksheet 2: Annual resource and waste data

Inputs	Annual quantity	Unit charge	Annual cost (Kshs)
Raw material 1	tonnes or m^3	Kshs/unit	
Raw material 2	tonnes or m^3	Kshs/unit	
Raw material 3	tonnes or m^3	Kshs/unit	
Raw material 4	tonnes or m^3	Kshs/unit	
Raw material 5	tonnes or m^3	Kshs/unit	
Raw material 6	tonnes or m^3	Kshs/unit	
Raw material 7	tonnes or m^3	Kshs/unit	
Raw material 8	tonnes or m^3	Kshs/unit	

Water	m^3	Kshs/ m^3	
Packaging	Units	Kshs/unit	
Cleaning chemicals	L	Kshs/L	
Electricity	kW h	Kshs/Kwh	
Natural gas	MJ or Litres	Kshs/MJ	
Other			
Outputs	**Quality generated per year**	**Unit charge**	**Annual cost of disposal**
Waste water	m^3	Kshs/ m^3	
BOD	Kg	Kshs/kg BOD	
COD	Kg	Kshs/kg COD	
TN	Kg	Kshs/kg TN	
TP	Kg	Kshs/kg TP	
General waste	M^3	Kshs/m^3	
Recyclable waste	M^3	Kshs/m^3	

Worksheet 3: Current and target performance indicators

	Current performance (per unit of product)	Target performance(per unit of product)
Inputs		
Water	m^3/unit	m^3/unit
Electricity	kW h/unit	kW h/unit
Gas	MJ/unit	MJ/unit
Chemicals	kg/unit	kg/unit
Packaging	cartons/unit	cartons/unit
Other		
Outputs		
Solid waste (dumpsite)	m^3/unit	m^3/unit
Cardboard	m^3/unit	m^3/unit
Plastic	m^3/unit	m^3/unit
Glass	m^3/unit	m^3/unit
Other	kg/unit	kg/unit
Wastewater volume	m^3/unit	m^3/unit
Wastewater quality		

COD	mg/L waste	mg/L waste
BOD	mg/L waste	mg/L waste
TN	mg/L waste	mg/L waste
TP	mg/L waste	mg/L waste

Worksheet 4: True cost of water

	Heated water Kshs/M³	Chilled water Kshs/M³
Supply cost		
Heating/chilling cost		
Pumping cost		
Treatment cost		
Discharge cost		
True cost of water		

Worksheet 5: Water consumption for individual units of operation

Process area/unit of operation	Volume of water used weekly(m^3)	Volume of water used yearly(m^3)	% of total consumed
Process area			
Cleaning			
Services			
Boiler make-up			
Cooling tower make-up			
Domestic use			
Total			
Actual volume purchased			100

Variance/ unaccounted			

Worksheet 6: Energy consumption

Form of energy	Annual usage	Annual usage(common unit)	Annual cost(Kshs)	% of total energy cost
Electricity	kW h	MJ		
Natural gas	m^3	MJ		
LPG	MJ	MJ		
Fuel oil	kg	MJ		
Coal				
Other				

Energy Type	Conversion Factor
Electricity	3.6 MJ/kWh
Natural gas	39.5 MJ/m^3
Fuel oil	43.1 MJ/kg
Coal	30.7 MJ/kg
Steam	2.8 MJ/kg

Worksheet 7: Electricity consumption

Process area	Equipment	No. of items	Rating(kW)	Capacity/ load	Hours of use(h/ day)	Estimated Consumption(kW h/year)	Subtotal (kW h/year)	% of total
e.g. Coldroom1	*Atlas Copco comp- ressor*	*1*	*30*	*90%*	*24*			

Total								
Actual electricity consumed								

Worksheet 8: Solid waste audit

Waste steam	Source and cause of waste	Generation rate and pattern	Storage pre disposal	Service contractor and disposal location	Cost of Disposal(Kshs)	Comments
e.g. plastic packaging	*batch preparation*	*1.0 m^3 per day*	*15 m^3 skip*		*15/m^3*	*Investigate plastic recycling company*

Worksheet 9: Waste water charges

Component	Licence limit	Average load(mg/L)	Average daily load(kg)	Council charge	Actual cost of discharge (Kshs)
BOD	mg/L			Kshs/kg	
COD	mg/L			Kshs/kg	
TN	mg/L			Kshs/kg	
TP	mg/L			Kshs/kg	
Other	mg/L			Kshs/kg	
Volume	m^3			Kshs/m^3	
				Total cost	

Worksheet 10: Wastewater audit

Waste stream	Source and cause of waste	Generation rate and pattern	Mass load	Comments
e.g. product tank wastewater	*cleaning of product tanks*	*daily*	*500 mg/L BOD*	*Consider clean-in-place system*

Worksheet 11: Potential RECP opportunities

Opportunity

Potential resource saving

Passed

	Water	Energy	Packaging	Chemical	Solid waste	Waste water	Other(e.g. labour, maintenance)	preliminary evaluation Yes/No
e.g. Reduce timers on filling machine *cleaning cycle*								

Worksheet 12: Economic evaluation of RECP opportunities

Costs of implementing the opportunity • Estimate the likely cost of equipment and installation and any other up-front costs associated with the change? • Estimate any on-going costs such as running costs, maintenance, materials, labour etc. (for a 12-month period). **Total costs (a + b)** **Savings from implementing the opportunity** • Determine the possible savings in terms of materials, water, energy, treatment, disposal etc. (for a 12-month period)? • Is the change likely to lead to increased sales of current or new products? What would be the likely range (for a 12-month period)? e Quantify any other associated costs or benefits. **Total savings (c + d + e)** **Payback period** Payback period in months = $\frac{\text{Total cost}}{\text{Total savings}}$ 3 12 months	

Worksheet 13: Summary of RECP opportunities

RECP opportunity	Capital cost	Annual saving (resources)	Annual saving (Kshs)	Payback(months)	Implement (date)	Responsible person(s)
Water		m^3				
Energy		kWh/MJ				
Packaging		m^3				
Chemicals		L				
Solid waste		m^3				
Wastewater		m^3				

GLOSSARY

BAT-best available technology and best available techniques (from an environmental viewpoint

Best practice: the practice of seeking out, emulating and measuring performance against the best standard identifiable

BOD-Biological oxygen demand a measure of the quantity of dissolved oxygen consumed by microorganisms' due to breakdown of biodegradable constituents in wastewater

CFC- Hydrogenated Chlorofluorocarbon

CFC-chloroflouro carbon. An ozone depleting substance

CIP- cleaning in place or circulation of a cleaning solution through or over the surface of production equipment.

CO_2-Carbon Dioxide

COD-Chemical Oxygen Demand is a measure of the quantity of dissolved oxygen consumed during chemical oxidation of waste water.

EMS- Environmental Management System

Eutrophication- High growth of algae causing poor penetration of light in the water and high oxygen consumption

ISO 14001- International Standard Iso14001 Environmental Management System specification with guidance for use under International organization for standardization

KDB-Kenya dairy board

KNCPC-Kenya National Cleaner Production

MVR- Mechanical Vapor Recompression

N-Nitrogen

NOx -Nitrogen oxides; covers both NO_2 (nitrogen dioxide) and NO (nitrogen monoxide)

PAHs – Poly Aromatic Hydrocarbons. Occur in flue gases from combustion of fuel

P-Phosphorus

PU -A measure of pollution units used in The Netherlands (1 p.u. equals the organic pollution of wastewater from one person)

PVC-Polyvinyl chloride, a commonly used plastic. Some are carcinogenic

RECP-Resource Efficient and Cleaner Production

SOx-Sulphur oxides; covers the various forms of gaseous sulphur oxide compounds found in combustion gases.

SS-Suspended solids

TVR-Thermal vapour recompression

UCPC-Uganda Cleaner Production Centre

UF-Ultrafiltration

UNEP DTIE-United Nations Environment Programme, Division of Technology, Industry and Economics

UNIDO-United Nations Industrial Development Organization

UN-United Nations

USD- United States Dollar

ANNEX 2 REFERENCES AND BIBLIOGRAPHY

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Units

Bar-unit for measuring pressure (1 bar = 0.987 atmosphere)
J-joule (1 W = 1 J/s)
Kg-kilogram
KW.h-kilowatt hour (1 kW.h = 3.6 MJ)
L-litre
Lb-pound (1 lb = 0.454 kg)
M-metre
M^{2}-square metre
M^{3}-Cubic metre (= 1000 L)
MJ-1 million joules (1 MJ = 0.278 kW.h)
MW.h-megawatt hour (1 MW.h = 1000 kW.h)
Nm^{3} -Normal cubic metre

ABOUT LAKE VICTORIA ENVIRONMENTAL MANAGEMENT II (LVEMPII)

1.0 LVEMP II BACKGROUND

LVEMP II aims at contributing to the East African Community's (EAC) Vision and Strategy Framework for Management and Development of the Lake Victoria basin of having a prosperous population living in a healthy and sustainably managed environment providing equitable opportunities and benefits. The phase I of the Project runs in the period 2009-2013 and the second phase may last possibly to 2017 and will contribute to broad-based poverty alleviation and improvement of shared natural resources of the Lake Victoria Basin (LVB).

1.1 LVEMP II Specific Objectives

a) Improve collaborative management of trans-boundary natural resources of LVB for the shared benefits of the EAC Partner States.
b) Reduce environmental stress in targeted pollution hot spots and selected degraded sub-catchments to improve the livelihoods of communities who depend on the natural resources of the LVB.

1.2 LVEMP II is regarded as an instrument to:

1. Achieve stress reduction outcomes in priority hotspots i.e. the project's interventions are expected to have measurable impact on the estuaries, bays, and gulfs due to point source pollution control.
2. Lay a foundation for the long-term program for sustainable improvement in the environmental status and water quality.

2.0 CLEANER PRODUCTION SUB-COMPONENT OF LVEMP II

The sub-component on Promotion of Cleaner Production Technologies seeks to reduce point sources of pollution from industry, by supporting the uptake of cleaner technologies and techniques in industry so as to rehabilitate priority degraded sub-catchments of Lake Victoria. The Cleaner Production project seeks to increase the competitiveness of the Lake Basin industries by reducing wastes, and negative impacts whilst enhancing raw material utilization efficiencies by deploying cleaner technologies and techniques.

The project targets at building the capacity of industry through education, training and a "learning-by-doing" cleaner production audits. This is in line with the region's Vision Strategy that is looking at shifting industrial transformation from regulatory intervention to promotion of voluntary initiatives. The vision strategy specifically aims at (i) building the capacity of enterprises to formulate and implement pollution prevention strategies and programmes that will improve their competitiveness and productivity (ii) building up the capacity of the region to formulate and manage an overall strategy for industrial development within the framework of an open economy (iii) strengthening the capability of both the private and public sector players to manage development resources within the region leading to a quality environment and employment creation for poverty reduction.

2.1 Long Term Impact

The Cleaner Production project is expected to contribute towards the long-term impact of sustainable industrial development in the Lake Victoria Basin. This shall be realized through increased industrial productivity as well as by reduced industrial pollution loadings into the lake.

2.2 Project Development Objective (PDO)

The PDO of this project is "to promote the Utilization of Cleaner Production Technologies by industries in the Lake Victoria Basin"

The success of this Project Development Objective shall be evaluated through the following:

» Adoption of integrated environmental management by industries and switch to Cleaner Production technologies and techniques
» Reduced point source pollution from industries and enhanced efficiency of resource utilization

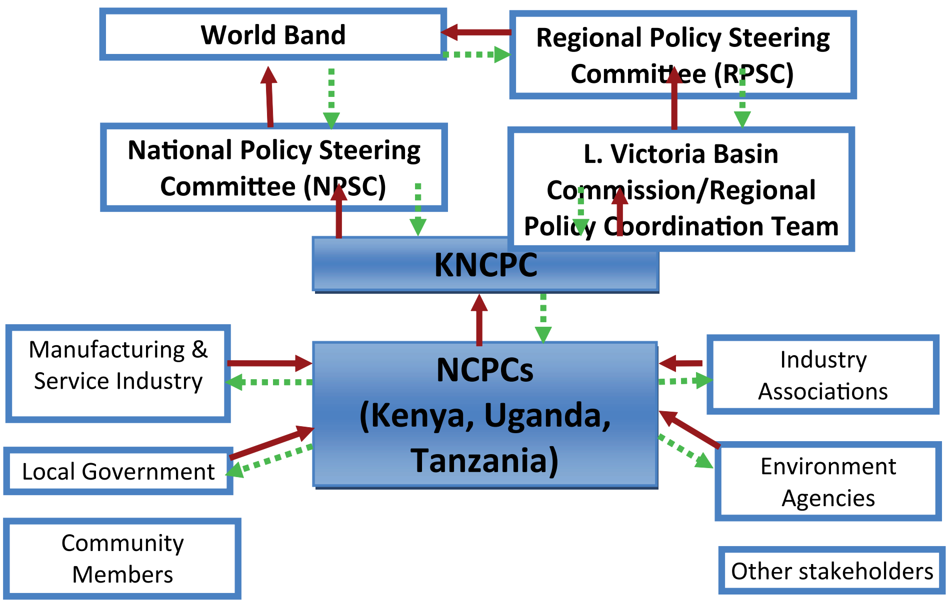
The interventions of the Cleaner Production sub-component shall be on:
Component 1: The promotion of education, information dissemination, and training on resource efficient and cleaner production

Component 2: Promotion of cleaner production demonstration projects in enterprises through rapid and detailed in-plant assessments

3.0 INFORMATION FLOW

3.1: Information Flow Chart

Information flow and reporting hierarchy shall flow as below indicated.



KNCPC: Kenya National Cleaner Production Centre
NCPC: National Cleaner Production Centres

4.0 DATA COLLECTION

The sub-component shall collect both raw and historical data from industry pertaining to wastewater quantity and quality (BOD, COD, TN, and TP), solid waste volumes, production levels, energy and water consumption. These shall be used to determine the baseline performance levels before cleaner production intervention. Measurements of the same indicators shall be made after the CP intervention and improvement levels determined. All industries operating in the Lake Basin are expected to participate in the program.

5.0 THE MAIN INDICATORS FOR PROJECT PERFORMANCE

The principal indicator of the project success will be the enhanced readiness of industry and municipalities to develop and ultimately invest in cleaner production. It is recognized that the decision to invest will not depend exclusively on economic considerations, but will also consider company culture and social aspects. That is why awareness sessions to remove "myths" on cleaner production have been designed. In addition, the regional policy initiatives and of Governments will create a favourable working environment within which industry can implement cleaner production.
Specific indicators for success of the sub-component are:

i. Number of industries and technical staff trained in Cleaner Production from industry
ii. Number of industries implementing Cleaner Production Programs
iii. Number of Cleaner Production options identified and being implement
iv. The quantities of pollution reduced in tons per year and wastewater quality released
v. The efficiencies realized by industry in material, water and energy consumption per ton of product
vi. Public and industry awareness levels of the benefits of pollution prevention and waste minimisation and are involved with the project
vii. Indicators of formulated and implemented Cleaner Production strategies
viii. Development and implementation of national and regional Cleaner Production action plans

6.0 DATA ANALYSIS & REPORTING

Data collected from industry shall be written in a uniform report comprising the following:

- Rapid assessment: Short analysis, which assesses the quality of the crucial processes, pollution intensities, material and energy flows in order to identify the potentials for resource efficiency and cleaner production (RECP).
- Detailed assessment: Systematic modeling of production processes, identification of RECP options for waste reduction, technical and financial evaluation and implementation.
- EST transfer: Identification and evaluation of both front-and end-of-pipe technology transfer and development including support for the preparation of technology investment projects. This shall enable the implementing partners to provide technical assistance to industry to

develop effluent discharge management plans and environmental management systems to enable industry clusters/sectors comply with regulations & standards.

7.0 DISSEMINATION, FEED BACK AND REVIEW MECHANISM

The economic and environmental benefits realized from the Cleaner Production interventions in industry shall be disseminated in workshops, through newsletters, print media, the regional RECP network and websites. The regional communication strategy shall also guide on other appropriate channels for disseminating the information.