Cleaner Production Assessment in Dairy Processing

Prepared by

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for

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Division of Technology, Industry and Economics

and

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PREFACE

The purpose of the Industrial Sector Guides for Cleaner Production Assessment is to raise awareness of the environmental impacts associated with industrial and manufacturing processes, and to highlight the approaches that industry and government can take to avoid or minimise these impacts by adopting a Cleaner Production approach.

This guide is designed for two principal audiences:

- People responsible for environmental issues at dairy processing plants (environmental managers or technicians) who seek information on how to improve production processes and products. In many countries, managers are ultimately responsible for any environmental harm caused by their organisation's activities, irrespective of whether it is caused intentionally or unintentionally.
- 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 the air, water and land. The Cleaner Production opportunities described in this guide will help improve production as well as environmental performance.

Chapter 1 provides a brief introduction to the concept of Cleaner Production and the benefits that it can provide.

Chapter 2 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 3 describes 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 4 provides a case study demonstrating the application of Cleaner Production at a dairy processing plant.

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

Annex 1 contains a reference and bibliography list.

Annex 2 contains a glossary and list of abbreviations.

Annex 3 contains a list of literature and contacts for obtaining further information about the environmental aspects of the industry.

Annex 4 contains background information about the UNEP Division of Technology, Industry and Economics (UNEP DTIE).

Monetary figures quoted in this guide are based on 1995–98 figures and are presented as US dollars for consistency. As prices vary from country to country and from year to year, these figures should be used with care. They are provided as indicators of capital expenditure and savings only.

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EXECUTIVE SUMMARY

This document is one in a series of Industrial Sector Guides published by the United Nations Environment Programme UNEP Division of Technology, Industry and Economics (UNEP DTIE) and the Danish Environmental Protection Agency. The documents in the series include:

- *Cleaner Production Assessment in Dairy Processing*;
- *Cleaner Production Assessment in Meat Processing*; and
- *Cleaner Production Assessment in Fish Processing*.

This document is a guide to the application of Cleaner Production in the dairy industry, with a focus on the processing of milk and milk products at dairy processing plants. Its purpose is to raise awareness of the environmental impacts of dairy processing, and to highlight approaches that industry and government can take to avoid or minimise these impacts by adopting a Cleaner Production approach.

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 pasteurised and homogenised 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 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 Cleaner Production. Case studies of successful Cleaner Production opportunities are also presented.

Cleaner Production

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

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

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

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

Water consumption

In the dairy processing industry, water is used principally for cleaning equipment and work areas to maintain hygienic conditions, and accounts for a large proportion of total water use. Rates of water consumption can vary considerably depending on the scale of the plant, the age and type of processing, whether batch or continuous processes are used and the ease with which equipment can be cleaned, as well as operator practices. A typical range for water consumption in reasonably efficient plants is 1.3–2.5 litres water/kg of milk intake.

In most parts of the world, the cost of water is increasing as supplies of fresh water become scarcer and as the true environmental costs of its supply are taken into consideration. Water is therefore an increasingly valuable commodity and its efficient use is becoming more important.

Strategies for reducing water consumption can involve technological solutions or equipment upgrade. However substantial benefits can also be gained from examining cleaning procedures and operator practices. Some key strategies for reducing water consumption are listed below and the use of these techniques would represent best practice for the industry. By doing so, water consumption can be reduced to as little as 0.8–1.0 litres water/kg of milk intake.

- using continuous rather than batch processes to reduce the frequency of cleaning;
- using automated cleaning-in-place (CIP) systems for cleaning to control and optimise water use;
- installing fixtures that restrict or control the flow of water for manual cleaning processes;
- using high pressure rather than high volume for cleaning surfaces;

- reusing relatively clean wastewaters (such as those from final rinses) for other cleaning steps or in non-critical applications;
- recirculating water used in non-critical applications;
- installing meters on high-use equipment to monitor consumption;
- pre-soaking floors and equipment to loosen dirt before the final clean;
- using compressed air instead of water where appropriate;
- reporting and fix leaks promptly.

Effluent discharge

Most water consumed at dairy plants ultimately becomes effluent. Dairy plant effluent is generally treated to some extent on site and then discharged to municipal sewerage systems, if available. For some municipalities, dairy effluent can represent a significant load on sewage treatment plants. Effluent may also be used for land irrigation in rural areas.

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. Milk loss can be as high as 3–4%, with the main source of loss being residues which remain on the internal surfaces of vessels and pipes, accidental spills during tanker emptying and overflowing vessels.

The organic load discharged in the effluent stream varies depending on cleaning practices and whether batch or continuous processes are used, since batch processes require a greater frequency of cleaning. A typical figure for the COD load in dairy plant effluent is about 8 kg/m^3 milk intake.

Strategies for reducing the organic load of dairy effluents focus on minimising the amount of product that is lost to the effluent stream. Some key strategies are listed below and the use of these techniques would represent best practice.

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

Energy consumption

Approximately 80% of a dairy plant's energy needs is met by the combustion of fossil fuels (coal, oil or gas) 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.

Energy consumption depends on the age and scale of a plant, the level of automation and the range of products being produced. Processes which involve concentration and drying, for example the production of milk powder, are very energy intensive, whereas market milk, which requires only some heat treatment and packaging, requires considerably less energy. A typical range for energy consumption in plants processing milk is 0.5–1.2 MJ/kg of milk intake.

Energy is an area where substantial savings can be made almost immediately with no capital investment, through simple housekeeping efforts. Energy savings of up to 25% are possible through switch-off programs and the fine tuning of existing processes, and an additional 20% can be saved through the use of more energy-efficient equipment and heat recovery systems. Some key strategies are listed below, and the use of these techniques would represent best practice for the industry. By doing so, energy consumption for the processing of milk can be reduced to as low as 0.3 MJ/kg of milk intake.

- implementing switch-off programs and installing sensors to turn off or power down lights and equipment when not in use;
- improving insulation on heating or cooling systems and pipework etc.;
- favouring more energy-efficient equipment;
- improving maintenance to optimise energy efficiency of equipment;
- maintaining optimal combustion efficiencies on steam and hot water boilers;
- eliminating steam leaks;
- capturing low-grade energy for use elsewhere in the operation.

Evaporation of milk to produce concentrated or dried milk products is an area of high energy use but also an area were energy savings can be made. The use of multiple effect evaporation systems, combined with thermal or mechanical recompression, can provide significant savings if not already being used.

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.