LAKE VICTORIA ENVIRONMENTAL MANAGEMENT PROGRAM II
SUB COMPONENT 2.2 PROMOTION OF CLEANER PRODUCTION TECHNOLOGY

RESOURCE EFFICIENT AND CLEANER PRODUCTION (RECP) GUIDANCE MANUAL FOR THE TEA SECTOR

ACRONYMS AND ABBREVIATIONS

BOD:	Biological Oxygen Demand
COD:	Chemical Oxygen Demand
CP:	Cleaner Production
CPA:	Cleaner Production Audit
CPCT	Cleaner Production centre of Tanzania
CTC:	Cut Tear and Curl
EE:	Energy Efficiency
EET:	Energy Efficient Technologies
EMS:	Environmental Management Systems
FBD:	Fluid Bed Drier
GDP:	Gross Domestic Product
GLSS:	Green Leaf Storage System
HACCP:	Hazard Analysis Critical Control Point
ICC:	International Chamber of Commerce
IRR:	Internal Rate of Return
KNCPC:	Kenya National Cleaner Production
KTDA:	Kenya Tea Development Agency
NPV:	Net Present Value
RECP:	Resource Efficiency Cleaner Production
RR:	Renewable Resources
RRT:	Renewable Resources Technologies
SMEs:	Small and Medium Enterprises.
SSE:	Small Scale Enterprises
TN:	Total Nitrogen
TP:	Total Phosphorous
UCPC:	Uganda Cleaner Production Centre
VSD:	Variable Speed Drive

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. It also 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:

- People responsible for environmental issues at tea sector (environmental managers or technicians) who seek information on how to improve production. In many countries, managers are ultimately responsible for any environmental harm caused by their organization'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 tea industry on environmental issues.

This guide describes Cleaner Production opportunities for improving resource efficient and preventing the release of contaminants to the environment. The Cleaner Production opportunities described in this guide will help improve production as well as environmental performance.

Chapter 1: Country overview of the Tea sector

Chapter 2: Provides an overview of the tea processing industry including process descriptions, environmental impacts and key environmental indicators for the industry.

Chapter 3: 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 4: Describes the Resource Efficient and Cleaner Production assessment methodology in details. This can be used as a reference guide for carrying out a RECP assessment within an organization.

Chapter 5: Provides a case study demonstrating the application Cleaner

Production in a tea factory.

Chapter 6: Describes barriers to RECP and how to overcome them

Appendix 1: Contains RECP Checklist

Annex 2: Contains a reference and bibliography list

ACKNOWLEDGEMENT

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 Resource Efficient and Cleaner Production at company level. It is a tool to help managers and staffs think about Resource Efficient and Cleaner Production 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.

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 Resource Efficient and Cleaner Production such as water or energy use.

EXECUTIVE SUMMARY

This Manual has been jointly developed by the Kenya National Cleaner Production Centre (KNCPC), Uganda Cleaner Production Centre (UCPC) and Cleaner Production Centre of Tanzania (CPCT). The development of this team Sectoral Resource Efficient and Cleaner Production (RECP) Manual is menant to guide in the implementation of Resource Efficient & Cleaner Production (RECP) in the Sector. This Manual Is one of the outputs of the project "*Lake Victoria Environnemental Management Program II (LVEMP II)*", Through Sub component 2.2 : Promoting Cleaner Technologies in Industries.

This Manual contains an analysis of the tea production process, including a description of the entire production cycle, main environmental problems and water, energy and material productivity issues. It provides a Resource Efficiency improvement and pollution reduction opportunities for the sector.

This guide contains the 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 tea processing plants through the application of Resource Efficient and Cleaner Production. Case studies of successful Cleaner Production opportunities are also presented.

The manual can be used for companies who are implementing Resource Efficient and Cleaner Production, Consultants who are advising the sector and also those who are training.

CONTENTS

INTRODUCTION

1.1 COUNTRY OVERVIEW OF THE TEA INDUSTRY

This chapter is designed to help the user of the manual get a brief and orientational understanding of the contribution of the tea sub-sector to the respective national GDP. It is envisaged to enable the user contextualize the manual.

1.2 KENYA

The agricultural sector continues to dominate Kenya's economy, although only 15 percent of Kenya's total land area has sufficient fertility and rainfall to be farmed, and only 7 or 8 percent can be classified as first-class land. In 2006 almost 75 percent of working Kenyans made their living on the land, compared with 80 percent in 1980. About one-half of total agricultural output is non-marketed subsistence production. Agriculture is the second largest contributor to Kenya's gross domestic product (GDP), after the service sector. The performance of Kenya's main agriculture exports in 2010 was strongest for tea which recovered rapidly from 2009 weather conditions. A combination of volume and price increases will see the sector perform even better than in 2008, which had previously been the best year for the sector.

Tea sub-sector

Kenya is a major tea-producer. It has more than 110,000 hectares of land devoted to tea. In Kenya, tea is grown in the highland areas with adequate rainfall and low temperatures. The main tea-growing area is in the Kenyan Highlands, west of the Rift Valley, at altitudes between 5,000 and 9,000 feet. Tea is a major foreign exchange earner, and the main source for 17 to 20 percent of Kenya's total export revenue. In 1995, the tea industry brought US$342 million into the country and Kenya became the largest exporter of black tea in African and third largest in the world.

Small-scale farmers grow more than 80 per cent of it while the rest is by large-scale producers. Small-scale farmers market their produce through the umbrella Kenya Tea Development Agency (KTDA), who is in charge of collection, processing and selling of processed leaves. Large-scale producers of Kenyan tea include Brooke Bond, George Williamson, Eastern Produce and African Highlands. Unlike small-scale farmers, large-scale growers are responsible for processing and marketing of their own crop. Kenya's production is usually in the region of 245 million kilos per year. The majority of the Kenyan tea production is sold through the Mombasa auction, with Pakistan, the UK and Egypt being the biggest buyers.

Kenya Tea Development Agency and Association of Tea Growers develop and market Kenyan teas worldwide. These organization's aims are to promote recognized standards and certification for the industry in general. They have made outstanding contributions to the Kenyan economy through excellence, innovation and quality in exporting overseas. They also provide a market for the 314,875 farmers who depend on tea growing as a livelihood. Established under an act of parliament (cap. 343) in June 1950, the Tea Board of Kenya licenses tea growers manufacturing and exports. The board also carries out research on tea through the technical arm; The Tea Research Foundation of Kenya is composed of the government, Kenya Tea Development Authority, Kenya Tea Growers Association, Nyayo Tea Zone, Development Corporation and East Africa Tea Trade Association.

Kenya production is almost exclusively CTC manufacture (cut, twist and curl). This type of manufacture produces strong-liquoring teas, which yield a high number of cups per kilo, when brewed both loose and in teabags. The bushes are harvested throughout the year, with the best quality being produced in January and February and again in July, during the drier periods of the year.

1.2.1 Environmental challenges

The highest intake BOD pollution load was 10,350 mg/litre and the lowest was 30 mg/litre. At the final discharge point to the environment, the highest BOD loading was 1,320 mg/litre. The most efficient treatment systems reduced BOD levels from 1,080 mg/litre to 30 mg/litre and 3,600 mg/litre to 31.1 mg /litre giving an average of 98% efficiency. The National Environment Management Authority (NEMA) recommended discharge value of BOD for discharge to the environment is 30 mg/litre. Due to poor maintenance and improper design of treatment systems in some factories, effluent discharge BOD levels exceeded the intake levels thus giving negative treatment efficiencies. A number of systems gave treatment efficiency less than 20%.

The highest intake COD level was 16,000 mg/litre and the lowest was 200 mg/litre. At the discharge point, the highest COD level was 12,800 mg/litre. The most efficient system reduced the COD level from 9,000 mg/litre to 40 mg/litre which is below NEMA recommended level of 50 mg/litre for effluent to be discharge to the environment. Poor maintenance and improper design of the treatment systems resulted in effluents with high COD levels being discharged to the environment in most tea industries. None of the tea factories had their TN and TP within the recommended limit values at discharge point to the environment.

1.3 TANZANIA

Tea is one of the cash crops in Tanzania. More than three-quarters of Tanzania's tea is exported. Tea contributes more than US $ 30 million to Tanzania's export earnings, making it the fifth largest export crop after cashew nuts, coffee, cotton and tobacco. The tea industry in Tanzania provides employment to 50,000 families and directly or indirectly affects about 2 million people. Although tea is economically important for Tanzania, the country produces 25,000 tons, which is less than 1% of the estimated world annual tea production of 3 million tons (Tanzania' Tea Sector: Constraints and Challenges, www. Wordbank.org/afr/wps/wp69.pdf).

1.4 UGANDA

1.4.1 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. Fisheries are one of the sub-sectors that constitute the Agricultural sector hence being paramount to national development.
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.

1.4.2 Tea sub-sector

Favorable climate and soil conditions enabled Uganda to develop some of the world's best quality tea. Tea is the third major export crop in Uganda after coffee and cotton. There has been significant rehabilitation of the tea sector in Uganda. As a result, tea production has increased. The privatization of the government estates and factories has added great value to the sub-sector in terms of competition and acted as a catalyst for further private sector involvement. The process of privatization of the tea factories is still going on with shares being sold to smallholders who now have a chance to become owners of the factories. Tea production increased in Kenya by 37.2% from 12,692 Mt in 1995 to 17,418 Mt in 1996. Correspondingly, the quantity exported increased by 35.5% from 10,682 Mt to 14,980Mt. This increase is attributed to the rehabilitation of tea plantations and the encouragement of out-growers. Tea is being grown by large estates (46% production). Small growers (small estates and out-growers) produce 54% of the tea. Uganda produces mainly black CTC tea from tender leaves, which are mostly handpicked. Tea is largely grown along the Lake Victoria Crescent and the lower slopes of Ruwenzori Mountains as well as above the Western Rift Valley. In Uganda, tea is grown into three grades: grade 5/8 is commonly grown and approximately there are 3,000 plantations each producing about 2,500 kg per hectare annually. The other brands of 303/573; 31/8 and 31/37 are international proven good quality tea and approximately 8,000kg per hectare can be realized but these grades have just been introduced in Uganda.

Currently, there are 22 companies actively involved in exporting processed tea from Uganda. Most of Uganda's tea goes to auction in Mombasa, but an increasing (though still small amount of the best grades are sold as specialty teas, exported directly to tea houses. In 2007, the average auction tea price was $ 1.36 per kg. Some of the tea is sold as certified fair trade which earns a premium to the small holder farmers. There are plans to venture into organic tea.In 2007, a total of 44,912 tons of tea was produced, of which 43,636 tons were exported. Farm gate price for out growers is between $ 0.15 and $ 0.2 per kg of green leaf.

However, the Tea sub-sector uses a number of resources including nitrogen based fertilizers for soil enhancement, fossil fuel and fire wood for energy generation and water for drying and cleaning. Also, it is known that Green House Gases such as CO2 and Nitrous Oxide are generated. All these call for an efficient approach to minimize resource loss, which in turn may lead to environmental pollution.

2. RESOURCE EFFICIENCY AND CLEANER PRODUCTION

2.1 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.

2.2 Definition of 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.

2.3 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.

2.4 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.

2.5 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

2.6 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.

2.7 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.

2.8 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. OVERVIEW OF TEA PROCESSING

3.1 Tea Processing

Tea processing involves the drying and crushing of leaves. This leads to controlled fermentation (enzymatic oxidation) of the liquor present. There are two main methods of black tea production orthodox and CTC (Crushed -Torn-Curled or also referred to as Cut-Torn-Curled). Both largely mechanized processes, involve withering (reducing moisture), rolling, oxidation and drying. In the CTC process however leaves are cut and rolled in several, special ways. Both orthodox and CTC teas come in different grades (qualities) that are based on the *size* of the processed and dried leaves, which is determined by their ability to fall through screens of specific meshes. In general CTC grades are more granulated or powder-like in appearance and orthodox tea looks more like twisted flakes or longer leaf (particles).

3.2 Withering

Green leaf of good quality is received in the factory and is loaded onto withering troughs. Using axial fans, air is blown into and out of the leaf to evenly remove the moisture from 80 % moisture content to 65-68 % moisture content. At this stage, the leaf undergoes both physical and biochemical changes necessary for the manufacture of quality black tea. The extent to which physical and biochemical changes take place depends on the physical conditions such as humidity and temperature the leaf is exposed to. This process takes about 8-12 hours depending on capacity constraints.

Chemical Wither: Desirable biochemical changes from plucking to initiation of processing (manufacturing), normally 14-20 hrs.

Physical withers: Moisture loss, leaf becomes flaccid.

Percent wither (% withers): The weight of 100kg fresh leaf at the end of the withering process.

Table 1: *Showing Different % moisture contents of fresh leaf results in different % moisture contents of withered leaf*

Fresh leaf	Withered leaf, i.e. 100 kg fresh leaf reduced to moisture							
	80kg	75kg	70kg	65kg	60kg	55kg	50kg	45kg
82%	78%	77%	75%	73%	71%	68%	65%	61%
80%	76%	74%	72%	70%	68%	65%	61%	57%
78%	73%	72%	69%	67%	64%	61%	57%	52%
76%	71%	69%	67%	64%	61%	57%	53%	48%
74%	68%	66%	64%	61%	58%	54%	49%	43%

Percent wither can be calculated by measuring the recovery % of made tea against withered leaf.

Table 2: *Showing Fresh leaf moisture Recovery % of Tea Made against withered leaf*

Fresh leaf moisture Recovery % of Tea Made	Withered leaf								
82%	19	22	25	27	30	31	35	38	43
78%	23	26	30	33	35	38	42	47	53
74%	28	31	36	38	42	45	50	56	62

Fresh leaf moisture content determines withering (and drying) loads; 8 percentage points less moisture results in 40 - 45% increase in recovery.

Example: At 80% wither; a reduction from 82% to 74% moisture gives an extra 45% recovery

Controlled Wither

(i) Normal requirement for controlled wither.

Table 3: *Showing requirements for controlled wither*

	Moisture content of Withered leaf	Equivalent, % wither on		
		Moist	Average	Dryish
CTC	70%	58	73	80
Orthodox (plains)	66%	52	65	74
Orthodox (hills)	33%	26	33	39

(ii) Equipment: Heated lofts, drums and troughs.

(iii) Method: When more moisture is there in the fresh leaf, more % wither must be given to achieve 70% moisture in withered leaf:

3.4 Green Leaf Storage System (GLSS)

Keeps green leaf in fresh and an undamaged condition for up to 48 hours. GLSS can be used in conjunction with the existing troughs so that the same troughs may be used up to 3 times a day. This adds to saving on power and space up to 60%.

Table 4: *Showing troughs dimension, capacity and power required for GLSS*

Dimensions	37.27m x 2m x 3.7m
Capacity	14000 kg
Power required	HP-6KW - 4.5

Table 5: *Showing spread requirements in lofts*

Type	Weight and dimension
Orthodox	1 kg on 2 mt^2, 0.5 kg per mt^2
CTC	I kg on 1.5 mt^2, 0.7 kg. Per mt^2

Table 6: *Showing spread requirements in troughs*

	CTC	Orthodox	
		Plains	Hills
Kg per running m of trough 1.8 m wide	38-48	33-43	28-38
Kg per mt^2	20-25	17-23	15-20

3.5 Withering air in troughs

a) Air volume controlled with fan and damper (or bypass) ratio varies from 0.4 m^3/kg with fine leaf at 15 cm deep to 0.7 m^3/kg with standard leaf at 20 cm deep depending on leaf quality and spread, the air volume per m^2 trough surface will vary from 8 to 18 m^3/min.

b) Controlled by adding hot air. Heaters should supply 1/10 of the required volume at 100 degrees centigrade maximum. Fan inlet temperature should not exceed 38 degrees cent (plains), 30 degrees cent (hills).

c) Hygrometric Difference: The depression of wet bulb below dry bulb temperature should ideally be about 4 degrees C. High differences speed up moisture removal, but can give uneven wither. They can be used for drying off surface moisture initially,

d) Air pressure: Normally 12 mm Water Gauge. This should not drop below6mm when working against the normal spread of leaf.

3.6 Building troughs

a) Selecting a fan for an existing through :
Kg leaf to be loaded x air ratio selected = air requirement in m^3.

b) Compare this with air delivery figure in fan manufacturers' table, at 12mm Water Gauge pressure: choose nearest larger standard size of axial flow fan.

Larger diameter fans use less power per volume than smaller fans. By using pairs of smaller fans, flexibility is obtained, but this requires troughs 3-4 m wide.

c) Making a trough for an available fan
Fan capacity (rating), m3= kg leaf capacity air ratio selected

Divide leaf by spread selected (see 6.10 b above) to get running m of a 1.8 m wide standard trough, or required m2 of trough surface.

d) Calculating requirements Total no. of troughs = *1% of estimated annual GL (KG) spread selected (KG/M^2) x planned area per trough (M^2)*

(Includes additional capacity large enough for any anticipated peak day; will prevent the collapse of quality control under adverse climatic conditions.)

RECP challenges at withering stage.

- Wastages due to spills form the conveyer belt
- High energy use by the radiator fans

3.7 Cutting

Once the leaf has attained the desirable wither, it is taken for crushing and cutting to ensure that the enzymes and reactants are mixed at the same time reducing the particle size. The crushing is done by use of resistor and vanes, forces the leaf through a small opening (iris) hence crushing the plant cell, a process often referred to as maceration. The enzyme usually located in the vacuole mixes with the catechins in the cell and the oxidation reaction starts.

The CTC (Cut, Tear, curl). Machine cuts the leaf, tear off the fibre part and curls to make a rounded particle hiding the tinny fibres, hence the name CTC. Good withers are 'plastic' and will give a good curling while fresh leaf is brittle and hence flaky.

An exothermic oxidation reaction becomes more aggressive as the rollers introduce frictional heat in addition to the heat of reaction. This reaction is more aggressive and is required to take place under controlled conditions hence the process of fermentation.

3.8 Rolling

Rolling is a process where rollers are used to rupture the cell walls of the withered leaves for oxidation of the polyphenols in the presence of oxygen from air.

3.9 Fermentation

Fermentation is the process during which the polyphenols in the tea leaf are oxidized in presence of the enzymes and subsequently condensed to form colored compounds contributing to the quality attributes of tea. Fermentation starts immediately after cell rupture. In this enzymatic reaction, catechins are oxidized, and combine to form Theaflavins (TF) and Therubigins (TR), a process which takes about 1½ hours and the dhool changes from bright metallic green (chlorophyll) to bright golden brown colour (TF bright orange and TR brown red).

High temperature and prolonged time favours the formation of TR at the expense of the TF. This results in deep colour and body at the expense of brightness. Prolonged time (beyond 150 minutes) would reduce catechins to the minimum (residual), which contribute negatively to strength of the cup. Fermentation controls therefore aim at achieving the optimal combination of conditions where the most desirable parameters are achieved. This is done by controlling temperature, aeration and constant turning for uniform fermentation.

Temperature

Optimum: 24’C-29’C

Factors affecting temperature

i) Leaf temperatures at the end of green leaf processing,

ii) Thickness of spread

iii) Temperature of air in fermenting room.

Humidity

Optimum: $1^{O}C–1.5^{O}C$HygrometricDifference

Any larger H.D. requires humidification of the room.

Normal method: Mist chambers or spray units.

Table 7: *Showing Orthodox and CTC spread on the floor, sheet or table*

Thickness	Orthodox	CTC
2 cm thick, 1 Kg leaf takes	0.18m^2	0.12m^2
3 cm thick, 1 Kg leaf takes	0.12m^2	0.08m^2
4 cm thick, 1 Kg leaf takes	0.08	0.06..
5 cm thick, 1 Kg leaf takes	0.09	0.05..
Approx. space requirements	Orthodox Roll/CTC	RV/CTC
For 1000 Kg throughput per hr	600	225

Air for floor fermentation

10-12 changes of air per hour if natural ventilation does not as that all air in the room is renewed every 5-6 minutes, fan assistance may have to be given, air speed to be kept as low as possible.

Fermenting Machine

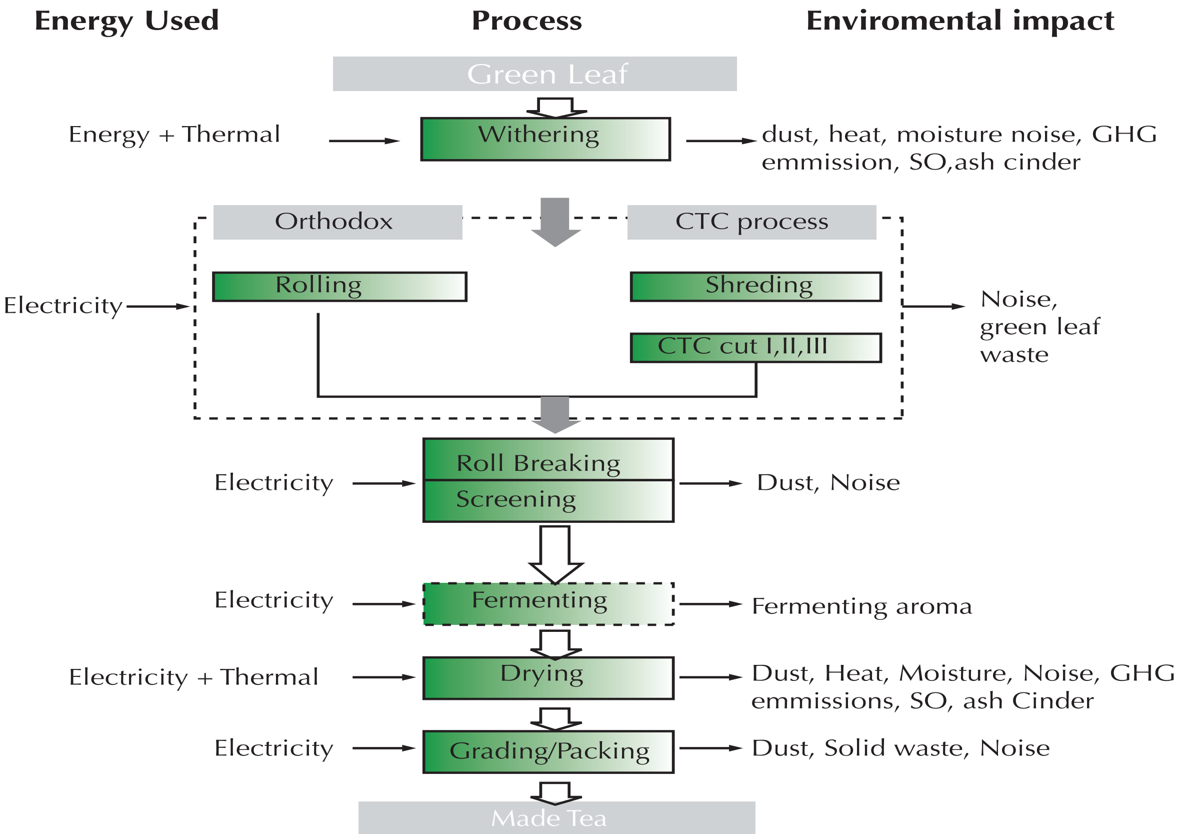
Size aid capacity varies from manufacturer to manufacturer. Dimensions Of 17m x 4m x 3.5m would suffice to Supply two 1.8 m dryers

3.10 Drying, Sorting & packing

Once the desirable parameters have been achieved, the fermentation process must be stopped. This is done by exposing the tea to high temperatures (140^{o}C) and in so doing denaturing the enzymes and removing the excess water. This process also helps get the pigments to acquire the black coloration of the tea as the water is removed. Aroma of the tea is formed as the volatiles are formed. The process is achieved by using fluidized bed driers hot air is heated by steam radiators and 'fluidizes the tea.' As the tea leaves the drier, it is black with moisture content of 3-3.3%. This moisture is low for fungal growth and the tea is easy to store, grade sort and pack for market.

In sorting, the tea is graded according to particle size and the fibre content. Fibres are distractive in leaf appearance and are removed by utilizing electrostatic attraction difference between the woody content. PVC rollers rub against a felt material, generating the electrostatic charge, which attracts the fiber as the tea passes underneath. Tea is hygroscopic and hence should be kept in air tight conditions. Left in the open, the tea would absorb moisture and generate an atmosphere favorable for fungal growth. The shelf life would be greatly reduced.

Fig 1: Pictorial presentation of tea processing



4. RESOURCE EFFICIENCY AND CLEANER PRODUCTION OPPORTUNITIES

The environmental impacts of the tea industry are considerable. There is significant biodiversity loss when high biodiversity areas such as forests are converted to tea plantations. Along with habitat conversion, logging for firewood to process tea, in particular, has caused extensive deforestation. It is projected that the increase in the cost of petroleum will force many tea manufacturing industries to switch to increased wood fuel usage, increasing demand for the same to new levels, and will have the multiple effects in higher prices, increased illegal logging, and pressure on land to grow wood fuel.

A single factory that runs 22hrs/day may use up to 15, 000 tons of wood fuel a year, harvested over 2,000 to 3, 000 hectares of natural forest. Exotic trees, when grown for wood fuel, will require much less land (about 1, 000), but their water absorption characteristics, according to some professional quarters, have been documented to alter local climates. Tea factories should monitor fuel inputs and meter all power outlets to minimize misuse or wastage of power. From the production process, opportunities exist to reduce on both electrical and thermal energy use, steam management and renewable sources.

4.1 Recommendation

The RECP manual recommends the following improvements on efficiency in the tea processing

4.1.1 Efficiency and the Use of Renewable Resources

- Use firewood as a fuel for drying to reduce nonrenewable fossil fuel consumption. All fuel wood must be derived from sustainable sources.
- Boiler and factory efficiency should be optimized. Factories should invest in more efficient boilers if necessary.
- Biofuels derived from waste (e.g. bio-briquettes tea fluff and sugarcane bagasse) should be considered to supplement fuel wood use.
- Smaller farms should seek to develop co-operative fuel wood growing schemes given

their own landholding constraints.

- Where sustainable fuel wood sources are limited, alternatives should be investigated to avoid extraction from native forest reserves.
- Use of fossil fuel for power generation, vehicles, irrigation engines and factory start-up should be minimized.
- Where practical, develop hydro-electricity or wind power schemes to support power needs.
- Factories should monitor fuel inputs and meter all power outlets to minimize misuse or wastage of power.
- Tea bush pruning's should be left as a mulch in the field and never used for fuel.

4.1.2 Greenhouse Gas Emissions

- Factories should minimize fossil fuel consumption and hence CO2 emissions.
- Nitrous oxide is produced from anaerobic soils, especially after adding N fertilizers. Applications of nitrogen (N) should be reviewed carefully for areas with high water tables.

4.1.3 Polluting Gaseous Emissions

- Factories should install scrubbers in factory chimneys.
- Fertilizers which can easily volatilize, such as urea should be avoided. Urea volatilizes into ammonia which is oxidized in the atmosphere to nitric acid, a component of acid rain.
- If it is not economically sustainable to eliminate urea, factories should find ways to reduce volatile loss, such as neem coated urea, pellets and timing of application.

4.1.4 Potential Areas for Improvement

- Factories should utilize human waste to generate biogas as a source of fuel.

4.1.5 Factory Process Water

- Factories should minimize process water use (e.g. recycling steam condensate, dry cleaning of factory lines).
- Factories should not discharge untreated factory effluent into watercourses.

4.1.6 Water Harvesting and the Sustainability of Water Supply

Factories should:

- Ensure that any water harvesting is not at the expense of other users downstream.

- Maintain in-field dams and water catchments.
- Buildings with appropriate roofing can feed water tanks to collect rain water for domestic use. Larger buildings, such as factories, should also enhance harvesting of rainwater for sanitation use.
- Ensure that refueling and lubrication operations for pumping equipment do not pollute watercourses.
- Investigate differences in process water use between factories, and implement best practice on process water utility and handling of factory effluents

4.2 RECP Opportunities in the withering section

4.2.1 The load on dryers.

Table 8: *Showing Kg of water to be evaporated in dryer/100 kg of fresh leaf (Containing different percentages of moisture.*

Moisture content i.e. Percent Wither of fresh leaf (%)	100 Kg fresh leaf reduced to *(Kg)*						
	90	80	75	70	60	50	45
82	72	62	57	52	42	32	27
78	68	58	53	48	38	28	23
74	64	54	49	44	34	24	19

N.B. Respiration losses of solids and moisture remaining in dryer mouth tea more or less balance and have not been considered. With a soft wither on rains leaf, 3.77 times drying Capacity is required compared to a hard wither on dryish leaf (72: 19) under average conditions. A percentage withers of 85 instead of 75, means 17% more dryer hours. Changes from 75% to 65% wither will save one dryer in 5 or reduce drying hours by 1/5.

Table9: *Showing Dryer adjustments variables and effects*

Variables	Affected by
Exhaust temperature	Inlet temperature, spread, air-volume, tray speed
Spread	Spreader, adjustment

Time through dryer	Tray speed adjustment,
Air volume	Damper adjustment
Inlet temperature	Heater adjustment
% Moisture at dryer mouth	Time through dryer, inlet temperature, air volume

Table 10: *Showing Limiting factors for variable adjustments*

	Too high	Too low
Exhaust temperature	Waste of heat	Low temperature stewing
Spread	Reduced air flow, incomplete drying	Loss of air
Time through	Burning dryer	Incomplete drying
Air volume	Leaf blow out	Stewing
Inlet temperature	Burning/case-hardening	Exhaust too low
Moisture % at discharge	Incomplete drying	Waste of heat,

4.2.2 Dryer capacity

a) It varies with: Dryer design and condition, Air volume, available heat, Operational adjustment and is measured in Kg of water evaporated/hr

b) The weight of dryer mouth tea is a measure of capacity only if the moisture content of fermented leaf is stable and known.
Depending on wither, 30 cm of dryer width can, give 25-40 Kg made tea/hr. Fluid Bed Dryer (FBD) which is used for CTC manufacture only gives 280-400 Kg made tea/hr depending on the degree of wither and the design of the machine.

c) Capacity Test:
   i) Stabilize the exhaust temperature, inlet temperature and time through dryer.
   ii) Weigh all fermented leaf, before feeding it into dryer for 60 mms. Starting and finishing without reserve leaf at spreader.
   iii) Weigh all dryer mouth tea for 60 minutes.

Dryer capacity = (ii) - (iii) Kg of water evaporated.

Table 11: *Showing spacing and power requirements for a conventional dryer*

Conventional Dryer :	6 feet (180 cm)	4 feet (120 cm)
Power for chamber drive HP	2	2
KW	1.5	1.5
Fan HP	12.5-15	10-12.5
KW	9-11	7.5-9
Floor space	4m **x** 13.5m	3m x 12.5m

Table12: *Showing spacing and power requirements for a fluid bed dryer*

Fluid Bed Dryer	3 feet (90 cm)	4 feet (120 cm)
Power (Installed capacity)		
Drying system HP	23-28	33-56
KW	17-21	25-42
Dust collection HP	10	22.5
KW	7.5	16.8

4.2.3 Moisture uptake

a) At the dryer mouth, if not ventilated/cooled, the newly fired tea re-absorbs moisture, 'sweats', also called high temperature stewing.

b) From ambient air during sorting etc: In high temperature and high relative humidity (small wet bulb depression) tea absorbs moisture rapidly to 8%, more slowly to 15%. Redrying, 'final firing' again reduces the moisture content to approx 3%.

4.2.4 Fuel utilization

a) Assuming leaf of average moisture content, 100 Kg = 78 Kg water, 22 Kg tea. Assuming 75% withers, water content is 53 Kg, or 2.40 Kg water for I Kg tea. Theoretically, it takes 600 kilo-calories to evaporate 1 kg water.

$$\%Efficiency = \frac{1440 \text{ kilo-calories} \times \text{Kg tea made} \times 100\ \%}{\text{Kilo-cal/Kg fuel} \times \text{Kg fuel used}}$$

b) Common fuel consumption figures per 1 Kg tea.

Table 13: *Common fuel consumption figures per 1 Kg tea for a Conventional Dryer*

	Coal (Kg) Hand stoked	Oil (1)		Natural gas (m^3)
	Indirect	Direct	Indirect	Direct
Drying only	1-1.10	0.3-0.4	0.5-0.6	-
Including wither	1.15-1.25	0.4-0.5	0.6-0-7	0.50-0.85

Table 14: *Common fuel consumption figures per 1 Kg tea Fluid Bed Dryer*

	Coal (Kg)	Oil (1)	
Drying only	0.39-0.70	0.17-0.20	0.17 Kg

4.3 Energy utilization

Energy consumption for tea processing is also high which is aggravated by often inefficient and outdated machinery. Tea processing is energy intensive. Withering, drying, grading and packing tea requires 4 to 18 kWh per kg of made tea. Different types of feedstock and energy are used, such as firewood, oil, natural gas, electricity. Roughly 85 percent of the total energy used is thermal energy, each kilogram of made tea requiring 2.5 - 3 kg of steam. Due to insufficient supplies of industrial wood fuel, Kenya's tea industry relies on furnace oil to supply 40-50% of their thermal energy requirements. Although situated in the countryside, all of the tea processing factories have access to grid electricity, but because almost 90% of the energy requirements of tea processing are thermal, the high and rising costs of furnace oil still present a major problem. The environmental impact of tea processing depends on such factors as the use of renewable/ renewed feedstock and the energy efficiency of the machinery. Drying, the most energy-intensive phase of tea processing, is mainly carried out using firewood from natural forests. Energy efficiency is often low because the machinery used is often old and because energy costs represent only a small portion of total production costs (30 percent at factory level) not much attention has been given to this aspect.

4.3.1 Electrical energy

Electrical energy is required for driving the various electro-mechanical machines, fans, blowers, pumps and lighting. About 80% of the total electrical energy demand goes to motor driven systems while the rest is taken up by lighting, and heating. This implies that to optimize the systems, a good understanding on motors and motor driven systems would give one a head start in electrical energy optimization.

4.3.2 Steam Energy

During the distribution of steam, it is essential to consider the energy lost due to transportation. Steam pipe-work layout is important and some areas are important to look into especially when new end users are being introduced or realigned. The length of the steam pipe should be kept as short as possible using the shortest route and avoiding numerous bends so as to reduce the pressure drop. Adequate trapping should be done to eliminate water logging. Expansion bends should be properly fitted to avoid damage of pipeline due to expansion.

It is necessary to keep the steam pipe inclined at a gradient of 13:3000. Branch mains should always be taken from the top of the steam pipe. Adequate lagging is important. Leaks should be addressed as a matter of urgency. Most leaks are found in the poorly closing gate and check valves, flanged joints around the gaskets and in poorly welded joints. In this case a lot of steam does not return as condensate for recovery system and large amount of energy is lost as condensate has over 20% more energy than make up water.

4.3.3 Steam Trapping

A steam trap is an automatic valve that opens to the flow of condensate and prevents the flow of steam. The mechanical steam traps are the most commonly used in the tea industries. These operate by opening when the liquid lifts up the ball and falls closed when the liquid is released. This type follows the saturation curve as the steam has to condensate to open by lifting the float. Depending on whether a steam trap fails shut or open, the steam system suffers two principal consequences. Steam traps that failed shut causes condensate to backup and flood the upstream radiators, reducing heat transfer within the radiators and increasing cycle time. This leads to bursting of the radiators and low temperature of air.

Steam traps that fail open allows steam to directly enter the condensate return system, increasing the pressure in the condensate lines. As line pressure increased, less condensate is able to enter the condensate return system, which further aggravates drainage problems from some radiators especially the flush steam radiator. Eventually, condensate line pressure increases, leading to Ogden dumping more condensate into the drainage system. In both cases, lost condensate required the addition of make-up water to the system.

An inventory of the plant's steam traps is required, alongside training system operators to identify failed traps. There is need to improve communication between maintenance and production personnel so that failed traps are quickly repaired or replaced. We also need to identify traps that were improperly sized or were of the wrong type, and plan for their immediate replacement.

4.3.4 Condensate recovery

It is very essential to recover the thermal energy in the condensate and reduce the amount of makeup water added to the system. Research has shown that for every 6°C rise in feed water temperature, the energy consumption by the boiler reduces by 1% besides saving on chemical treatment costs. An effective water treatment programme is an essential part of planned preventive maintenance schedule of any boiler for maximizing efficiency and reducing down time and operating costs. Poor water treatment leads to scale formation and reduces heat transfer to the water and leads to high fuel gas temperatures. A thickness of 0.5 mm scales can drop efficiency by 7.5%, 1 mm by 10%, 2 mm by 12% and 3 mm by 15%.

Corrosion of the boiler and blockages of the steam lines could also occur, leading to catastrophic damage of the plant. Oxygen pitting is a form of corrosion, which can take place quite rapidly. Oxygen scavenging is therefore essential to eliminate the free molecules of oxygen that could react with the fabric of the plant.

4.5 Energy Efficient Technologies (EET) Options for Tea Industry

4.5.1 Housekeeping Measures

- Reduce heat losses by insulation, avoiding leaks and using proper sized equipment e.g. (motors)
- Preventive maintenance system adoption
- Control of air flow in withering and drying process
- Improve heat transfer efficiency by cleaning tubes and ducts
- Usage of dried fire wood in comparison to moist firewood
- Operational improvements like excess air control
- Improve capacity utilization
- Improve load factor
- Proper production, planning and control

4.5.2 Use of Energy Efficient equipment

- Using energy efficient equipment, like fluidized bed dryers, combined dryers, dual speed trough fans, and direct- fired heaters.
- Use of cleaner and energy efficient fuels
- Recovery of heat from flue gases and recirculation from dryer exhaust

4.5.3 Use of alternate energy sources

- Solar energy for withering or air pre-heating
- Generation of electricity using mini- hydro plants
- Biomass gasification

4.6 Energy Efficient Options for Energy Utilization

4.6.1 Electrical Energy

- Keep the power factor as high as possible preferably around 0.9
- The load factor should be more than 0.6
- For part- load operation, use delta-star connection
- For part- load operation, use variable speed drives
- Fans should be operated at its maximum operating efficiency obtained from the characteristic curves
- Use energy efficient fans
- Use energy efficient motors
- Use energy efficient lighting systems
- Proper operation and proper maintenance of electrical systems and equipments

4.6.2 Thermal Energy

- Proper storage and handling of fuels
- Proper preparation of fuel like sizing etc
- Proper selection of burners/grates
- Proper combustion and control of excess air
- Waste heat recovery equipment installation
- Adequate thermal insulation

4.7 Some specific measures for energy conservation in tea drying

4.7.1 Withering

- Use correct size air fans giving the quality of air only required for withering
- Insulate hot air ducts
- To monitor the quality of air ,use a wet and dry bulb thermosterter at hot air duct and ambient air
- Ventilate withering area well. Never allow withering fans to starve for air
- May use dryer exhaust air for withering green leaf
- Dual speed dual rating energy efficient motor reduces the specific energy consumption in withering.

4.7.2 Drying after fermentation

- Direct-fired heaters are 45% efficient in heat exchange over indirect –fired having 20% efficient
- Recover the waste heat form the flue gases and the dryer exhaust. Around 40% of the total energy input to the heater cum dryer system is lost through the flue gases
- By recalculating the dryer exhaust air ,a fuel saving is recognized

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 15 lists some of the steps described in the more well-known methodologies.

Table 15: *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 in Figure 2

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

Figure 1 ***Overview of the Cleaner Production assessment methodology***
(UNEP, 1996)

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.

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?

5.2.2 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.

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.

Table 16: *Example of information recorded for identified options*

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.

Examples of the types of aspects that could be checked to evaluate improvements are shown in Table 16 above.

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 1)

6. CLEANER PRODUCTION CASE STUDY

This chapter contains a case study of a Cleaner Production assessment carried out at a tea factory in Kenya. The case study provides examples of some specific Cleaner Production opportunities that have proved successful.

6.1 RECP Improvement opportunities

6.1.1 Water Loss

Water is delivered to the factory via electricity driven pump stationed at the River. The pumping station is based at the factory owned piece of land within the river banks. The water is used for washing, steam generation and for domestic purposes. Water is only metered at the pumping station (inlet). On the basis of the estimated water use within the factory, a typical water cost was calculated as follows:

1. Key water use Areas

Area of Use	Rate	Amount (M^3/year)
1.Boiler 1 use	4M^3/hr	3456
Boiler 2 use	3.2M^3/hr	230.4
2.Factory use-Cleaning and Toilets	30M^3/day	7200
3.Domestic use	22M^3/day	5280
Total		**16166.40**

2. Electricity Water Costs

Amount of Electricity used	10800Kwh/month
Amount of Pumped water	2475 M^3/month
Rate of electricity use per M^3 pumped	4.36 Kwh/M^3
Cost per Kwh (Kshs)	14.63

Pumping Cost Electricity	1.84 shs/M^3
Amount of Boiler water treatment	720 liters per year???
Cost of electricity for water treatment (Kshs/year)	176,400.00
Cost of Boiler water treatment per year (Kshs/KwH).	47.85

4. Domestic water treatment costs

Chemical	Amount used/year	Kshs/liter/kg	Amount (Kshs)
Sodium Hypochloride	280 liters	162/liter	45360
Chlorine	120kgs	225/kg	27000
Aluminium Sulphate	155kgs	198/kg	30690

Water pumped per year	24456M^3/year
Total cost for water treatment chemicals per year (Kshs)	279,497.85
Rate of domestic chemical cost per year.	11.43kshs/M^3

6. Cost of water extracted from the river (clarify headings)

Cost in Kshs/year	Amount in M^3/year	Cost per M^3
92000	24456	3.76

8. Amount of water that is not accounted for

Based on the estimated water use, it was revealed that **8289.6M^3/year** could not be accounted for.

9. Weighted cost of water use

Electricity Pumping Cost (Kshs/ M^3)	63.84
Cost of Boiler water treatment per year (Kshs/ M^3)	7.21
Domestic Total Chemical cost per year per M^3 (Kshs/ M^3)	2.47
Cost of extracting the water from the river (Kshs/ M^3)	3.76
Weighted cost of water use per M^3 (Kshs/ M^3)	

From the calculated weighted cost of water, a misuse of one cubic meter of water means Kshs 77 down the drain. Thus the water that was unaccounted for **8289.6M³/year.**

Intervention measures that were put in place

- Sub metering of all the major water use points
- Regular maintenance to fix all the water leaks
- Water saving devices e.g. use of hand triggered horse pipes for washing, use of push taps etc
- Rain water harvesting on replacing the asbestos roofing materials
- Measuring/Record keeping on water use daily
- Training all users on water saving tips
- Attitude change on water as a costed resource

All the RECP measures above were implemented and the factory was able to save **Kshs 638,299/ year.**

6.1.2 Energy use and losses

The factory used wood fuel, furnace oil, diesel and electricity as the main sources of energy. Of all these sources of energy used in the factory, electricity has remained the biggest challenge.

a) **Firewood**

- The firewood was locally sourced from farmers who delivered at a cost of KSH.1400 /M^3. A M^3 produces 300 kg MT
- The species of wood delivered to the factory was not uniform
- There was high competition for the wood and at times there was no enough stock for the factory

Interventions

- Due to the limited wood, the factory installed a multi feed boiler that could use some of the locally available materials that were treated as waste e.g, the maize cob remains (from the maize farmers), bagasse (from the sugar factories), saw dust (saw millers), etc
- The factory started paying the farmers delivering the firewood on the basis of the moisture content of the wood.
- The factory liaised with the farmers delivering the wood to ensure that the wood delivered

was to the desired size that was be fed directly to the boiler to avoid resizing at the factory. This cut down on the cost of energy of resizing (electricity), labour (those resizing), feed time reduced to avoid opening the boiler feed door for too long as this affected the boiler firing, etc

- To avoid any losses of wood, proper recording on wood fed to the boiler to tally with the delivered wood.

b) Furnace oil and Diesel

- The furnace oil used by the boiler. This was one of the most expensive energy sources thus the factory opts to use wood more than the oil.
- The diesel used by the standby generators and the factory vehicles.

RECP Options

- Total avoidance of spillages especially at the emptying area (delivery time)
- Regular maintenance to avoid any spillage and leakage
- On/in time scheduling of the green leaf ferrying vehicles to the factory to avoid wastage of fuel
- Recording of the fuel consumption of the generator to determine its efficiency
- The waste oil generated due to the servicing of the machines, generators, tractors and vehicles was collected, measured and sold to waste oil handlers. This was a source of revenue since right now there is no programme in place for waste oil handling.

The factory was able to save 30% on the good housekeeping practices on oil and diesel handling.

c) Electricity

- Main source of energy
- The energy is mainly used for machine driving, lighting and tea processing
- It is one of the most expensive sources of energy for the factory

RECP Options

- Use of transparent roofing materials in most areas (e.g. the offices, withering section, processing area) to provide adequate lighting during the day. This minimized the use of electricity for lighting

- Metered all the major energy consuming departments for easier monitoring and inform on decision making.
- Trained the all the users on energy management tips
- Attitude change
- Idle machines should not be switched on
- Replaced some of the old machines, fans and mortars that are not energy efficient
- De-lamping some of the areas that had more lighting bulbs than the light area
- Used energy saving bulbs

6.1.3 Green leaf and Tea processing product loss

The main raw materials for tea processing are green leaf. The factory has the capacity to process up to 20 million green leaves a year. The main RECP challenges that the factory faced in the tea processing included the leakages and spillages that affected the overall quantity and quality of made tea. Besides, poor processing led to production of waste that needed disposal.

RECP Intervention

- Regular maintenance of the conveyor belts where most of the spillages and leakages occurred.
- Reworks of the made tea minimized
- Measured all the quantities of spilled products
- Optimized the operations to avoid undesired production

All these measures in the factory within a very short period time saved the factory 45% of the cost of production.

7. BARRIERS TO RESOURCE EFFICIENT AND CLEANER PRODUCTION AND HOW TO OVERCOME THEM

The foregoing chapters have established that RECP 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 tea processing plants. The actual combination of barriers prevailing in each tea 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.

7.1 Attitudinal barriers

There is misconception that implementation of RECP 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 tea 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 CPA 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

Mills 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 CPAs.

In-house CP maintenance provisions

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

Training a plant level CP 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 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 staff often faces 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

- Mechanism to cope with organizational barriers include:
- Sharing 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 (shoo floor workers).

Recognizing and awarding CP 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 SMEs, 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 cannot 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 workshops 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 industry is detrimental to CP 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. Government 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.

8. APPENDICES

APPENDIX 1: RESOURCE EFFICIENT AND CLEANER PRODUCTION (RECP) ASSESSMENT CHECKLIST

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/M^3	Chilled water Kshs/M^3
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 compressor*	*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 = Total cost / 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.

CO2: 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

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

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

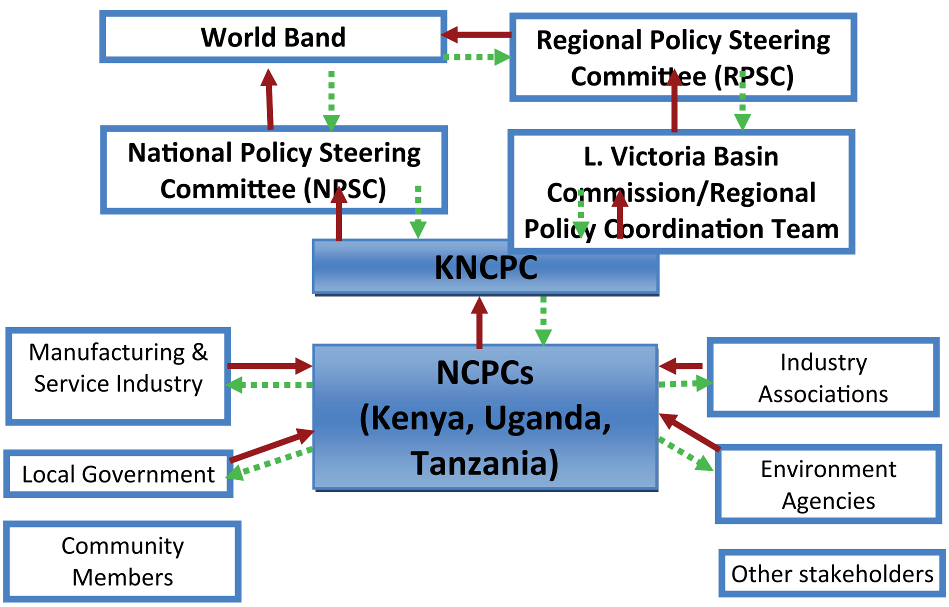
The interventions of the Cleaner Production sub-component shall be on:
Component 1: The promotion of education, information dissemination, and training on resource efficient and cleaner production

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.