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

# RESOURCE EFFICIENT AND CLEANER PRODUCTION (RECP) GUIDANCE MANUAL FOR THE SUGAR PROCESSING INDUSTRY

Jointly prepared by KNCPC, UCPC & CPCT

# ACRONYMS

| | |
|---|---|
| BOD: | Biological Oxygen Demand |
| COD: | Chemical Oxygen Demand |
| CP: | Cleaner Production |
| CPCT | Cleaner Production centre of Tanzania |
| EE: | Energy Efficiency |
| KNCPC: | Kenya National Cleaner Production |
| RECP: | Resource Efficiency Cleaner Production |
| RR: | Renewable Resources |
| RRT: | Renewable Resources Technologies |
| SSE: | Small Scale Enterprises |
| TN: | Total Nitrogen |
| TP: | Total Phosphorous |
| UCPC | Uganda Cleaner Production Centre |

# PREFACE

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

This guide is designed for two principal audiences.

- People responsible for environmental issues at 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 industry on environmental issues.

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

**Chapter 1:** Gives an introduction covering mainly background information about the sector and its contribution to the GDP and impacts to the environment.

**Chapter 2:** 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 3:** Provides an overview of the industry including process descriptions, environmental impacts and key environmental indicators for the industry.

**Chapter 4:** Describes the Resource Efficient and Cleaner Production opportunities

**Chapter 5:** Describes the RECP assessment methodology in detail. This can be used as a reference guide for carrying out a RECP assessment within an organization.

**Chapter 6:** Provides a case study demonstrating the application Cleaner Production in a factory.

**Chapter 7:** Describes barriers to RECP and how to overcome them

# 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 RECP at company level. It is a tool to help managers and staffs think about RECP in a strategic way by assessing the company's current resource use and waste generation, determining whether there is room for improvement, identifying ways to make the improvements and then progressively implementing the changes.

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

# EXECUTIVE SUMMARY

This 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 sectoral. 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 sugar 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 sugar processing plants through the application of Resource Efficiency 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.

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# 1: INTRODUCTION

## 1.1 Kenya Country Overview of the Sugar Sector

### 1.1.1 Background

The sugar industry in Kenya dates back to 1922, with the establishment of the first sugar factories. The industry directly and indirectly supports 5 million Kenyans representing about 16% of the entire Kenyan population. Sugar cane growing is also a major source of income to over 150,000 shareholders. In Kenya, sugarcane is grown on fairly flat regions in the Western, Nyanza and Coast Provinces. About 85% of the total cane supply is from small-scale growers whilst the remaining is from the nucleus estates of the sugar factories.

The Kenya sugar sub-sector supports 20% of Kenya's population and accounts for 15% of agricultural GDP. There are seven major sugar factories in Kenya with a total installed capacity of 22,150 tonnes of cane per day (TCD), which at full capacity for 300 days a year would produce approximately 550,000 tonnes of sugar. This is short of local demand now estimated at over 600,000 tonnes. The consumption of sugar in Kenya is mainly for direct human consumption and industrial use.

**Table 1: Showing Installed capacity of sugar factories in Kenya**

| Factory | Year Built | Installed Capacity (TCD) |
|---|---|---|
| Miwani Sugar Company Ltd (currently closed) | 1927 | 1,500 |
| Chemelil Sugar Company Ltd | 1968 | 3,500 |
| Mumias Sugar Company Ltd | 1973 | 8,400 |
| Nzoia Sugar Company Ltd | 1978 | 3,25 |
| South Nyanza (Sony) Sugar Company Ltd | 1979 | 2,400 |
| West Kenya Sugar Company Ltd | 1981 | 900 |
| Muhoroni Sugar Company Ltd (operating under receivership) | 1966 | 2,200 |

### 1.1.2 Environmental Challenges.

From the wastewater laboratory results analyzed during LVEMP II project, the sugar sector recorded the highest BOD and COD pollution loadings due to high contents of organic matter which serves as food for bacteria. This results in the increase of microorganisms in the water. These increased number of bacteria then use up all the dissolved oxygen in the water. The factory with the highest BOD level at intake to the treatment ponds was 45,600 mg/litre and the lowest was 645 mg/litre. At discharge point to the environment, the highest BOD level was 39,600 mg/litre and 67.5 mg/litre being the lowest. No sugar factory met the required NEMA limits of 30 mg/litre. The best performing effluent treatment plant systems had an intake value of BOD 645 mg/litre and this was reduced to 67.7mg/litre .Another system had an intake value of 4,080 mg/litre and this was reduced to 81 mg/l mg/litre even though this is above the NEMA standards for discharge to the environment, the facilities obtained treatment efficiency of 89.5 % and 98% respectively.

COD was also a challenge to the whole sugar factories as none of them met the recommended NEMA limits of 50mg/litre. The highest intake value was 60,000 mg/litre and the lowest was 1,200 mg/litre. At discharge point, the highest COD levels discharged to the environment was 55,000 mg/litre and the lowest being 400 mg/litre. All the factories have open pond system for wastewater treatment apart from Kibos Sugar Company which is using reverse osmosis to treat its effluent. Only two factories had total nitrogen and phosphorus within the recommended limits at nil and 1.25 mg/litre. NEMA limits at discharge point is 2 mg/litre.

## 1.2 Tanzania country overview of the Sugar sector

### 1.2.1 Background

Tanzania Sugar Industry dates back to the 1920's and 30 are with smallholder cane juggery production in Kilombero and Mtibwa valleys. Production of granular sugar dates from 1931 at Arusha Chini, Moshi by M/s A.S. Tanganyika Planting Company and later at Karangai, Bukoba and Turiani in Arusha, Kagera and Morogoro regions respectively. After independence in 1961, the Government initiated strategies to strengthen production at commercial scale, thereby, witnessing establishment of the Msolwa sugar factory at Kilombero.Government nationalization of private firms in 1967 saw the National Food Corporation (NAFCO) taking charge of the development of the sugar sector; resulting into establishment of the Mtibwa sugar Estates in 1973 and Ruembe sugar factory (Kilombero II) in 1976.

The small Kagera sugar plant damaged by war in 1978 was also re-erected into a large sugar plant commissioned in 1982. In 1974, Government established the Sugar Development Corporation (SUDECO) in place of NAFCO to develop the sugar industry and handle sugar distribution, exportation and importation. In 1992, Sugar trade was liberalized followed by privatization of the sugar companies starting with Kilombero in 1997/98, in 1998/99 Mtibwa, TPC 2000/01 and finally Kagera in 2001/2002. Enactment of the Sugar Industry Act of 2001 caused transformation of SUDECO into the now Sugar Board of Tanzania (SBT) charged with improvement, development and regulation of the Sugar Industry and matters related thereto. The Country's sugar production has in a space of 10 years increased from 113,622 tons in 1998/99 to 279,850 tons in 2008/09. This represents an increase of 140.30 percent sugar production However, the country still depends on sugar imports to satisfy domestic requirement because the current demand is about 41% more than the estimated production.

The sugar industry in Tanzania earns foreign exchange and savings amounting to US$ 28 million per annum. The industry contributes about Tshs. 24 billion to Government revenue (i.e. approx. 1.35% total tax revenue) and provides direct employment to about 14,000 people. The sugar cane out growers total about 30,000 which provide secondary employment under the sector amounting to about 81,360 people. The sector provides cane farmers with total earnings of about Tshs. 24.3 billion (2008/09) whose benefits spread covers a population of over 160,000 people. It also plays a vital role in rural areas in the development and provision of social amenities including schools, hospitals, water supply, townships and farm roads. The sugar sector in Tanzania impacts on the environment due to chemicals used in the plantations as well as by-products generated from the sugar factories.

## 1.3 Uganda country overview of the Sugar sector

### 1.3.1 Background

In 2010, Uganda adopted the National Development Plan (NDP) (2010/11-2014/15). The NDP is the country's medium term strategic direction, development priorities and implementation strategies with a thrust to accelerate socio-economic transformation to achieve the National Vision of a transformed Ugandan society from a peasant to a modern and prosperous country within 30 years. The Plan categorizes agriculture as one of the 8 primary growth sectors i.e. sectors and sub-sectors that directly produce goods and services. The Sugar industry is 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 programs should be able to make use of natural resources gainfully and sustainably to promote competitiveness, independence, self sustenance and a dynamic economy, which is resilient to any external shocks; an economy which supports stability and protection of biological and physical systems.

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

### 1.3.2 Sugar production

Uganda's once substantial sugar industry, which had produced 152,000 tons in 1968, almost collapsed by the early 1980s. By 1989 Uganda imported large amounts of sugar, despite local industrial capacity that could easily satisfy domestic demand. Government in partnership with the private sector with support from development partners have managed to rehabilitate the sugar industry. Uganda's sugar is principally from sugar cane which is grown mainly around Lake Victoria region. By 2010, Uganda produced a total of 297,769 tons of cane sugar with Kakira Sugar Works being the major producer followed by Kinyara, the Sugar Corporation of Uganda Limited (SCOUL) and others producing 157,914 tons, 86,521 tons, 48,334 tons and 5,000 tons respectively (USCTA, 2010).

One interesting aspect of sugar production in the country is the practice of power generation from the cane fiber known as bagasse. Kakira Sugar Works has successfully increased their co-generation capacity to 22 megawatts out of which 12 megawatts are sold to the national grid. SCOUL and Kinyara are also co-generating but for their in-house. Kakira plans to increase its production of sugar, and electricity generation and production of ethanol. If these plans materialize Kakira's electricity generation will rise to 50 megawatts of which 30 megawatts shall be sold to the national grid. Sugar production involves a number of activities that range from cane growing and cutting, transportation, cane crushing and treatment, cleaning using water and disposal of solid wastes and effluents. As a result, the activities concentrate consumption of energy, water and fertilizers among other inputs as well as waste generation in form of noise, odour, solid waste, effluents and emissions among others.

# 2. RESOURCE EFFICIENT AND CLEANER PRODUCTION (RECP)

## 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 THE SUGAR PROCESSING

## 3.1 Sugarcane processing

### 3.1.1 Cane reception, cleaning and size reduction

The cane is received at the mill and prepared for extraction of the juice. At the mill, cane is mechanically unloaded, placed in a large pile. The milling process occurs in two steps: breaking the hard structure of the cane and grinding the cane. Breaking the cane uses revolving knives, shredders, crushers, or a combination of these processes. For the grinding, or milling, of the crushed cane, multiple sets of three-roller mills are most commonly used although some mills consist of four, five, or six rollers in multiple sets. Conveyors transport the crushed cane from one mill to the next.

### 3.1.2 Imbibition and Clarification

Imbibition is the process in which water or juice is applied to the crushed cane to enhance the extraction of the juice at the next mill. In imbibition, water or juice from other processing areas is introduced into the last mill and transferred from mill to mill towards the first two mills while the crushed cane travels from the first to the last mill. The crushed cane exiting the last mill is called bagasse. The juice from the mills is strained to remove large particles and then clarified. In raw sugar production, clarification is done almost exclusively with heat and lime (as milk of lime or lime saccharate). Small quantities of soluble phosphate also may be added. Lime is added to neutralize the organic acids, and the temperature of the juice is raised to about 95$^{o}$C (200$^{o}$F). A heavy precipitate forms which is separated from the juice in the clarifier. The insoluble particulate mass, called "mud", is separated from the limed juice by gravity or centrifuge. Clarified juice goes to the evaporators without additional treatment. The mud is filtered and the filtercake is washed with water.

### 3.1.3 Evaporation

Evaporation is performed in two stages: initially in an evaporator station to concentrate the juice and then in vacuum pans to crystallize the sugar. The clarified juice is passed through heat exchangers to preheat the juice and then to the evaporator stations. Evaporator stations consist of a series of evaporators, termed multiple-effect evaporators; typically a series of five evaporators. Steam from large boilers is used to heat the first evaporator, and the steam from the water evaporated in the first evaporator is used to heat the second evaporator. This heat transfer process continues through the five evaporators and as the temperature decreases (due to heat loss) from evaporator to evaporator, the pressure inside each evaporator also decreases which allows the juice to boil at the lower temperatures in the subsequent evaporator. Some steam is released from the first three evaporators, and this steam is used in various process heaters in the plant. The evaporator station in cane sugar manufacture typically produces syrup with about 65 percent solids and 35 percent water. Following evaporation, the syrup is clarified by adding lime, phosphoric acid, and a polymer flocculent, aerated, and filtered in the clarifier. From the clarifier, the syrup goes to the vacuum pans for crystallization.

### 3.1.4 Crystallization

Crystallization of the sugar starts in the vacuum pans, whose function is to produce sugar crystals from the syrup. In the pan boiling process, the syrup is evaporated until it reaches the super saturation stage. At this point, the crystallization process is initiated by “seeding” or “shocking” the solution. When the volume of the mixture of liquor and crystals, known as massecuite, reaches the capacity of the pan, the evaporation is allowed to proceed until the final massecuite is formed. At this point, the contents of the vacuum pans (called “strike”) are discharged to the crystallizer, whose function is to maximize the sugar crystal removal from the massecuite. Some mills seed the vacuum pans with isopropyl alcohol and ground sugar (or other similar seeding agent) rather than with crystals from the process.

### 3.1.5 Centrifugation

From the crystallizer, the massecuite (A massecuite) is transferred to high-speed centrifugal machines (centrifugals), in which the mother liquor (termed “molasses”) is centrifuged to the outer shell and the crystals remain in the inner centrifugal basket. The crystals are washed with water and the wash water centrifuged from the crystals. The liquor (A molasses) from the first centrifugal is returned to a vacuum pan and reboiled to yield a second massecuite (B massecuite), that in turn yields a second batch of crystals. The B massecuite is transferred to the crystallizer and then to the centrifugal, and the raw sugar is separated from the molasses. This raw sugar is combined with the first crop of crystals. The molasses from the second boiling (B molasses) is of much lower purity than the first molasses. It is reboiled to form a low grade massecuite (C massecuite), which goes to a crystallizer and then to a centrifugal. This low-grade cane sugar is mingled with syrup and is sometimes used in the vacuum pans as a “seeding” solution. The final molasses from the third stage (blackstrap molasses) is a heavy, viscous material used primarily as a supplement in cattle feed. The cane sugar from the combined A and B massecuite is dried in fluidized bed or spouted bed driers and cooled. After cooling, the cane sugar is transferred to packing bins and then sent to bulk storage. Cane sugar is then generally bulk loaded to trucks, railcars, or barges.

**The following is a schematic process flow for sugar production showing stages where RECP are applied.**

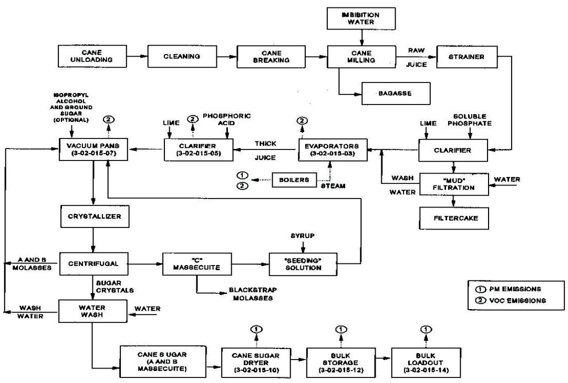


Figure 1: A typical Sugar Production Process showing stages where RECP are applied

# 4. RESOURCE EFFICIENT AND CLEANER PRODUCTION OPPORTUNITIES

## 4.1 Energy Resource

### 4.1.1 To reduce energy loss through steam loses

- Proper and regular cleaning of equipment to prevent leaks and losses
- Optimize location of steam traps to prevent discharge in closed flumes
- Ensure proper level of liquid to be concentrated in boilers and evaporators
- Ensure high and constant syrup concentration
- Send condensate from first body directly to the de-aerator tank without previous flashing
- Reuse vapour by re-injecting in the evaporation vessels
- Train and instruct workers on resource efficiency
- Proper installation of pipes and flanges
- Install plate heat exchanger prior to the first evaporation body
- Re-use heat from hot condensate to pre-heat mixed juice by means of plate heat exchangers
- Recycle vapours by means of Thermal and Mechanical Vapour Recompression (TVR, MVR)

### 4.1.2 Reducing high energy consumption

- Implement improved maintenance and monitoring through visual observation and control records. Some points to be checked are defects of boilers, insulation, boiler running, air entrance and insufficient recycling of condensates.
- Improve combustibility of bagasse by obtaining good conditions of floatation and by regular and controlled feeding.
- Send condensates from 1st body (and eventually part of 2nd), directly to the de-aerator tank without previous flushing.
- Reduce heat losses from un burnt matter and ashes
- Recycle the heat content of boiler bleedings through direct heat exchange water
- Setup a cogeneration plant
- Decrease sucrose and water content in bagasse by improving juice extraction
- Decrease water content of bagasse by installing bagasse dryers
- Carry out proper insulation of steam pipelines and flanges
- Recycle exhaust heat through heat exchanger
- Install modern high pressure boilers
- Apply complete automation of boiler running
- Reduce the number and duration of stoppages
- Improve the system of repartition in the power distribution
- Install variable drive motors
- Install static capacitor

- Install high efficiency continuous centrifugation

## 4.2 Material loss

### 4.2.1 Mechanical losses of sucrose

- Prevent cane spillages, juice leakages and accumulation of bagasse and cane trash
- Implement internal centrifugal separator
- Install wire mesh entrainment separator
- Install external centrifugal separator between last body and condenser
- Prevent overflow from tanks by installing automatic control
- Recuperate mechanical loses from overflow of massecuite, syrup, molasses etc.
- Control cleanness and systematic melting and recycling of lines
- Change to multi-tube dryer with small diameter
- Improve efficiency of sugar cyclone

### 4.2.2 Chemical loses of Sucrose

- Proper and regular sanitation
- Perform periodic lab tests such as reassurance test
- Use superheated water from de-aerator instead of steam or warm water
- Apply cleaning water with high pressure hoses with small nozzles
- Apply optimal pH, temperature and retention time (RT) in tanks, heater and clarification
- Apply proper concentration of process auxiliaries
- Install efficient bagasse separators
- Install screens at the clarifier exit to remove last final scums and bagacillo
- Apply appropriate instrumentation and automation devices
- Adopt appropriate coagulant to the nature of the juice e.g. preliminatry laboratory tests
- Improve scraper condition and apply as low as possible scraper speed
- Use high quality process auxiliaries (Lime, sulphur, polyelectrolyte)
- Install well dimensioned equipment
- Optimize design of clarifier
- Replace tubular heaters with plate heat exchanger Transform clarifier into higher speed clarifier
- Install high speed clarifier
- Optimize flow and temperatures
- Improve fouling control and cleaning system
- Pre-heat clear juice entering the body, preferably by using plate heat exchanger
- Prevent recirculation in the tubes by internal designing
- Install parallel bodies to enable continuous cleaning

### 4.3 Water resources

#### 4.3.1 Minimizing condensing and cooling water

- Monitor and control the coolers efficiently permanently
- Measure and evaluate water flows at decentralized sections within the factory
- Monitor and repair water leaks through valves, joints, glands etc.
- Recycle used condenser and cooling water

#### 4.3.2 Minimizing evaporator losses

- Increase the exchange superficies of tower or pool aspersion coolers
- Transform actual pool aspersion cooler into mist condensing system
- Replace actual co-current barometric condenser by counter currents condenser

#### 4.3.3 Cutting down water used for sanitation and cleaning

- Use condensate from purity 1 tank of cold or warm water as imbibition water
- Use condensate from purity 1 tank instead of cold water to prepare the lime suspension
- Re-use filter coat wash water (in case of rotary filter belt type) as imbibition water
- Use condensate from purity 2 tank to dilute the molasses and magma for re-melting
- Use warm water instead of cold water for heat exchange cleaning
- Use dry cleaning method instead of hoses to wash the floors
- Step up cleaning activities of the water recalculating system
- Use a dry cleaning method instead of water to remove trashes from lane conveyors
- Use sprinklers of paddles instead of water hoses for equipment cleaning and sanitation

# 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 2 bellow lists some of the steps described in the more well-known methodologies.

**Table 2: 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<br>2. Pre-assessment<br>3. Assessment<br>4. Evaluation and feasibility study<br>5. Implementation and continuation |
| UNEP, 1991 | *Audit and reduction manual for industrial emissions and waste Technical report series NO. 7* | 1. Pre-assessment<br>2. Material balance<br>3. Synthesis |
| Dutch Ministry of Economic Affairs, 1991 | *Prepare Manual for the Prevention of Waste and Emissions* | 1. Planning and Organization<br>2. Assessment<br>3. Feasibility<br>4. Implementation |
| **USEPA, 1992** | *Facility Pollution Prevention Guide* | 1. Development of pollution prevention<br>2. Programme<br>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 1 bellow.

**Phase I: Planning and organization**

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

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**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?

### 5.2.3 Establish a focus

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

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

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

## 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 sugar. 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 2: Example of information recorded for identified options**

| Problem type | Problem description | RECP options |
|---|---|---|
| **Examples:**<br>• Resource Consumption<br>• Energy consumption<br>• Air pollution<br>• Solid waste<br>• Wastewater<br>• Hazardous waste<br>• Occupational health and safety | **Examples:**<br>• Name of process and department<br>• Short background of Problem<br>• Amount of materials lost or concentration of pollutants<br>• Money lost due to lost resources | **Examples:**<br>How the problem Can be solved<br>• Short-term solution<br>• Long-term solution<br>• Estimated reductions<br>• In resource<br>• Consumption and<br>• Waste generation |

## 5.4 Evaluation and feasibility study

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

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

### 5.4.1 Preliminary evaluation

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

### 5.4.2 Technical evaluation

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

### 5.4.3 Economic evaluation

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

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

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

### 5.4.4 Environmental evaluation

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

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

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

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

Given the wide range of environmental issues, it will probably be necessary to prioritize those issues of greatest concern. In line with the national environmental policy of the country, some issues may have a higher priority than others.Aspects to be considered in the evaluation are:

#### i) Preliminary evaluation

- Is the Cleaner Production option available?
- Can a supplier be found to provide the necessary equipment or input material?
- Are consultants available to help develop an alternative?

- Has this Cleaner Production opportunity been applied elsewhere? If so, what have been the results and experience?
- Does the option fit in with the way the company is run?

**ii) Technical evaluation**

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

**iii) Economic evaluation**

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

**iv) Environmental evaluation**

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

### 5.4.5 Select options

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

## 5.5 Implementation and continuation

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

### 5.5.1 Prepare an implementation plan

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

- Activities to be carried out;

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

### 5.5.2. Implement selected options

As for other investment projects, the implementation of Cleaner Production options involves modifications to operating procedures and/or processes and may require new equipment. The company should, therefore, follow the same procedures as it uses for implementation of any other company projects.However, special attention should be paid to the need for training staff. The project could be a failure if not backed up by adequately trained employees. Training needs should have been identified during the technical evaluation.

### 5.5.3 Monitor performance

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

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

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

### 5.5.4 Sustain Cleaner Production activities

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

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

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

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

Like the Cleaner Production assessment, an environmental management system should be assessed and evaluated on an ongoing basis and improvements made as required. While the specific needs and circumstances of individual companies and countries will influence the nature of the system, every environmental management system should be consistent with and complementary to a company's business plan. (See attached checklist in appendix 1)

# 6: CLEANER PRODUCTION CASE STUDY

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

## 6.1 Water Conservation at a Kenyan Sugar Factory

The factory establishment dates back to 1970`s. Initial Water Consumption was 2,240,172 $m^3$/yr at the beginning of the exercise. There was no metering and sub-metering of water at point of river abstraction and different points of use. The end result was that, the company was only estimating its water use.

## 6.2 Intervention

Together with the company RECP teams formed, KNCPC and the company

- Embarked on a cultural change initiative
- Put in place metering and sub-metering of water consumption
- Adopted routine maintenance of the water distribution pipe work
- Established baseline water consumption for purposes of benchmarking future improvements
- Initiated Cultural Change – Managing Mindsets
- Made a commitment through an environmental policy
- Underscored the need for employees to go out of their way to "walk the talk" even when the going got tough
- Engaged all staff and made them part of the solution
- Secured an appropriate financial commitment
- Cultural change – Managing Mindsets
- Set up committees to develop "small improvement steps"
- Set up action teams for "huge leaps"
- Provided feedback to all staff on improvement measures
- Managed to change 25-year old mindsets to embrace eco-efficiency
- Encouraged staff to forget "how they've always done things"
- Encouraged management to adopt an "invest to save" culture

### 6.2.1 Small steps

- We installed percussion (push taps) on all wash hand basins
- We recommended low flush toilets and passive infrared sensors
- We initiated a system for fixing leaks as soon as they are reported

- We put in place infrastructure for rain water harvesting for flushing toilets

### 6.2.2 Big steps

- As a baseline, we metered and sub-metered water abstraction, water use in different consumptive departments, effluent discharge and set 50% reduction targets – savings to a reward scheme
- We fixed all leaks and overflows immediately
- We installed hand trigger nozzles on all hose pipes
- We introduced a culture of using a brush to sweep up slurries rather than using a hose
- Cascade water from high purity uses to lower grade uses, e.g. using boiler steam condensate in juice extraction.

## 6.3 Result

Water savings of up to 50%. This contributed to the competitiveness of the sector as water, energy and effluent treatment costs were reduced. It was difficult to distinguish water management from energy management given that steam as a form of energy eventually becomes water.

## 6.4 Some Learnt Lessons

- Most industries have a Weak measurement and record Keeping culture
- Kept production records are not analyzed to inform decision making
- There is need for the development of key performance indicators to aid in benchmarking and continual improvement
- The team work spirit is not easy to introduce in most industries
- Adoption of simple CP options translate into immense savings

## 6.5 Conclusion

It was evident that with adoption of CP, enterprises can save up to 50% on resources input. Most of the cp options highlighted in this case study are of No-Cost and Low-cost options.

# 7: BARRIERS TO CP AND HOW TO OVERCOME THEM.

The foregoing chapters have established that CP is a proactive approach to improve profitability, internal working environment and pollution and waste and emission reduction in the sugar industry. Often times however, several types of barriers can block or slow the progress of a CP programme.Discussed here below are major barriers to be overcome for smoother CP 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 sugar processing plants. The actual combination of barriers prevailing in each 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 CP costly. However, in actual fact this has been found to be not always true as in each enterprise there are CP opportunities which can be adopted at very minimal cost. But this mind set tends to act as an attitudinal barrier to CP implementation. CP 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

### 7.1.1 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 sugar processing industries in the context of short term profit making business strategies.

### 7.1.2 Resistance to change

Plant employees generally resist change that demands adoption of CP 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 CP 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 CP successes

**7.1.2.1 Early success:** Since early success might encourage management as well as staff to continue experimentation with CP, 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.

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

**7.1.2.3Encouraging 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, eg 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.

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

### 7.1.3 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 CP 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 CP 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

### 7.1.3.1 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.

### 7.1.3.2 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.

### 7.1.3.2 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 CP 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 CP.

*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 CP maintenance provisions
- Training a plant level CP 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 a head 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 CP team at the start of a CPA is highly recommended. Such training should clarify the objective of CP 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

CP success stories can help to create and raise CP 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 CP. Sectoral as well as generic manuals and workshops can contribute to the dissemination of such success stories.

### 7.1.4 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 CP. Shop floor supervisors and technical staff members should be involved in the project team, which in turn should cooperate with outside consultants.

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

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

### 7.1.4.1 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 shareof decision-making responsibility, employees lack the initiative to take up new and challenging assignments such as CP, and if a CP team is formed, its members might not feel they have a real stake in the process.

### 7.1.4.2 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 CP and housekeeping standards to boost output.

### 7.1.4.3 Non-involvement of employees

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

### Enabling Measure

Mechanisms to cope with organizational barriers include:

- Sharing of information
- Organizing a capable project team
- Recognizing and rewarding CP 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 CP team is key to developing the CPA and eliminating barriers to CP. It might be difficult to establish and effective team, however, given the widespread lack of recognition and low prioritization of CP, 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 CP 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 CP 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.

### 7.1.4 Technical barriers

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

- Limited technical capabilities

- Limited access to technical information
- Technology limitations

### Limited technical capabilities

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

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

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

*Limited maintenance facilitie*s: The maintenance departments 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 CP.

### 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 CP 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 CP. This staffs members easily absorb the CP 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 CP solutions or to translate improvements suggested by outside experts in such solutions.

**Disseminating success stories about CP techniques and technologies**

Disseminating success stories of CP techniques and technologies could do a great deal to abate existing technical constraints. The publication of CP technical manuals and the organization of workshops and seminars are useful media for disseminating such stories. To standardize the practice of successful CP 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.

### 7.1.5 Economic Barriers

Major economic barriers to CP 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

#### 7.1.5.1 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 CP to secondary levels of importance.

#### 7.1.5.2 Low prices and easy availability of raw materials

The impetus to identify and implement CP 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.

#### *7.1.5.3 Ad hoc* investment policy

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

*Limiting economic analysis to obvious direct costs and benefits*: The economics of all investments, including CP 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 CP measures. Failure to include such criteria in economic analysis is therefore unfavourable to the acceptance of CP.

*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 CP, 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.

#### 7.1.5.4 High cost and low availability of capital

Most financial institutions are not willing to finance cost incentive CP 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 CP 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 CP investment.

### Implementing financially attractive options

Implementing cost-effective low- and no-cost CP 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 CP programme. To illustrate the potential for savings from CP, 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 CP 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 CP options, financial schemes that give priority to CP 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 CP investments for SMEs. Governments could also institute fiscal incentives for CP, such as a 100 per cent depreciation allowance on private CP investments, a government purchasing policy favourable to companies committed to CP and a concessional corporate tax for companies that perform automatic capacity enhancements.

## 7.1.6 Government Barriers

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

#### 7.1.6.1 Industrial policies

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

#### 7.1.6.2 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 CP practices which are not necessarily recognized by these authorities

### Enabling measures

Governments can adopt the following measure to foster CP:

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

### Financial Incentives

Government could develop financial schemes that give priority to CP 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 CP investments for SMEs. Governments could also institute fiscal incentives for CP such as 100 percent depreciation allowance on private CP investments, a government purchasing policy favourable to companies committed to CP and concessional corporate tax for companies that perform automatic capacity enhancements.

### Area-wide volunteer CP groups

The government could set the stage for area-wide volunteer CP 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 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* | | | |
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| **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* |
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**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* |
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**Worksheet 11: Potential RECP opportunities**

| Opportunity<br>Potential resource saving<br>Passed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Water** | **Energy** | **Packaging** | **Chemical** | **Solid waste** | **Waste water** | **Other(e.g. labour, maintenance)** | **preliminary evaluation Yes/No** | |
| *e.g. Reduce timers on filling machine cleaning cycle* | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

## Worksheet 12: Economic evaluation of RECP opportunities

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

# 9. Appendix 2: 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

**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

**N**-Nitrogen

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

**P**-Phosphorus

**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

**UCPC**-Uganda Cleaner Production Centre

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

**UNIDO**-United Nations Industrial Development Organization

**UN**-United Nations
**U**

# 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

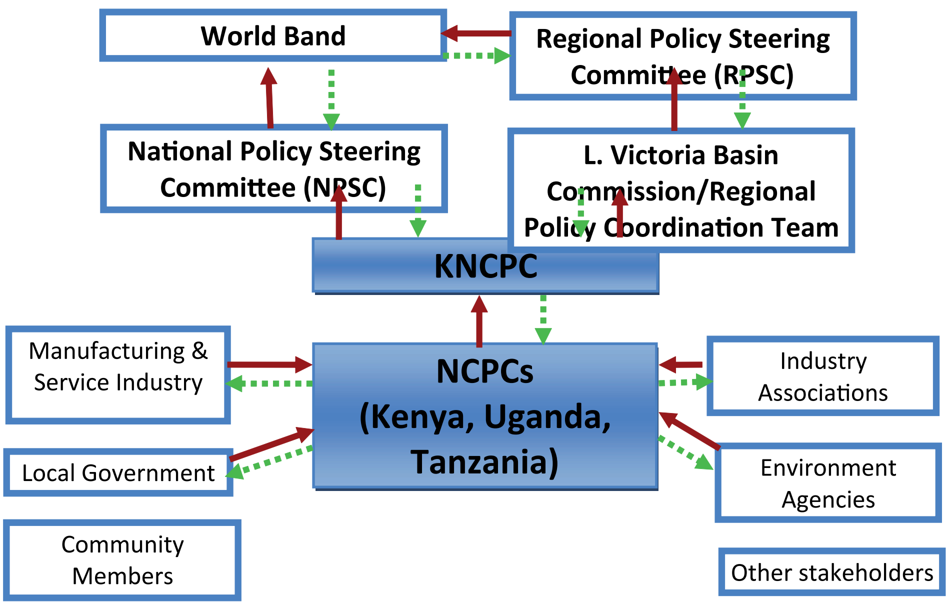
The interventions of the Cleaner Production sub-component shall be on:
Component 1: The promotion of education, information dissemination, and training on resource efficient and cleaner production

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.