

GREENING UGANDA'S URBANIZATION AND INDUSTRIALIZATION
Developing Material and Energy flow plan and Industrial Symbiosis
layout plan for Soroti Industrial and Business Park

Submitted to



By

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Acronyms

BOD	Biochemical Oxygen Demand
CE	Circular Economy
CO ₂ eq	Carbon dioxide equivalent
IS	Industrial Symbiosis
COD	Chemical Oxygen Demand
EU	European Union
GHG	Greenhouse Gases
J	Joules
Kv	Kilo Volts
kVA	Kilo-Volt-Amperes
kVAr	KiloVolt-Ampere Reactive
kWh	Kilo Watt-hour
MFA	Material Flow Analysis
MJ	Mega Joules
MW	Mega Watts
MWE	Ministry of Water and Environment
MTIC	Ministry of Trade Industry and Cooperatives
NPA	National Planning Authority
NEMA	National Environment Management Authority
NIP	National Industrial Policy
NDP	National Development Plan
RECP	Resource Efficiency and Cleaner Production
SMEs	Small Medium scale Enterprises
UGGDS	Uganda Green Growth Development Strategy
UIA	Uganda Investment Authority
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization

Abstract

Global Green Growth Institute (GGGI) has partnered with the European Union (EU) as part of the EU-inclusive green economy uptake program (Green UP). GGGI currently delivers a project titled “Greening Uganda’s Urbanization and Industrialization” (2020-2023). The program is aligned with the government of Uganda’s Vision 2040, the third National Development Plan (NDP III), and the Uganda Green Growth Development Strategy (UGGDS). The project promotes sustainable development and inclusive green growth in Uganda. It focuses on green city development, green industrialization, efficient waste management, and green growth integration into planning and budgeting. The main objective is to develop green masterplans including symbiotic infrastructure plans and project concept notes for the Entebbe International Airport Freezone (EIAFZ), Soroti Business and Industrial, and Dero Pakwach Eco-Industrial Zone

This report presents a Resource Efficient and Cleaner Production (RECP) assessment carried out at Soroti Industrial and Business Park. The RECP assessment entailed carrying out material and energy flow analysis to establish waste generation trends of potential sectors and selected feasible sectors/processes based on the environment-bearing capacity of the park, identify potential areas for substitutions of materials, detect opportunities for new technologies that help reduce inefficiencies in energy and materials use, increase domestic reuse or recycling, and the use of alternative materials. Material and energy flow analysis was carried out following the guidance of the UNIDO RECP toolkit. The RECP assessment also included mapping industrial symbiosis synergies using the UNIDO industrial symbiosis identification tool. The proposed RECP improvement measures were informed by the best available techniques/technologies in manufacturing enterprises.

According to the Uganda Investment Authority, Soroti Business and Industrial Park will be dominated by agro-food processing enterprises. The agro-food processing enterprises are water and energy-intensive generating large volumes of wastewater and solid waste. In the business-as-usual scenario, Soroti Industrial Park is projected to have a total energy demand of about 1,828,599 GJ per year, total water demand of 2,499,718 m³ per year, and generate over 2,499,718 m³ of wastewater and 220,926 tons of organic solid waste annually. Transition to the eco-industrial park through the adoption of Resource Efficient and Cleaner Production and Industrial symbiosis can reduce total energy demand by 1,021,845.39GJ per year, water demand by 1,280,854.22 m³ per year, and zero organic waste generation. The recommended RECP measures to facilitate the transition to an eco-industrial park include; the installation of frequency converters (or variable speed drivers, the use of Energy-efficient lighting systems, the use of high-premium efficient motors (IE4), the use of Closed-circuit cooling, adopting an Energy efficiency plan or energy management system, use of a low-pressure foam and/or gel, opting for high-pressure cleaning, Use of automated flow regulators, optimization of chemical dosing and water use in cleaning-in-place and maximization of condensate return.

Investment in shared infrastructure can enhance the capacity of Soroti Industrial Park to harness industrial symbiosis synergies. The potential industrial symbiosis synergies for Soroti Industrial and Business Park include peel oil recovery from orange peels, carbon dioxide recovery from ethanol production, and phosphate recovery from wastewater. Harnessing such synergies can achieve zero (organic) waste generation thus contributing to the transition to an eco-industrial park. The proposed shared infrastructures include a shared steam generation and distribution system using a parallel modular boiler system, a power distribution and stabilizing system for the SME hub, a park house with cold storage powered by a parallel compressor racks refrigeration system, and an Aflatoxin test laboratory.

The implementation of RECP and Industrial symbiosis measures has the potential to reduce GHG emissions of Soroti Industrial and Business Park by 200,334.48 tCO₂eq per year.

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1. Background

1.1. Introduction

Based in Seoul, the Global Green Growth Institute (GGGI) is an intergovernmental organization founded to support and promote green growth. It targets key aspects of economic performance such as poverty reduction, job creation, social inclusion, and environmental sustainability. GGGI works with countries around the world, building their capacity and working collaboratively on green growth policies that can impact the lives of millions. The organization partners with countries, multilateral institutions, government bodies and the private sector. This is to help build economies that grow more economically and efficiently. Ultimately, they become more effective and sustainable in the use of natural resources, less carbon intensive, and more resilient to climate change.

GGGI is partnered with the European Union (EU) as part of the EU inclusive green economy uptake programme (GreenUP). At present, it is delivering a project entitled “Greening Uganda’s Urbanization and Industrialization” (2020-2023). The programme is aligned with the government of Uganda’s Vision 2040, the third National Development Plan (NDP III), and the Uganda green growth development strategy (UGGDS). The project promotes sustainable development and inclusive green growth in Uganda. It focuses on green city development, green industrialization, efficient waste management and green growth integration into planning and budgeting.

1.2. Objectives

To support Uganda in becoming mid-income status via industrialization, the project hopes to support the development of 3 industrial locations at Entebbe, Soroti and Pakwach. The overall goal is to design the infrastructure to allow the industrial park and its contextual city to thrive, as an economic system. Develop green masterplans including symbiotic infrastructure plans and infrastructure project concept notes for the 3 locations.

The scope of work is predicated by the ambition to achieve industrial-urban symbiosis. Thus, future strategic infrastructure is to be planned and designed to serve both the industrial park and the wider city in a green way. This extends to planning and engagement with not only those responsible for the development of the industrial park but also, the city council and local businesses. The consultant will be the primary expert for resource efficiency and cleaner production deliverables with supervision from the team leader.

1.3. Status of Soroti Industrial Park

Soroti Industrial and Business Park covers 219 acres and is in Temere, Arapai Sub County, 5 Kilometers North of Soroti Town, in the Eastern part of Uganda. At the time of assessment, UIA has allocated most of the IP land with just 6 acres left for SMEs and no count on infrastructures, as shown in Annex 3 “Schedule of Leases for Soroti Industrial and Business Park May 2023.”

2. Methodology

2.1. Stakeholder Identification and Consultations

The consultant carried out a stakeholder analysis to identify the key stakeholders that may influence or be impacted by sustainable industrialization in the target areas. (See annex 1) Stakeholder consultations aimed at ensuring that the proposed sustainability options are in the interest of stakeholders. The consultant engaged with the above stakeholders to integrate their opinions in designing of RECP improvement measures, carrying out material and energy flow analysis, and identifying industrial symbiosis synergies. Stakeholders’ consultations were conducted through holding online and physical meetings.

Discussions with stakeholders were guided by questionnaires and toolkits (indicated in annex 4). Data collected was analysed to inform proposed green projects for Soroti Industrial and Business Park.

2.2. Material and Energy Flow Analysis

Material Flow Analysis (MFA) is the study of the physical flows of natural resources and materials into, through and out of a given system. Material flow analysis helps to identify waste of natural resources and other materials in a defined system that would otherwise go unnoticed in conventional economic

monitoring systems. Material flow analysis enables manufacturing entities to trace the flow of raw materials through the company; retrace waste to the point where it is generated; identify weaknesses in the production process; and set priorities for appropriate measures aimed at minimizing waste and emissions.¹ Material flow and energy flow analysis was carried out for Soroti Industrial and Business Park to:

- i. Establish waste generation trends of the potential sector, and select feasible sectors (process and activities) based on the environmental bearing capacity of the site,
- ii. Identify potential areas for substitutions of materials.
- iii. Detect opportunities for new technologies that help reduce inefficiencies in energy and materials use, increase domestic reuse or recycling, and the use of alternative materials.

Material and energy flow analysis was carried out following the guidance of UNIDO RECP toolkit see [PR-4-Worksheets-4_0.doc \(live.com\)](#). Material flow was calculated based on the law of mass balance with the formula in equation 1.

$$\sum_{i=1}^n M_i = \sum_{o=1}^n P_o$$

Equation 1

Data used in the toolkit was obtained from operational enterprises in in the park and enterprises operating outside the park with similar unit/process operations as those allocated land in the park that are either in pre-state or construction phase. Additional data was obtained from published resource use and environment performance indicators of the target sectors.

Data and information obtained from material and flow analysis were used to establish energy, water, and emission (effluent) intensities of potential sectors. The established intensities were used to calculate projected energy and water demand, GHG emission, and wastewater pollution load using the formulas below.

$$\text{Pollution load} = K \sum_1^n C_i Q_i \Delta t \quad \text{GHG reduction} = \sum_j^n F_j E_j \quad \text{Water Demand} = \sum_p^n W_p O_p$$

$$\text{Energy Demand} = \sum_p^n E_{in_p} O_p$$

Where

k-Conversion constant	F-GHG emission factor	p- type product processed.
C-Concentration of a Pollutant	E-energy saving potential.	W-Water Intensity
Q-wastewater flow rate	j-Energy Efficient Option	O-Production Output
Δt-Period of Production	i-Pollution parameter	E _{in} -Energy intensity

¹ [PR-3-Textbook-heft3_14072003neu \(unido.org\)](#)

2.3. Identification of Resource Efficient and Cleaner Production options

In practical terms, RECP entails the continuous application of preventive environmental strategies to processes, products and services to increase efficiency and reduce risks to humans and the environment. RECP addresses the three sustainability dimensions individually and synergistically: a) heightened economic performance through improved productive use of resources, b) environmental protection by conserving resources and minimizing industry's impact on the natural environment, and c) social enhancement by providing jobs and protecting the well-being of workers and local communities.

To identify RECP options for the feasible sectors. The consultant engaged the technical team of operational enterprises in Soroti Industrial and Business Park to establish the baseline manufacturing practices. He further engaged operating enterprises outside the park with similar process operations as enterprises allocated land in Soroti Industrial and Business Park to establish business-as-usual manufacturing practices. The proposed RECP measures were informed by successfully implemented RECP options in manufacturing enterprises in Uganda as well as published best available practices and technologies.²

2.4. Identifying Industrial Symbiosis Synergies and Infrastructure Layout Plan

Industrial parks use large quantities of resources, resulting in considerable waste. This accelerates the rate of raw materials' depletion and waste accumulation creating a need for stakeholders to shift from linear to circular business models by adopting novel strategies. Industrial Symbiosis (IS) employs a cross-organizational perspective to seek synergistic pairings of one company's waste output to another company's input, enabled by inter-firm cooperation through resource and information sharing.³ IS encompasses all types of interfirm cooperation to achieve a green, waste-free supply chain and at the same time to attain profits.

To develop an industrial symbiosis layout plan, the consultant undertook a mapping of industrial symbiosis synergies using UNIDO industrial symbiosis identification tool accessible from [Eco-Industrial Parks - Tools | UNIDO Knowledge Hub](#). The identified Industrial symbiosis synergies were screened, evaluated and selected priorities synergies (project).

² [BAT reference documents | Eippcb \(europa.eu\)](#)

³ Zhiquan Yeoa,b, Donato Masic, Jonathan Sze Choong Lowb, Yen Ting Ngb Puay Siew Tanb, Stuart Barnesa Tools for promoting industrial symbiosis: A systematic review, WMG, International Manufacturing Centre, University of Warwick, Coventry, CV4 7AL [Tools for promoting industrial symbiosis: A systematic review \(warwick.ac.uk\)](#)

3. Findings From the RECP Assessments

3.1. Material and Energy flow analysis

3.1.1. Mango and Orange Processing

The field mission revealed that there is one factory (Soroti Fruits Factory Ltd) processing oranges and mangoes and one factory (Teso Foods Ltd) under construction with plans to establish an orange and mango processing facility. According to the Quality control Manager, Soroti Fruit Factory (TEJU) has two production lines to process Mangoes and oranges Each line has a designed production capacity of 6 tons per hour. The actual production output of each line is reported to range from 1400 tons to 6000 tons (of oranges and mangoes) per year. The factory processes mango puree and orange concentrate twice a year (during harvest season). On average the factory operates at 20% of the installed production capacity. The major factor that limits production at Teju is the ability to market mango puree and orange concentrates. The company is aware of this challenge and has plans to increase the sales of its products in the export markets. The factory has acquired an additional land of about 5 acres with plans to double production capacity.

According to the Chief Operation Officer Teso Foods Ltd plans to establish a fruit processing factory with two production lines to process oranges and mangoes. The planned production capacity of each production line is 1000 liters of juice per hour.

Material flow of Mango and Orange processing

The mango processing industries generate millions of tonnes of solid waste, approximately 40-50% of the raw material. The peels and fiber of the mangoes make up 7-24% of the total weight of the fruit. Based on the variety of mango, the mango seed accounts for 20-60% of the fruit weight. The mango kernel inside the seed accounts for 45-75% of the seed's weight. For every ton of Orange processed 16.9 kg of essential oil can be produced and 483.1 of orange peels and seeds as organic waste.

Data from Soroti Fruits Factory was used as a basis for projecting water, energy demand as well as wastewater generation for mango processing. Data from Soroti Fruits Factory shows that processing one ton of mango requires 80kWh electricity, 65 liters of diesel (steam), and 7 m³ of water while processing one tone of oranges requires about 43kWh electricity, 30 liters of diesel (steam) and 3 m³ of water.

Table 1 Material flow for Orange Concentrate Production

Company	Calculate d Production Capacity in tons per day	electricity kwh/ton	thermal litres of diesel/ton	water m3/ton	wastewater m3/ton	peels and seed kg/ton
Specific consumption		43	30	3	3	500
Teso Foods	32	1376	960	96	96	16000
Soroti Fruits Factory	96	4128	2880	288	288	48000
Soroti Fruits Factory expansion	96	4128	2880	288	288	48000

Table 2: Material flow for Mango puree production

Company	calculated production capacity in tons of mangos per day	Electricity in kWh/ton	Thermal litres of diesel per ton	Water m ³ /ton	Wastewater m ³ /ton	Peels and fibre kg/ton	Seed coat kg/ton	Seed kernel kg/ton
Specific Consumption		80	65	7	7	160	152	228
Teso Foods	32	2560 kW	2080 L	224 m ³	224 m ³	5120 kg	4864 kg	7296 kg
Soroti Fruits Factory	96	7680 kW	6240 L	672 m ³	672 m ³	15360 kg	14592 kg	21888 kg
Soroti Fruits Factory expansion	96	7680 kW	6240 L	672 m ³	672 m ³	15360 kg	14592 kg	21888 kg

3.1.2. Edible seed oil Processing

Two enterprises secured land in Soroti Business and Industrial Park with the intention of producing edible seed oil these are Green Gold International Ltd/ Kaperebiogo cooperatives and Asalalamaal Ltd. According to the chairperson, of Green Gold international, the company plans to do cold pressing of oil from ground nuts and data from UIA shows that Asalalamaal Ltd plans to operate an integrated oil mill for seed oil.

The production of seed oil (Peanuts, soybean, sesame and sunflower seeds) including shelling and cleaning of seeds (peanuts, soybeans, sesame, sunflower). In the subsequent phase, a roller mill cracks the kernels into smaller pieces. Then, the cracked seeds are conveyed to the cooker dryer where they cook for about 20 to 30 minutes at 190 degrees Fahrenheit with moisture levels controlled at 9-11%. The cooking temperature is crucial in improving oil extraction yield. After cooking, the material is dried to 2-3% moisture. The dried mash seeds are then sent to the pressing machine where about 80-90% of oil is extracted. After the first pressing, the meal might still contain 14-20% residual oils (RO), while the second pressing can reduce RO to about 6%. The unique dual-press design efficiently crushes the seed material twice in a single pass. Using mechanical force to double-squeeze oil from the peanuts, the Super Duo discharges a press cake containing about 5-7% RO.

Table 3 Oil yield for different seeds⁴

Seed	Yield
Peanuts	38-45%
Sunflower seed	32-40%
Sesame	50-56%
Soya beans	18-20%

⁴ See [8 Steps To Start a Small Edible Oil Manufacturing Business \(oilexpeller.com\)](http://oilexpeller.com)

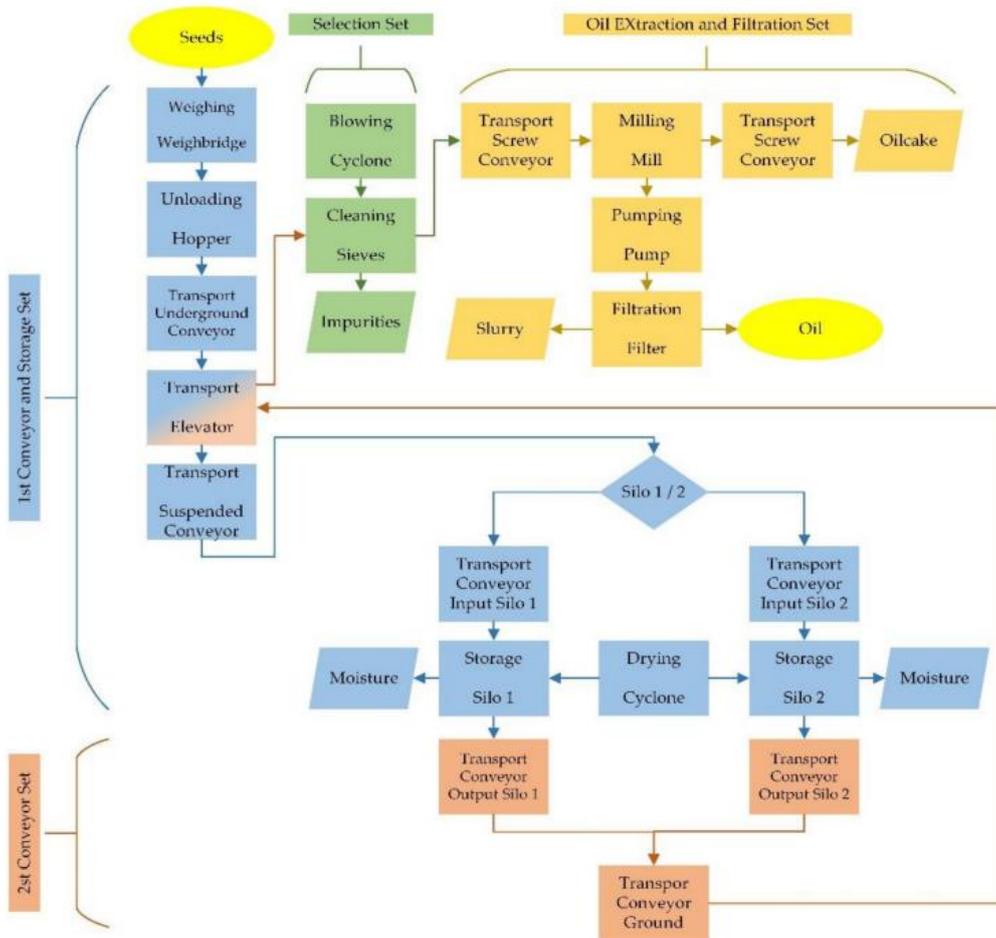


Figure 1 Material flow for cold press oil mill

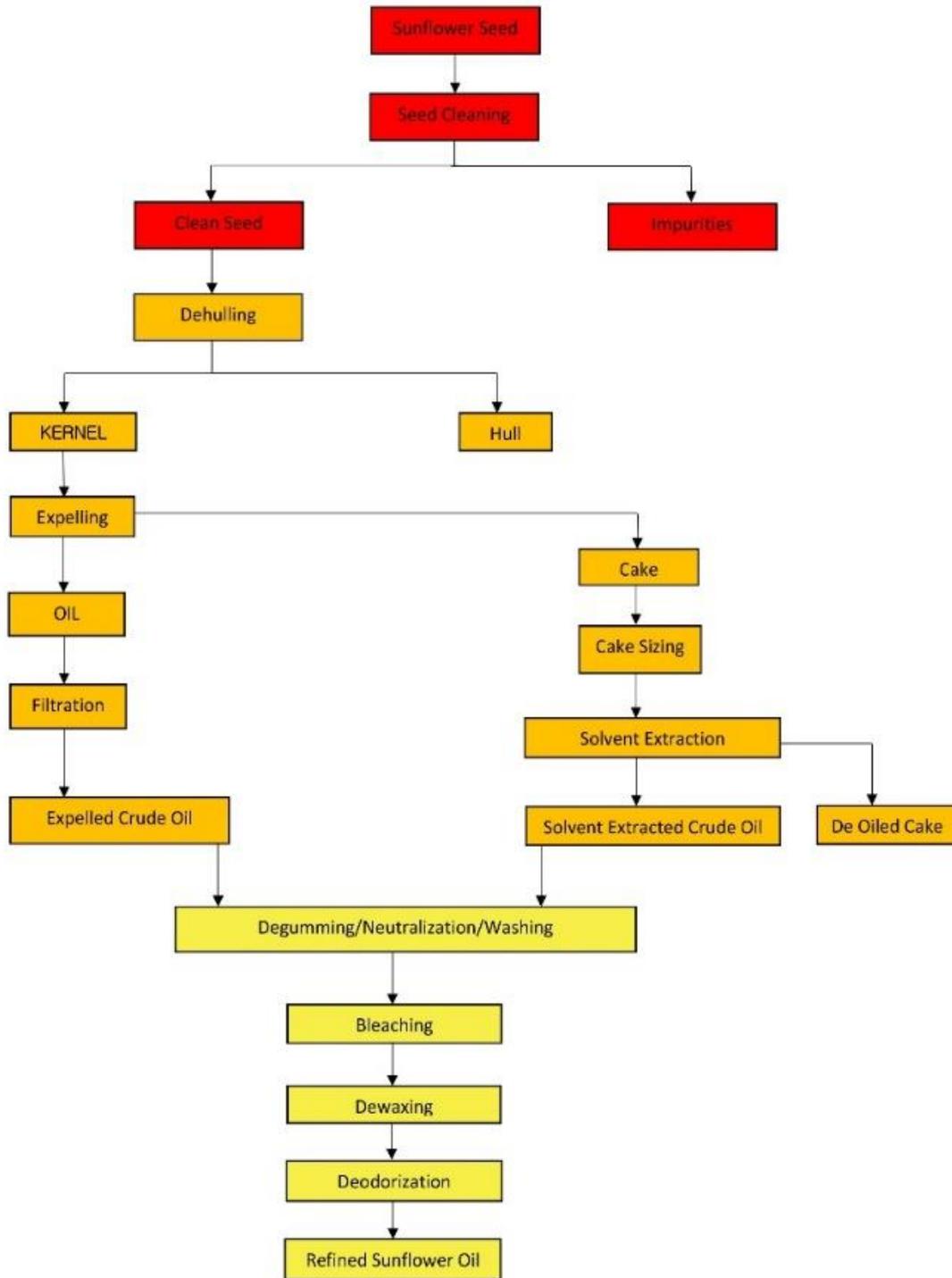


Figure 2 Process flow of an integrated oil mill

Material flow and energy flow of seed oil processing

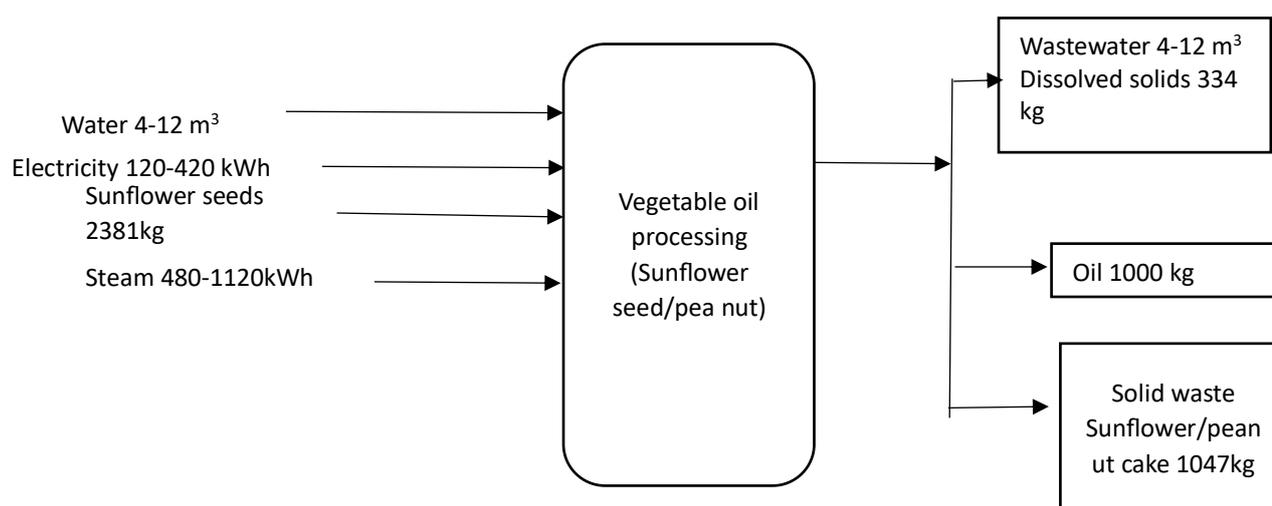
The oil content in peanuts is reported to range from 35% to 50%. The cold pressing can achieve up to 85% extrusion of oil from peanuts. The residue is a cake meal containing a maximum of 15% oil that be extracted using solved extraction or double pressing. Water audits in Oil mills in Uganda show that water demand varies between 2 to 5 m³ per ton of filtered oil. However, soya oil mill is reported to consume up to 6 m³ per ton of filtered oil. Discussions with the health and safety manager of AK Oils indicate that the electrical energy demand for cold-hot press oil mills ranged from 80-130kWh per ton. For the integrated oil mills and refinery, the energy demand and water demand are shown in Table 4.

Table 4 specific energy and water consumption of integrated seed oil mill

	electricity	Steam	water	wastewater
Integrated oil mill and refinery	120-420 kwh/ton	480-1120kWh	4-12 m ³	4.5 to 13

In refined edible seed oil, several chemicals are used including phosphoric acid, Sodium Hydroxide Sulphuric acid. For Phosphoric acid, an acid strength in the range of 20 to 60 wt % is preferred. In the neutralization of crude oil, a total of 1–6 kg NaOH /t oil is used depending on the function of the type of oil. Sulphuric acid used in soap-stock splitting amounts to 100–250 kg H₂SO₄/t soap. Phosphoric acid is used; 0.1–2.0 kg/t oil is consumed.

Material flow for an integrated oil mill and refinery



From the field assessment, Green Gold International hadn't established the size of the planned processing line it would use to produce peanut oil. Similarly, there was no data on the planned processing facility for Asalalamaal. The estimated production capacities of both companies were estimated based on literature values.

Ideally, A plant with a capacity of 30 tons per day needs about 2 acres of land to accommodate the processing plant and utilities. ⁵ Therefore, 5 acres of land allocated to Asalalamaal Ltd can accommodate a processing facility with a production capacity of about 75 tons of oil per day. This translates into an annual production capacity of 23,400 tons of oil. Similarly, Green Gold International Ltd is also allocated 5 acres of land which equally accommodates a processing facility with a capacity of 23400 tons per year. However, Gold Seed International is anticipating extracting oil from peanuts while Asalalamaal Ltd is from Sunflowers.

⁵ See [Set up an Edible Oil Refining Business in India \(kumarmetal.com\)](http://www.kumarmetal.com)

Table 5: Material and energy balance for seed oil processing companies in Soroti Industrial Park

	Calculated production capacity of seed per days tons per day	Electricity kwh/ton	Theermal kwh/ton	Water m ³ /ton	Wastewater m ³	Peanut cake in tons/ton
Gold Seed International	178.6	115518.48	900.144	900.144	115518.48	79
Asalalamaal Ltd	178.6	115518.48	900.144	900.144	115518.48	79

Environment impact of seed oil Processing

Key environmental aspects of oilseed crushing, and vegetable oil refining are the consumption of water, steam, electricity, hexane, bleaching earth, acids, caustic soda, emissions to air (VOCs, H₂S, CO₂) and wastewater. Pre-treatment of edible seeds is energy-demanding but has no direct water requirements. Extraction and refining consume large volumes of water and generate effluent that is difficult to remediate. Seed oil mill extraction generates wastewater with high organic loads. The soya bean oil mills are reported to demand more water on average of 6 m³ per ton of filtered oil BODs and COD loads of effluents from oil mills range from 600 to 900 and 800 to 1400. The pH of the wastewater from oil processing varies because both acids (e.g. H₃PO₄ for degumming, H₂SO₄ from soap splitting and alkalis (NaOH for neutralization during chemical refining) are typically added. The wastewater also contains high concentrations of organics, with chemical oxygen demand (COD) concentrations of up to 350 g/L being reported. High total phosphate (TP) concentrations are found in effluent from residual oil phosphatides from H₃PO₄ (if used for degumming). Anaerobic digestion is generally deemed unsuitable for the treatment of wastewater with high fat and/or oil content because of mass transfer limitations and inhibition of the functional microbial consortia caused by the presence of excess long and medium-chain fatty acids. However, a combined thermophilic anaerobic-aerobic system is reported to have been successfully used for the treatment of palm oil mill effluent (POME), which is discharged at high temperatures.

Table 6: Characteristics of wastewater from seed oil processing factories

Seeds	COD mg/l	TP mg/l	SO ₄ ²⁻ mg/l	TSS g/l
Sunflower	8300-9700	52-420	10800-11700	1500-2000
Peanuts	1500-8400	10-152		

3.1.3. Cassava Starch Processing

Operation Wealth Creation is allocated about 20 acres of land with plans to establish a cassava starch processing facility. According to Uganda Development Cooperation the 20 acres of land secured in Padel district will be able to accommodate a factory with a production capacity of 400 tons of cassava per day. Based on the proposed UDC starch processing factory with a daily production capacity of 400 tons on 20 acres of land. Similarly, its assumed that 5 acres of land allocated to Operation Wealth Creation can accommodate starch producing factory with a production capacity of 100 tons of cassava per day.

The production of 1 ton of starch requires about 4 to 6 tons of cassava 10 to 25 m³ of water, 190 to 260 kWh of electricity, and 1000 to 2000 MJ of heat (steam). To meet the energy (electricity and steam)

demand for processing 1 ton of starch requires about 90 to 140 m³ of biogas.⁶⁷ The waste stream from the production of 1 ton of starch includes low grad starch 4 kg, sand 170 kg, cassava peels 100kg, rhizomes 170kg, wet pulp 2500kg, and wastewater 8.4 to 20 m³. Wastewater from the cassava starch process is generally organic matter and has a high level of chemical oxygen demand or COD (4800–70,000 g m⁻³), high total volatile solids (1200–39,000 g m⁻³), and low pH (4.3–5.6). The figure below shows the material flow analysis of a cassava factory with a production capacity of 400 tons per day.

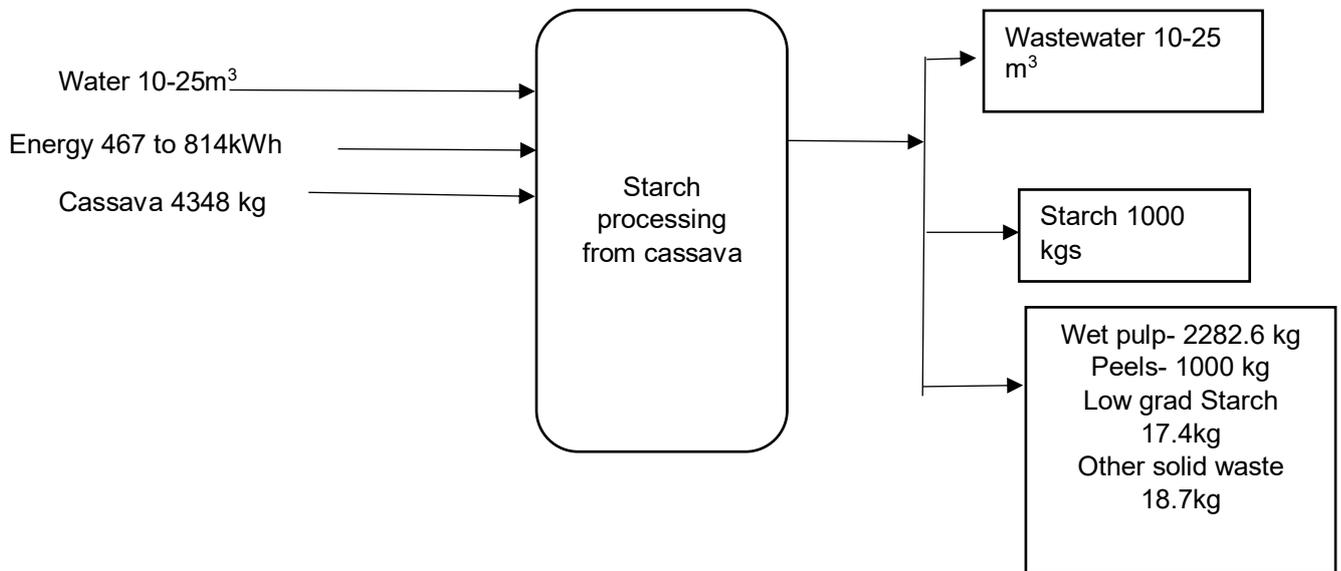


Table 7 Material and energy flow starch production from cassava

company	calculated production capacity in tons of Cassava per day	electricity kwh	thermal litres of diesel	water m3	wastewater m3	casava peels kg	Wet pulp kg	low grad starch kg	other solid waste kg
Operation wealth creation	100	18700		575	575	22946	52500	402	430

3.1.4. Ketchup Processing

Decisions with Chief Operations Officer Teso Foods Ltd, reveal that the company plans to establish a tomato ketchup production line with a production capacity of 1000 liters of a product per hour. Based on this planned production capacity. Assuming 8 hours of production per day and operating 26 days a month the annual production output is estimated to be 3456 tons of tomato ketchup. The material and energy flow of the tomato production line of Teso Foods Ltd is shown in the table below.

⁶ [Implementing circular economy concept by converting cassava pulp and wastewater to biogas for sustainable production in starch industry | Sustainable Environment Research | Full Text \(biomedcentral.com\)](#)

⁷ [Supply chain analysis for cassava starch production: Cleaner production opportunities and benefits - ScienceDirect](#)

This work found that energy demand in tomato ketchup processing ranges from to 8MJ kg⁻¹.⁸ Several installations producing tomato paste, powder and concentrate reported specific energy consumption levels in the range of 1.25–2.4 MWh/tonne of products. The water consumption of the tomato processing is reported to range from 8 to 15 m³. Discussions with shift supervisor Britinia (U) Ltd reveals that on average, processing one ton of tomatoes produces 370kg of tomato source, 60kg of rejects and 120kg of seed and skin.

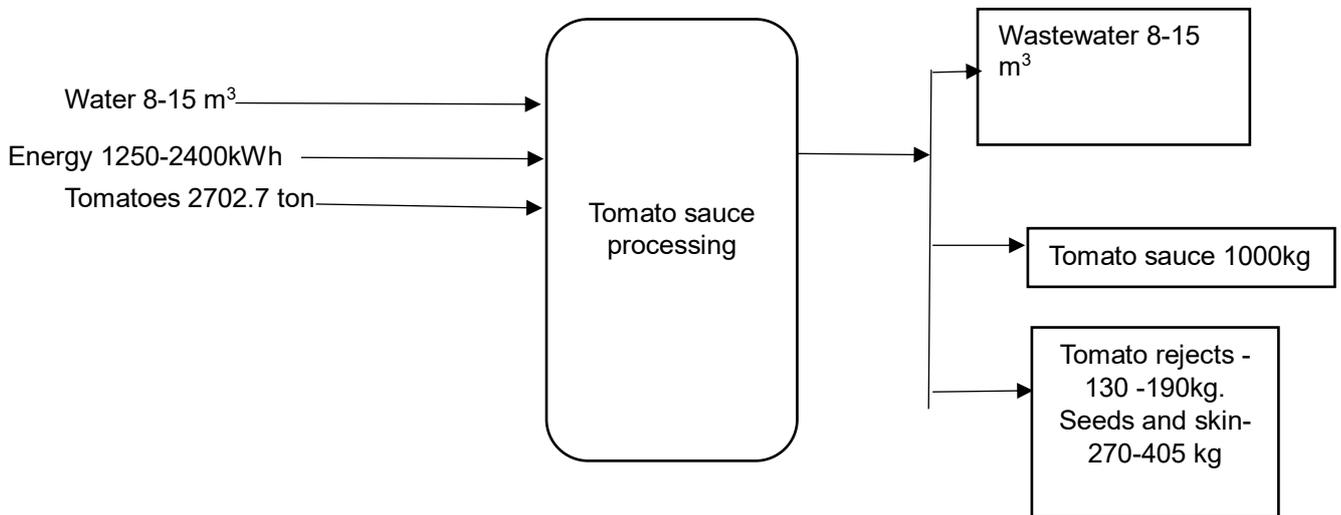
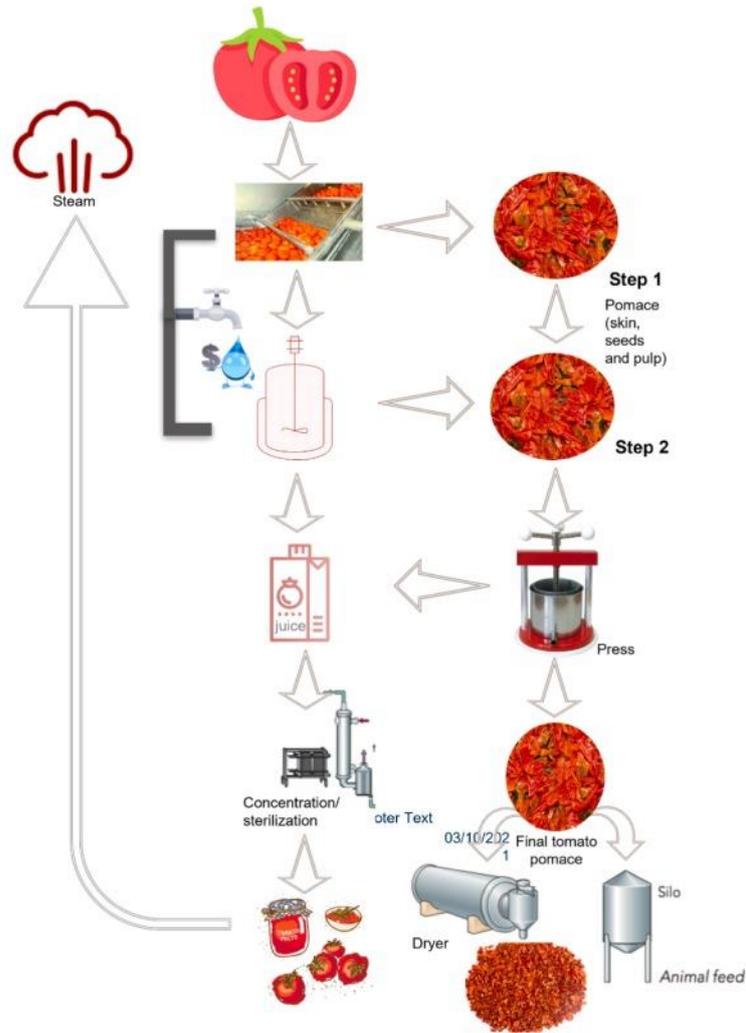


Table 8 Material and energy flow of ketchup production

Calculated annual production Tomatoes tons	Energy demand in kWh	Water demand m ³	Wastewater m ³	Waste in kg	
				Tomato Rejects	Seed and skin
39.8 tons	35352	220.95	220.95	2800	5964

⁸ See [\(PDF\) Energy use and efficiency opportunities in industrial tomato processing \(researchgate.net\)](#)



3.1.5. Ethanol Production

Data from Teso Foods Ltd indicates a planned ethanol production with an installed production capacity of 1000 liters of ethanol per hour. It's anticipated that ethanol will be produced cassava. Information from distilleries in Uganda shows that water demand in ethanol production ranges from 0.4-1.2 m³ per hecter liter of ethanol produced. The ethanol yield rate of ethanol is reported to range from 26-37% of cassava flour used.

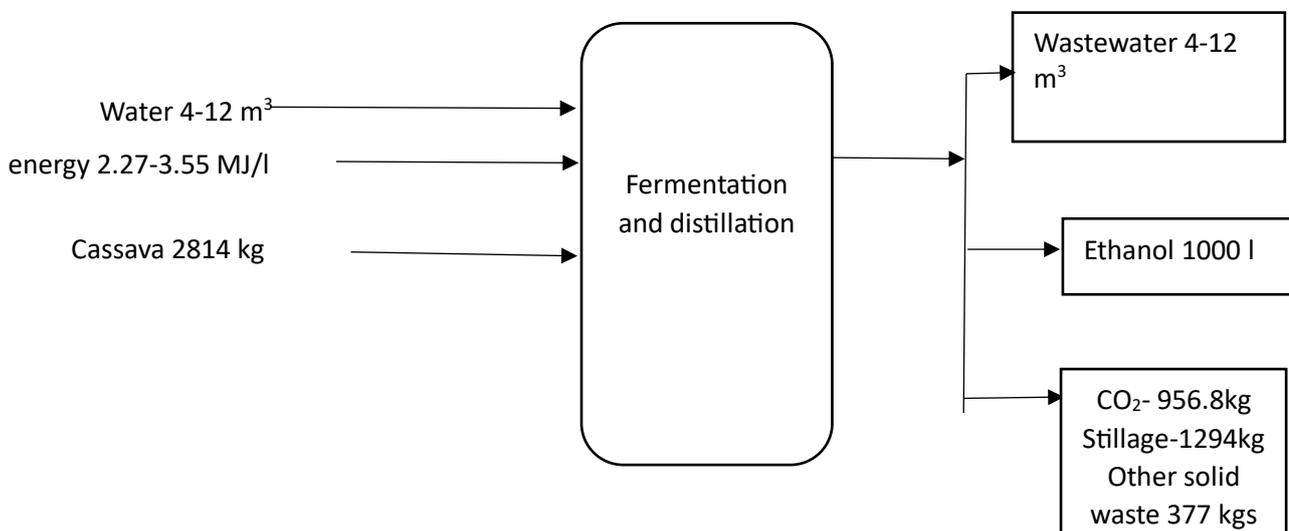


Table 9 Material and energy flow of ethanol production from cassava

Company	calculated production capacity in litre of ethanol per day	Energy kWh	Water m ³	Wastewater m ³	Carbon Dioxide kg	Cassava fibre kg	Stillage kg
Teso Foods	16 m ³	15733.6	192	192	15308.8	6032	20704

3.1.6. Dairy Processing (Dairy innovation hub)

Garden Agri-engineering Networking Limited works with over 100 local farmers. The company has plans to join Soroti Industrial and Business Park on land reserved for SMEs with the aim of facilitating its farmers to have access to Dairy processing facilities to produce yogurt and ice cream. Similarly, the Dairy Development Authority (DDA) a government agency runs a yogurt and ice cream processing demonstration center to incubate its members. Supporting value addition to milk will require the installation of new two production lines of yogurt and ice cream in the SME hub with production capacities of 1000 and 500 liter/hour respectively.

Furthermore, to minimize milk losses reported by DDA a milk collection/bulking Centre with milk coolers is proposed to be located in the SME park. Milk coolers are a critical unit in the dairy value chain. They ensure bulking is done at all levels of production; it eases transportation as milk tankers find reasonable volumes in one place. The material and energy flow of the proposed Yogurt and ice cream production lines is based on reported product loss in ice cream processing ranging from 30 to 150 kg per ton of product and electricity consumption in the ice cream industry varies in the range of 0.13-0.64 kWh/kg⁹. Bulk milk collection requires storage of milk at a low temperature of 4°C to inhibit bacterial growth. Maintaining milk at a constant temperature of 4 °C require about 1kWh per 52 liters of milk¹⁰ and an average of 2 liter of water per liter of milk produced, generating about 2.1 liters of wastewater.

Table 10 Projected energy and material flow analysis of the proposed Dairy Innovation Centre and bulking center

Product/Process line	Calculated Production capacity m ³	Energy demand in kWh	Water demand m ³	Wastewater m ³
Yogurt	8	2916	80	80
Ice cream	4	2560	40	40
Milk Collection center	10	192.3	20	20

⁹ See [\(PDF\) IMPROVING PRODUCTION EFFICIENCY IN THE ICE CREAM INDUSTRY \(researchgate.net\)](#)

¹⁰ See [Modelling of an on-farm direct expansion bulk milk cooler to establish baseline energy consumption without milk pre-cooling: A case of Fort Hare Dairy Trust, South Africa: African Journal of Science, Technology, Innovation and Development: Vol 10, No 1 \(tandfonline.com\)](#)

3.1.7. Grain Storage and Processing

Data collected from UIA shows that about 4 enterprises (pela commodities, Mega Holdings Ltd, Komolo Foods and Beverage, Serere Agro Enterprise Ltd are allocated land to process and handle grains within Soroti Industrial and Business Park. The four enterprises are anticipated to handle and process about 1930 tons of grains per day at full production capacity.

The desired storage moisture content of grains ranges from 8 to 13%. According to the operation manager Pela commodities farmers usually supply grains with moisture content above the desired values. On average the company receives grains with about 20% moisture content. Reducing moisture content from 20% to 13% is a very energy-intensive operation that requires burning fuel to produce heat and electricity. The energy demand for drying grain depends on the initial and final moisture content, the type of dryer, the ambient conditions, and the drying efficiency. The energy demand for grain handling and storage also includes the power required for conveying, elevating, cleaning, and aerating the grain. Water demand in grain processing can be as low as 0.01 m³ per ton while energy required for grain milling ranges from 50 to 350 kWh per ton. Thermal energy for drying grains ranges from 0.8 to 2.2 kWh for each kilogram of dry product¹¹

The energy demand for grain handling and storage can be reduced by improving the drying efficiency, using renewable energy sources, and optimizing the storage conditions. Alternatively, the grain companies can work with farmers through extension services to ensure that grains are supplied when they are dry enough at 14% moisture content. This can eliminate the need for fossil fuels for drying.

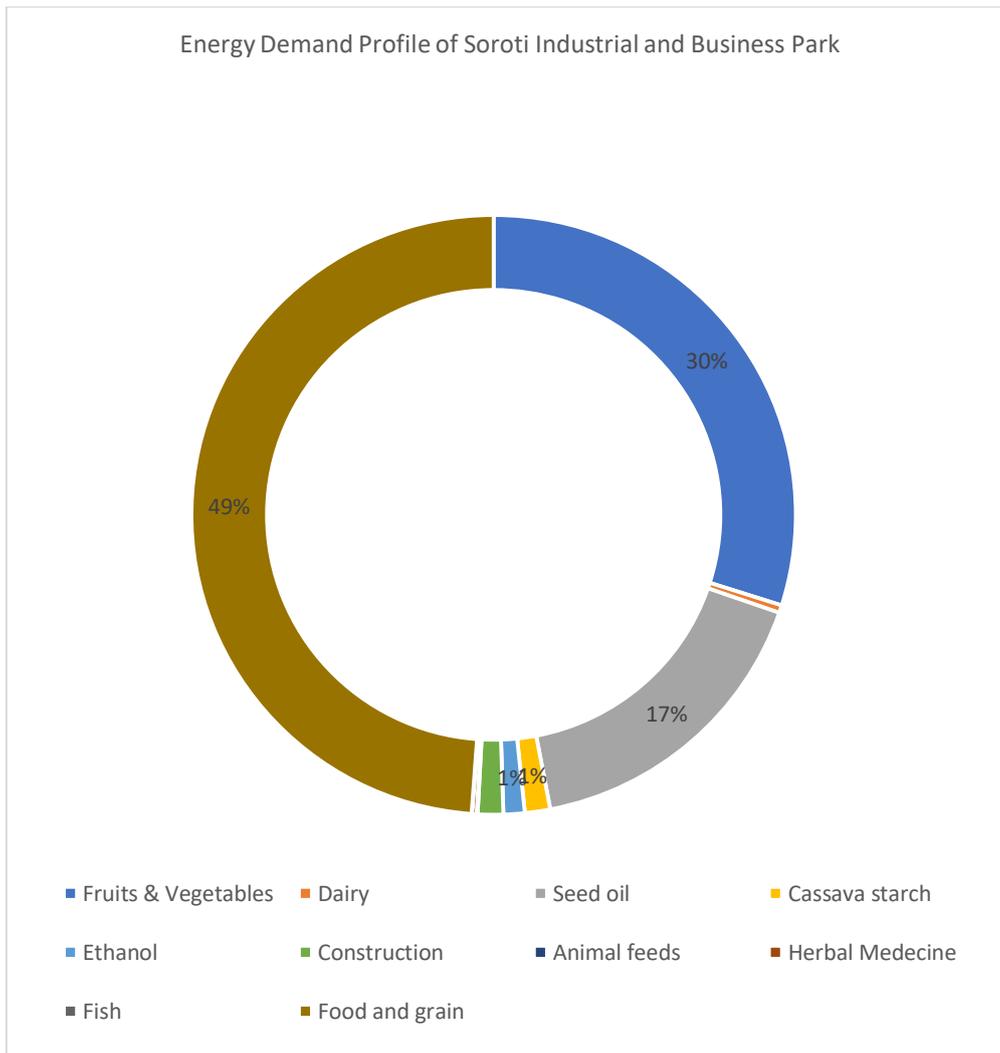
Table 11 Projected Material and energy flow of Soroti Industrial Park business-as-usual scenario

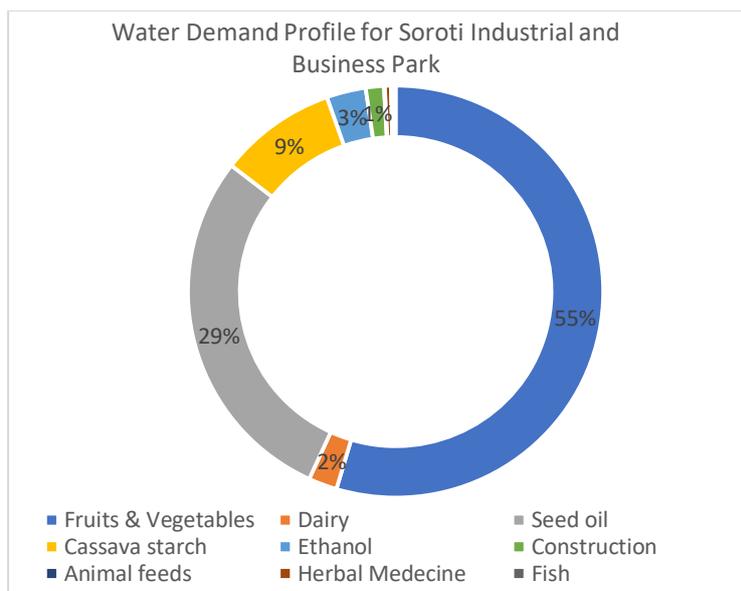
Sector	Company	P-Capacity	Energy	Water	Wastewater	Solid waste(organic)
Fruits	Soroti Fruits Factory Ltd (existing)	96 tons (mango)	76,944	672	672	51.8
		96 tons (orange)	36,096	288	288	48
	Soroti Fruits Factory Ltd (expansion)	96 tons (mango)	76,944	672	672	51.8
		96 tons (orange)	36,096	288	288	48
	Teso Foods Ltd	32-ton mango	25,648	224	224	17.3
		32 ton (orange)	12,032	96	96	16
	Komolo Foods and beverage	96 tons (mango)	76,944	672	672	51.8
		96 tons (orange)	36,096	288	288	48
Dairy	Dairy innovation Centre	8	2,916	80	80	
		4	2,560	40	40	
		10	192	20	20	
Seed oil	Green Gold International Ltd	178.6 tons (peanuts)	115,518	900	900	79

¹¹ See [Applied Sciences | Free Full-Text | Estimation of the Energy Consumption of the Rice and Corn Drying Process in the Equatorial Zone \(mdpi.com\)](#)

	Asalalamaal Ltd	178.6 (peanut)	115,518	900	900	79
Vegetables (tomatoes)	Teso Foods Ltd	39.8 tons tomato	35,352	221	221	7
	Operation wealth creation	100 tons Cassava	18,722	575	575	77
Cassava/starch						
Ethanol from cassava	Teso Foods	16 m ³	15,734	192	192	10
Construction	Wodma Investment	80 tons	18,614	70	70	
	Sanqua Engineering Ltd	21 tons [1]	233	18	18	
Animal feeds	Nicho Ventures td	2	700	4	4	
Sweet Potato puree		1.5	1,202	11	11	
Herbal medicine	Jena Herbal Ltd	5 tons (product)	3,370	30	30	3.5
Fish	Nicho Ventures	1 ton (raw fish)	294	3	3	
Food/Grain	Pela Commodities	600 tons	210,000	6	6	38
	Mega Holdings Ltd	490 tons	171,500	5	5	31
	Komolo Foods and beverage	600 tons [2]	210,000	6	6	38
	Serere Agro Enterprise Ltd	240 tons	84,000	2	2	15
Local Government land	Agro processing	9.9 acres	81,600	576	576	
Free Zone Land	Agro and inland depo	19 acres	163,200	1,152	1,152	
Total			1,628,026	8,012	8,012	708.10

At full production capacity, the total daily energy and water demand of Soroti Industrial Park is projected to be 1628.03 MWh and 8012 m². The energy consumption will result in GHG emissions of approximately 1009.37 tCO₂eq per day. To significantly reduce the energy demand for Soroti Industrial Park special attention should be given to food and grains, fruits and vegetables and seed oil. These sectors account for over 96% of the total energy demand of the park. Similarly, to reduce pollution loading and water demand priority should be given to seed oil and Fruits and Vegetables processing. These sectors account for 55% and 29% of total water demand respectively. This can be done through the implementation of RECP improvement measures. The industrial park is also expected to generate about 708.10 tons of organic waste per day. The organic waste includes orange peels, peanut cake, maize bran, mango peels and seeds. Through industrial symbiosis such waste can be valorised to produce animal feed, mango kernel butter, orange peel oil, recover energy, and produce organic manure through compositing.





3.2. Resource Efficient and Cleaner Production Opportunities

To improve resource productivity and contribute to the establishment of eco-industrial Park it's recommended that the enterprises in Soroti Industrial Park adopt Resource Efficient and Cleaner Production measures.

Resource Efficient and Cleaner Production (RECP) is a preventive, enterprise-level approach to improve resource use, reduce environmental pollution, and contribute to sustainable industrial development. RECP applies an integrated environmental strategy to processes, products, and services to increase efficiency and reduce risks to humans and the environment. Adoption of RECP will enable industries within Soroti Industrial Park to improve the productivity and competitiveness of enterprises by using materials, water, and energy more efficiently and minimizing waste and emissions. The proposed RECP options for Soroti Industrial and Business Park are shown in Tables 9 and 10.

Table 12 Projected Material and energy flow of Soroti Industrial Park Green manufacturing scenario

Sector	Company	P-Capacity	Energy	Water	Wastewater
Fruits	Soroti Fruits Factory Ltd (existing)	96	53760	288	288
		96	28800	192	192
	Soroti Fruits Factory Ltd (expansion)	96	53760	288	288
		96	28800	192	192
	Teso Foods Ltd	32	17920	96	96
		32	9600	64	64
	Komolo Foods and beverage	96	53760	288	288
		96	28800	192	192
Dairy	Dairy innovation Centre	8	440	32	32
		4	520	13.6	13.6
		10	130	10	10

Seed oil	Green Gold International Ltd	178.6	45007.2	300.048	300.048
	Asalalamaal Ltd	178.6	45007.2	300.048	300.048
Vegetables (tomatoes)	Teso Foods Ltd	39.8	17676	117.84	117.84
Cassava/starch	Operation wealth creation	100	10741	230	230
Ethanol from cassava	Teso Foods	16	10060.64	64	64
Construction	Wodma Investment	80	14178.4	22.4	22.4
	Sanqua Engineering Ltd	21	3721.83	5.88	5.88
Animal feeds	Nicho Ventures	2	100	2	2
Potato puree		1.5	840	4.5	4.5
Herbal medicine	Jena Herbal Ltd	5	2085	15	15
Fish	Nicho Ventures	1	216.4	2	2
Food/Grain	Pela Commodities	600	30000	6	6
	Mega Holdings Ltd	490	24500	4.9	4.9
	Komolo Foods and beverage	600	30000	6	6
	Serere Agro Enterprise Ltd	240	12000	2.4	2.4
Local government land	Agro processing	9.9	65280	384	384

Free zones Land	Agro and inland depo	19	130560	784	784
Total			718,263.67	3,906.616	3,906.616

3.3. Proposed Water Efficient Practices and Techniques

Table 13 Proposed cleaner Production Technologies to improve water use efficiency.

No	Resource Efficient and Cleaner Production option	Technical description	Benefits
1	Use of low-pressure foam and/or gel instead of water to clean walls, floors and/or equipment surfaces.	Low-pressure foam cleaning can be used instead of traditional manual cleaning with water hoses, brushes and manually dosed detergents. It can be used to clean walls, floors and equipment surfaces. A foam cleaner, such as an alkaline solution, is sprayed on the surface to be cleaned. The foam adheres to the surface. It is left for about 10–20 minutes and is then rinsed away with water. Centralized systems supply pre-mixed cleaning solutions and pressurized water from a central unit and during cleaning they automatically change between foam spreading and rinsing.	The use of low-pressure foam reduces water, chemical and energy consumption compared to the use of traditional water hoses, brushes and manually dosed detergents. Implementation of low-pressure foam in a cheese factory with production capacity of 25,000 tons per years resulted in savings of 19 800 m ³ water/year and 1 160 MWh/year.
3	Fitting of cleaning hoses with hand-operated triggers.	Trigger control shut offs can be fitted to cleaning hoses with no other modification, if a water heater is used to provide hot water. Automatic shut-off valves are often sold with nozzles attached. Nozzles increase the water impact and decrease the water flow rate.	Before installing triggers, the time the hose was running was 8 h/day and 4 h/day afterwards. For a water cost of USD 2.1/m ³ , an annual water cost saving of USD 4 987. An annual energy saving of 919 GJ has also been calculated.
4	High pressure cleaning: Spraying of water onto the surface to be cleaned at pressures ranging from 15 bar to 150 bar.	In high-pressure cleaning, water is sprayed onto the surface to be cleaned at pressures ranging from 15 bar, which is low pressure, up to 150 bar, which is high pressure. A pressure of about 40–65 bar has also been described as high.	Pressure cleaning reduces water and chemical consumption compared with mains hoses. The cost savings, in steam, water and wastewater, of high-pressure low-volume systems compared with low-pressure high-volume systems are reported to be around 85 %. There are also reduced

			costs associated with reduced consumption of chemicals.
5	Use of various automated control devices (flow regulators), e.g. photocells, flow valves, thermostatic valves, to adjust the water flow. Flow regulators are used to provide a constant flow at a predetermined rate. The flow regulators can be fitted on steam lines, cleaning systems and material transfer lines.	Flow measurement and control techniques can reduce material waste and wastewater generation in agro-food processing. Applying flow measurement and control in transfer lines allows the accurate addition of materials to storage and processing vessels and filling packaging, thereby minimizing the excessive use of materials and the formation of out-of-specification products. Sensors such as photocells can be fitted to detect the presence of materials and to supply water only when it is required. Water supplies can be turned off automatically between products and during all production stoppages.	Installing constant flow valves to ensure the correct flow rate to each of the water ring vacuum pumps reduced water use by approximately 60 000 m ³ /year, corresponding to 7.5 % of the site's mains water consumption. Water and wastewater costs fell and there was reduced energy consumption and wear of the vacuum pumps.
6	Use of correct number and position of nozzles; adjustment of water pressure.	Water nozzles are widely used in the agro food processing sector, e.g. for washing and sometimes for thawing the product, and cleaning the equipment during processing. Water consumption and wastewater pollution minimisation can be carried out by correctly positioning and directing the nozzles. In addition, water consumption can be optimised by monitoring and maintaining the water pressure of the water nozzles.	In the fish sector, a reduction in water consumption of about 0.13–0.2 m ³ /t of raw material has been reported due use of correct number and positioning of nozzles. In white fish filleting, water consumption can be reduced by up to 90 % by installing nozzles and sprinkling the water for one or two seconds out of every three.
7	Segregation of water streams; Water streams that do not need treatment (e.g. uncontaminated cooling water or uncontaminated run-off water) are segregated from wastewater that must undergo treatment, thus enabling uncontaminated water recycling.	Contaminated wastewater may be segregated to receive appropriate treatment according to its characteristics. It may then be possible for the high-volume, low-polluted streams to be either recycled following suitable treatment or discharged directly to the WWTP without treatment. In some cases, materials can be recovered from process water for use in the process or for other uses such as animal feed. Uncontaminated water for which there is no	Segregation of wastewater can involve a high capital cost at existing installations. However, this may be offset by the reduced operating costs due to the lower requirement for wastewater treatment (e.g. water-holding capacity, energy consumption), whether on site, at a MWWTP or a combination of both. Wastewater separation/segregation

		reuse opportunity available should be discharged without treatment provided that the requirement on the recipient quality can be met. If that is not possible, it should be considered whether treatment of the specific water stream is an option, thus preventing an unnecessary load on the WWTP	systems can be installed efficiently at new installations
8	Optimization of chemical dosing and water use in cleaning-in-place. Optimizing the design of CIP and measuring turbidity, conductivity, temperature, and/or pH to dose hot water and chemicals in optimized quantities.	Design and operational features that increase the efficiency of the CIP system include: (i) using a turbidity or conductivity detector to optimize both the recovery of material/product from water and the reuse of cleaning water during pre-rinsing; (ii) measuring pH to optimize chemical consumption.	Within a six-year implementation of CIP optimisation (collection and reuse of detergents) in a dairy installation, consumption of water decreased to 55 % and consumption of detergents decreased to 34 %. In a brewery installation, the application of one phase of CIP has resulted in a 30 % reduction of water consumption for cleaning
9	Maximisation of condensate return; Recovered condensate can be reused as feed to the boiler, heated water, for other equipment or cleaning other installations.	In this technique, water and heat which is contained in discharge condensate is taken advantage of. This recovered condensate can be reused as feed to the boiler, heated water, for other equipment or cleaning other installations. A condensate recovery unit is a vessel which receives condensate from all practical points where condensate is produced. The vessel stores the condensate and mixes it with fresh make-up water prior to it being used as boiler feed water. If hot condensate is not returned to the boiler it must be replaced by treated cold make-up water. The additional make-up water also adds to water treatment costs. Instead of routinely discharging condensate to the WWTP because of the risk of contamination,	If hot condensate is not returned to the boiler, it must be replaced by treated cold make-up water and wastes some 20 % of the energy absorbed in the generation of the steam from which the condensate is derived. This may be the greatest single energy loss in steam use. An investment cost of EUR 50 000 (EUR 45 000 for the pipeline return system and EUR 5 000 for the project and design) and payback periods of 1–4 years have been reported.
10	Recirculation of water from the cooling tower pond.	The technique involves the recirculation of water from the cooling tower pond through a vessel containing electrodes made from a combination	In a brewery, 80 % of the cooling towers' water consumption is reduced, and also 100 % of the chemical consumption,

		<p>of metal oxides which act as anode where oxidising ions are generated from water. Furthermore, the vessel wall acts as the cathode, reaching a pH of 13 which causes the precipitation of calcium salts on the vessel wall, preventing the concentration of salts in the tower pond and, therefore, preventing the need to purge water from the pond. Periodically, in a programmed way, the salty precipitate on the vessel wall is washed off and drained. By applying direct current voltage to electrodes in the chambers, OH ions are produced by partial electrolysis of the water</p>	<p>avoiding continuous chemical treatment. The maintenance and cleaning of equipment takes about half an hour per month.</p>
11	<p>Green Cooling. Use of refrigerants without ozone depletion potential and with low global warming potential</p>	<p>Use of natural refrigerants like water, ammonia and carbon dioxide prevents emissions of substances that deplete the ozone layer or have a high global warming potential</p>	<p>Substitution of refrigerants is energy-efficient for industrial cooling systems. The install cost for use of refrigerants without ozone depletion potential and with low global warming requires and addition investment which is about 20% to 30% high compared to conventional HCFC. However green cooling can save up to 27% in electricity consumption.</p>
12	<p>Closed-circuit cooling</p>	<p>The water is recirculated via a cooling tower, or a cooler connected to a central refrigeration plant, i.e. it is rechilled and returned to the equipment being cooled. If there is a need to prevent algae or bacterial growth, chemicals may be added to the recirculated water. Otherwise, the cooling water can be reused for cleaning purposes.</p>	<p>It is reported that closed-circuit cooling can save 80 % of water consumption, compared to an open system. In an example brewery with a capacity of 500 000 hl/year, a closed-circuit cooling system was introduced in a tunnel pasteurization unit to replace an open system that cooled using fresh water. The reduction in water consumption was estimated to be 50 000 m³/year</p>

3.4. Proposed energy Efficient Practices and Techniques

Table 14 Proposed techniques to improve energy use efficiency.

No	Proposed cleaner Production option	Technical description	Benefits
1	Frequency converters (or variable speed drivers) regulate the speed of the impeller to the required output of the motor.	Controlling the speed of the pump motor by frequency converters ensures that the speed of the impeller is exactly adapted to the required output of the pump, as are the power consumption and treatment of the liquid.	The reduction of the power consumption depends on the capacity and number of pumps and motors. Generally, a 10 % reduction in the output of a pump corresponds to a 28 % reduction in the energy consumption of the pump. In a Danish dairy, 203 motors were equipped with frequency converters. The total power of the motors was 1216 kW. The estimated cost of the investment was EUR 311 000. The estimated annual saving is EUR 90 000 (1 325 000 kWh).
2	Energy-efficient lighting; Measures such as energy-efficient lamps, use of natural light, solar lighting or automatic light control.	More energy-efficient lighting can be attained by replacing conventional tungsten light bulbs or other low-efficiency light bulbs with more energy-efficient lights such as fluorescent, and LED lights; ii. using devices such as sensors or room-entry switches to control the lighting; iii. allowing more natural light to enter, e.g. by using vents or roof windows; natural light has to be balanced with potential heat losses and use solar powered lights	In a Tea factor replacement of, two 36 Watts fluorescent tubes were replaced with two 12 W LEDs in 74 existing lamps. The investment cost was Ugx 18,250,000/=. This led to energy savings of over 10,000 kWh/year. The payback period was about 3.5 years.
3	Use of high-efficiency motors to minimise motor losses. Its recommended to use motor with efficiency rating of IE3 and IE4	Over 60% of all electrical energy consumed in industries is used by electric motors. Improving the efficiency of electric motors reduce operating costs and improve enterprise productivity. Motor losses can be minimised by specifying higher-efficiency motors where feasible	Procuring efficient motors can reduce energy required in running motors by over 25%.

<p>4</p>	<p>Reduction of air leaks and optimisation of pressure settings. Leak prevention measures and periodic leak tests are carried out. The pressure at the compressor is set at the maximum required and then regulated at each individual application.</p>	<p>Consumption losses during production downtime can be avoided by sectorisation of pressure (multiple changes to the pressure distribution). Several additional techniques can be implemented to optimise compressed air generation and use including.</p> <ul style="list-style-type: none"> i. replace pneumatic installations with electric ones. ii. use a variable speed compressor. iii. adjust the pressure level (more pressure is provided with a separate compressor); iv. adapt the compressor to the need (flow/pressure). <p>The pressure at the compressor can be set at the maximum required and then regulated at each individual application to minimise the energy required to produce compressed air and reduce leakage. For applications which require higher pressures or have longer operating hours than most of the applications which use compressed air, it may be more energy- and cost effective to install a dedicated compressor</p>	<p>In a grain milling installation with a permitted production capacity of around 500 tonnes/day the energy losses were reduced by 10 %. The cost of implementation was EUR 7 000, and the technique also achieved annual savings of EUR 7 000</p>
<p>5</p>	<p>Continuous Freezing of ice cream.</p>	<p>Continuous freezing of ice cream mix using optimized start-up procedures and control loops reduce the amount of start-up rework and waste. The improved control also gives a much more even output, closer to the desired target. This leads to less waste or alternatively the ice cream producer can make more sellable products from the additional amount of ice cream mix within the same available time and without use of extra raw material. Considering, for example, an ice cream bulk filling line with a capacity of 4 000 litres/hour: with two product changes per day, the COD effluent load in the</p>	<p>For example, an installation of continuous freezing with a production capacity of 2 000 liters of ice cream/hour, a production time of 3 000 hours/year, two basic start-ups per day, and two product changes per day, the benefits of applying this technique are reported as; less start-up waste 12 500 kg/year (23 000 litres); less product waste 25 000 kg/year (44 000 liters), reduced electricity consumption 12 000 kWh/year.</p>

		start-up waste could be reduced from 20 kg to 13 kg COD/tonne of ice cream mix.	
6	Energy efficiency plan	An energy efficiency plan entails defining and calculating the specific energy consumption of the activity (or activities), setting key performance indicators on an annual basis (for example for the specific energy consumption) and planning periodic improvement targets and related actions. The plan is adapted to the specificities of the installation. There are way to energy efficient plans, but most management systems are based on the plan-do-check-act approach (which is widely used in other company management contexts). ISO 50001 is one of the more globally widespread standards for energy efficiency management systems.	Energy efficiency plan provides a systematic way to adopt energy management with an enterprises.

3.5. Industrial Symbiosis Opportunities for Soroti Industrial Park

The agri-food industrial sector generates important quantities of agricultural wastes. The waste effluents from the agro-food sector have minimal toxicity and often contain substances having high-added value that can be recovered directly¹² The Agro-food processing industry provides great investment opportunities in wastewater and solid wastes, by conversion into value-added products. A way to take advantage of these wastes as inexpensive and sustainable materials is to convert useful products/bi-products or energy recovery. The table presents industrial RECP and symbiosis infrastructure.

Recommended RECP and Industrial infrastructures	Description and benefits
<i>Oil extractor from orange peels</i>	Recovery oil from orange peels makes oranges peels a better potential biogas feedstock as well as suitable material for composting.
<i>Animal feed mill</i>	The major anchor industries including fruits and vegetables, seed oil processing generates by-products (cake meal, orange peels, tomato pomace and seed cake and cassava fibre) that can potentially be processed into animal feeds. It is economically feasible to include a feed mill operation in in operations that generates large quantities of such by-products. Rejected fruit from grading, peel and rag from extraction, and washed pulp, and other solid waste is sent to the feed mill where it is dried and pelletized for animal feed.
<i>Carbon dioxide recovery plant from ethanol production</i>	<p>The fermentation process in ethanol production generates carbon dioxide as a by-product which can be recovered and sold to beverage companies.</p> <p>Installation of a carbon dioxide recovery plant in the ethanol production facility results into the following environmental and economic benefits.</p> <ol style="list-style-type: none"> i. Reduced CO₂ emissions at installation level. Typically carbon dioxide recovery from ethanol producing facility can reduce CO₂ emissions with this system is around 2 kg/hl (20 kg/m³) of beer brewed. ii. Reduced consumption of fossil fuels and energy to produce CO₂ especially for use in the installation (generating a tonne of CO₂ requires about 140 kWh). iii. Ethanol producing companies can supply CO₂, which is usually a co-product from its process operations, at a cheaper price.
<i>Biogas recovery plant from wastewater treatment</i>	The agri-food industrial sector generates important quantities of agricultural wastes. The waste effluents from the agro-food sector have minimal toxicity and often contain substances having high-added value that can be recovered directly. ¹³ A way to take advantage of these wastes as inexpensive and sustainable materials is to convert useful products/bi-products or energy recovery. Given the high organic load in the wastewater from agro-processing plant. The anaerobic pods in wastewater treatment plant generates

¹² [Valorisation of waste streams from the agro food sector | VALOWASTE | Project | Fact sheet | FP7 | CORDIS | European Commission \(europa.eu\)](#)

¹³ [Valorisation of waste streams from the agro food sector | VALOWASTE | Project | Fact sheet | FP7 | CORDIS | European Commission \(europa.eu\)](#)

	methane gas. This gas can be recovered as biogas for heating or cooking purposes
Phosphorus is recovered by precipitation in the form of struvite	<p>Wastewater from food processing industries is characterized by total phosphates above 50 mg/l. This makes it feasible to recover phosphorus in the form of struvite that can be sold as a fertilizer. The reaction takes place by adding magnesium, at pH levels of 7.5 to 10. The result will be the formation of struvite (magnesium ammonium phosphate)</p> $\text{HPO}_4^{2-} + 6 \text{H}_2\text{O} \rightarrow \text{MgNH}_4\text{PO}_4 + 6\text{H}_2\text{O}$ <p>An investment cost of around EUR 983 000 for the treatment of 120 m³/h of wastewater has been reported, for achieving an outlet P-PO₄ concentration of 20 ppm (inlet P-PO₄ concentration around 150 ppm). The cost of recovery is lower compared to phosphorus removal by chemical precipitation using, for example, FeCl₃. Phosphorus recovery as struvite can also result in a decrease in the costs for the treatment and disposal of sludge. There are potential revenues from selling the recovered struvite.</p>
Shared steam generation and distribution system	<p>Shared steam generation and distribution system is a centralized steam generation system with a steam pipeline network within an industrial area that caters to the demand for steam of member industrial.</p> <p>The modular on-demand boiler will be adopted to address the challenge of varying steam demand. Modular systems are designed specifically to meet varying load demands. The modular-on demand steam boiler will run on a series of biogas and biomass burners operating co-currently to allow substitution of diesel with renewable energy. The steam generation system will be installed in phases starting with a 4-ton/hr modular and consequently series of 2-ton/hr modular in corresponding to the establishment of new industries. Complementary components will be installed on the boiler these include.</p> <ul style="list-style-type: none"> (i) An automated boiler fuel feed control system mechanism, and a proper emissions monitoring mechanism, (ii) And a master controller to monitor steam demand through a steam sensor at the header and utilizes sophisticated software to optimize the staging sequence of the boilers for the best overall system efficiency. <p>The use of renewable energy, automated fuel control and emission monitoring systems will contribute reduction of GHG emissions. The project is anticipated to reduce emissions by 24,350 tCO₂eq¹⁴ per year.</p> <p>Adopting a shared modular-on-demand steam boiler instead operating individual small boilers is associated with following benefits.</p> <ul style="list-style-type: none"> i. Reduction in industrial air pollution by 65–70 per cent, with better emissions control and a 25-30 per cent reduction in fuel consumption due to use one point monitoring for State Pollution Control Boards (SPCBs).

¹⁴ Its assumed that use agro-residues have net zero emissions since it CO₂ emitted during consumption can be absorbed back by newly planted agro-products.

	<p>ii. Increased efficiency: Fuel-to-energy conversion improves as producing steam in bulk reduces the per unit fuel consumption.</p>
<p>Shared step-down distribution transform and Power factor correction system for SME hub</p>	<p>In order to ease SMEs access three-phase power, it is proposed to establish a common step-down transformer for the SME hub.</p> <p>The power supply system will include the installation of a 33kV/415V 630KVA step-down transformer, low-tension systems, 680 KVA voltage stabilizer, and 415 KVAr automatic power factor correction panel. This will not only protect, control, and optimize electric power distribution systems but also ease the process of accessing three-phase power for SMEs.</p> <p>The Low-Tension system will receive power from the service transformer and distribute the power to various sub-LT panels for each SME by receiving it from the transformer.</p> <p>A voltage stabilizer will ensure that the users are fed a voltage subject to a variation much lower than $\pm 0.5\%$ with regards to the nominal value. This protects machinery and equipment from malfunctioning or failure that could arise from voltage variation.</p> <p>The capacitor banks are connected across the supply to improve the power factor of the system. Capacitors are switched automatically (through programmable devices generated reactive power to be compensated).</p>
<p>Shared accredited aflatoxin testing laboratory</p>	<p>The national and international Standards require grain processing companies to ensure that the aflatoxin levels within the grain are below the minimum level as provided by the standards. To comply with standards requires these companies to collect samples of grains for testing at a national accredited laboratory to test for aflatoxin levels. The process of having samples tested and getting a laboratory report takes about 45 working days. The delays in getting aflatoxin test report slows down business. To address this problem, it's proposed to have an on-site accredited aflatoxin testing laboratory as common infrastructure for the Soroti Industrial and Business Park. The laboratory should be complemented with a mobile aflatoxin testing laboratory to support farmers monitor and control aflatoxin before they deliver produce to dealers/exporters. The aflatoxin testing laboratory should include apparatus and equipment as specified by the East Africa Grain Council (EAGC), for testing and determination of aflatoxin B1, B2, G1 and G2.¹⁵ The testing lab will minimize time delays in getting test results for aflatoxins.</p>
<p>Shared cold rooms from fruits and vegetables</p>	<p>A centralized system has better energy productivity and will provide lower overall costs than a decentralized system.</p>
<p>Carbonizing machine for the production of biochar from cassava peels</p>	<p>It's projected that Soroti Industrial and Business Park will be generated over 1435.2 tons of cassava peelings annually. The large volumes of cassava peels from the starch process can be converted into biochar. Cassava peelings biochar consists of hydrophilic surface functional groups (mainly -OH and -COOH). Studies show that the biochar is mainly composed of carbon (78.65%), oxygen (18.65%), phosphorus (0.26%), potassium (1.91%), calcium (0.30%), magnesium (0.13%), silicon (0.10%), and nitrogen (1.14%).</p>

¹⁵ [Uganda National Bureau Of Standards \(unbs.go.ug\)](http://unbs.go.ug)

	These properties make cassava peeling biochar is potential resource for improving fertility and carbon sequestration in soil.
<i>Automated external solar lightning.</i>	External lightning can be activated by movement detectors and powered by solar cells.
<i>Fire security and disaster risk management</i>	Fire detectors and fire rescue equipment need to be available in strategic locations. A fire brigade equipped with at least one truck should be on site and available upon request by Aminit Composting Site. Contingency plans (multi-risk) need to be developed, including simulations and training.

4. Conclusion

Uganda is on track to developing a green economy though it is struggling to keep pace with industrial growth and ever-accelerating urbanization. The goal of sustainable industrialization will not be met unless progress is greatly accelerated, to facilitate the development of eco-industrial parks. On the development of eco-industrial parks, Soroti Industrial and Business Park is lagging far behind the progress needed to attain sustainable industrialization. If no interventions are made to facilitate such, the energy and water are projected to exceed 1,828,599 GJ and 2,499,718 m³ annually. The relatively slow progress in the development of eco-industrial when compared with the goals of sustainable industrialization an urgent need to pick up the pace. There is widespread acceptance that RECP and Industrial symbiosis can facilitate the creation of eco-industrial parks. The RECP assessment conducted at Soroti Business and Industrial Park shows that the adoption of industrial symbiosis and RECP measures can improve resource productivity, create green jobs, and reduce GHG emissions contributing to the creation of the eco-industrial park. Several lessons have been learned within the sector.

- i. Sustainable RECP delivery depends on how the decentralized authority (UIA) and private sector are empowered to make well-informed choices about technical RECP options. It is recommended that UIA develop a partnership with UCPC to pre-screen all industrial park projects applying RECP tools (in particular the material and energy flow analysis) and this logical tree. This should be complemented by a program to train companies in RECP measures implementation and park management in monitoring those.
- ii. Industrial symbiosis interventions have more impact if approaches are intersectoral. It is therefore important to develop an engagement strategy for the identification of new tenants in the FZ/IP that can optimize symbiosis by characterizing waste and resource consumption as well as adherence to green standards.

5. Annex

5.1. Annex 1: Concept note installation of shared power distribution Transformer with stabilizer and a capacitor bank.

Table 15 Annex 1: Concept note installation of shared power distribution Transformer with stabilizer and a capacitor bank

Project Summary	
Sector	Energy
Project Title	Installation of a Shared Power Distribution Transformer, Power Stabilizer, and Capacitor Bank for SMEs in Soroti Industrial Park
Project Duration (Financial Years)	2 years
Estimated Project Cost	USD 285,891.4
Officer Responsible	Industrial Officer GGGI
Date of Submission	15 th November 2023
Section 1: Project Background	
<p>1.1 Situation analysis Provide a background to the project idea or the problem your project will focus on by: (i) describing current situation including past and on-going interventions; ii) recent developments in interest, achievements and challenges if any, iii) Explain projected trends using published forecasts. Quote official statistics to support your narrative.</p> <p>Soroti Industrial and Business Park has access to a power distribution line of 33kV. This requires enterprises within Soroti Industrial and Business Park to have three-phase transformers to step down distributed power from 33kV to 415 V for industrial applications. Large companies in Soroti Industrial and Business Park have privately owned three-phase step-down transformers, for example, Pela Commodities Ltd has a 500kVA three-phase step-down transformer. However, Small and Medium Scale Enterprises can't afford three-phase transformers and they must undergo a bureaucratic process that involves application and registration to a utility company (UMEME) and approval from the Electricity Regulatory Authority.</p> <p>Discussion with SMEs reveals that the process of applying for a three-phase transformer and getting approval can take up to 2 years. The cost of investing in a privately owned three-phase transformer can be above USD 45,000 for a 350KVA transformer. SMEs can hardly afford such investments and often resort to conventional alternatives like the use of diesel-powered engines or diesel generators.</p> <p>Information and data from Sanqua Engineering Ltd (a construction company located in Soroti Industrial and Business Park), shows that due to failure to access three-phase power, the enterprise kept its electric-powered machinery redundant and opted to use hand-operated machines. This has reduced the productivity of the enterprises from 21 to 4 tons of concrete blocks per day. This translates to about 80% reduction in revenue.</p> <p>Furthermore, power transmission and distribution are characterized by transmission and distribution losses. Energy audits conducted in SMEs in Uganda show that voltage drop often goes above $\pm 5\%$ which poses risks to electrical equipment and appliances. To address the challenge of voltage-drop manufacturing enterprises are often advised to install localized power/voltage stabilizers.</p> <p>Power quality is also reported as a major electricity challenge, especially harmonic distortion, and low power factor. According to the Ministry of Energy and Development, the power factor for most manufacturing enterprises ranges from 0.52 and 0.85. This is a problem because Uganda's Electricity (Primary Grid Code) Regulations (2003) require that the power factor for big consumers should not fall below 0.9. The government rolled out a program to provide capacity banks to improve the power factor, however this program ended in 2014. Without financial support to invest in three-phase transformers, capacitor banks, and power regulators. SMEs in Soroti Industrial and Business Park are more vulnerable to the high cost of three-phase power connection, voltage fluctuation, current surge, and low power factor. This can result in the use of alternative</p>	

sources of energy like diesel-powered engines which are associated with high GHG emissions, low productivity, and increased cost of doing business.

1.2 Problem Statement

Provide an explicit definition of the problem to be addressed in terms of challenges, constraints or gaps that the market or private sector cannot resolve and:

- (i) Mention the likely causes of the problem both direct and indirect,
- (ii) Give a brief insight into the likely consequences if no government intervention is made.

The grid connection costs for three-phase power are high (estimated to be over USD **45,000** per SME) forcing SMEs to switch to manual operations or use diesel-powered engines. Switching to hand/manually operated machinery reduces the productivity of SMEs while running diesel-powered engines increases the cost of production and GHG emission to the environment. The cost of running a diesel engine is projected at **30.2** cents per kWh which is relatively high as compared to **12.3** cents per kWh the cost of power from the national grid. The electrical energy demand of SMEs is projected to be at least **735,134 kWh** per year this equivalent to **167,076** litres of diesel. To ease the process and cost of accessing a three-phase electrical power a shared power distribution system including a step-down transformer, power stabilizer, and global capacitor bank is needed. The capital investment cost for such a system is high yet SMEs lack access to finance because most financial institutions perceive them to be risky. Failure to support SMEs invested in a three-phase power distribution system can result in increased use of fossil fuel and reduced profit margins for SMEs. The additional expenses likely to be incurred by SMEs while using fossil fuels are estimated to be USD 131,588.986 per year.

1.3 Relevance of the Project Idea

Justify the need for the proposed project by: (i) linking the project to the National Development Plan (NDP) strategic interventions by identifying the objective (s) that the proposed project is expected to contribute to; (ii) Linking the proposed project to Sector Investment Plan (SIP) objectives by describing the sector outcomes that the project is expected to impact.

The sustainable energy development program of National Development Plan 2021/22-2024/25 recognizes the need for improvement of the constrained electricity transmission and distribution infrastructure. The program plans to with access to electricity from 24 percent in FY2018/19 to 60%. Supporting SMEs to get a shared power supply system will contribute to the targets of the sustainable energy development program.

Furthermore, the Industrialisation programme aims at promoting inclusive and sustainable industrialization and fostering innovation. The programme recognizes the need to provide low-cost adequate energy to support manufacturing enterprises by extending the power network infrastructure to industrial areas. The programme also calls for environmentally sustainable serviced industrial parks.

Therefore, supporting SMEs in getting a shared power distribution infrastructure (including a service transformer) will not only contribute to the target of sustainable energy development of increasing energy access to 60% but also to the priority of the industrialization programme of creating an environmentally sustainable serviced industrial Park

Section 2: Technical Approach

2.1 Stakeholders

Identify the key stakeholders that are likely to be affected by the interventions including (i) Direct Beneficiaries (ii) Indirect Beneficiaries (iii) Project Affected Persons. Give a brief description of the likely impact of the project on the stakeholders.

- I. Uganda Investment Authority: The installation of a power distribution system including a service transformer will attract SMEs to join the SME park. This
- II. SMEs in Soroti Business and Industrial Park: Enhance access to clean, fordable, and reliable power which will consequently reduce the cost and ease of doing business.

2.2 Project Outcomes

Define the project objectives in terms of the positive impact that the project is expected to have on the economy and key stakeholders.

The objective is to ease the process and cost of accessing three-phase grid power and minimize the possibility of using diesel engines as south power by installing a shared power distribution system (including a service transformer) for SME Hub in Soroti Industrial and Business Park.

This project resulted in the following direct impact.

- i. Reduction cost of electrical power from 30.3 cents per kWh (when using diesel engines) to 12.3 kWh (when buying power from the national grid)
- ii. Reduction in GHG emission from 0.740 kgCO₂ per kWh (diesel power) to 0.550 kgCO₂kWh (grid power)
- iii. On the economy, the intervention will reduce foreign exchange loss by 223,881.84 Per year (cost spent on import of diesel)

2.3 Proposed Project Interventions

Describe the interventions, project outputs/components that need to be undertaken by the government through the proposed project to address the problem. For each output briefly highlight the major activities that you propose to implement to achieve the objectives mentioned in Section 2.2 above. Describe the strategy you will adopt to implement the proposed activities.

The proposed intervention will include the installation of a 33kV/415V 630KVA step-down transformer, low-tension systems, 680 KVA voltage stabilizer, and 415 KVAr automatic power factor correction panel. This will not only protect, control, and optimize electric power distribution systems but also ease the process of accessing three-phase power for SMEs.

The Low-Tension system will receive power from the service transformer and distribute the power to various sub-LT panels for each SME by receiving it from the transformer.

A **distribution transformer** provides a final transformation to 415 V. A voltage stabilizer ensures that the User is fed a voltage subject to a variation much lower ($\pm 0.5\%$ with regards to the nominal value) system. This protects machinery and equipment from malfunctioning or failure that could arise from voltage variation.

The capacitor banks are connected across the supply to improve the power factor of the system. Capacitors are switched automatically (through programmable devices generated reactive power to be compensated).

In conclusion, the proposed shared power distribution system will provide an efficient flow of electricity for production and management operations and compensate for the reactive power. The system will also protect the equipment and machinery from a fluctuating power supply that can in return result in the breakdown of machinery or any component and production delays due to sudden power deficiency. Moreover, for a system with multiple operations, any delay due to the interrupted power supply will hamper the process.

2.4 Coordination with other Government Agencies

Identify specific activities and issues for which you will need to coordinate the implementation of activities with other government agencies. List the relevant Government partner agencies and briefly describe their roles.

- i. The Electricity Regulatory Authority will approve and provide a permit for the installation of a service transformer at the SME hub in Soroti Industrial Park. It will also ensure that standards and

codes of conduct in respect of the distribution systems are observed during the installation of the Power stabilizer and capacitor bank.

- ii. Uganda Electricity Distribution Company will take the lead in supervising and monitoring the installation of a shared power distribution system for the SME hub.
- iii. The Ministry of Gender, Labor, and Social Development will monitor project development to ensure that Construction, Electrical, Mechanical, and Installations meet the Safety requirements as provided for by the law

5.2. Annex 2: Concept note a biomass powered shared steam generation and distribution system.

Table 16 Concept note for a biomass powered shared steam generation and distribution system.

Project Summary	
Sector	
Project Title	Adoption of a Biomass Powered Shared/Community Steam Generation and Distribution system for Soroti Industrial Park.
Project Duration (Financial Years)	10
Estimated Project Cost	USD 8.6 million
Officer Responsible	Industrial Officer GGGI
Date of Submission	15 th November 2023
Section 1: Project Background	
<p>1.4 Situation analysis Provide a background to the project idea or the problem your project will focus on by: (i) describing the current situation including past and on-going interventions; ii) recent developments in interest, achievements and challenges if any, iii) Explaining projected trends using published forecasts. Quote official statistics to support your narrative.</p> <p>Soroti Industrial Park is largely occupied by Agro-processing Enterprises, which are by nature energy intensive.. Usually Agro-processing depends on woody biomass and fossil fuel (diesel and furnace oil) to meet their thermal energy demand. The use of woody biomass in Agro-processing factories in Uganda is reported to be unsustainable for example in tea factories wood consumption is as high 2kg of wood per kg of tea processed. In recent studies, the direct combustion of fuel for energy in the industry sector was around 116,000 TJ, of which the vast majority (89%) was from biomass sources (Ministry of Water and Environment, 2019).¹⁶</p> <p>The operational enterprises in Soroti Industrial and Business Park use diesel to meet their thermal energy demand. For example Soroti Fruit Factory uses up to 60 liters of diesel to process 1 ton of mangoes. The business-as-usual projected thermal energy demand of Soroti is estimated to be about 299,387 GJ of energy. This is equivalent to the deforestation of 909 acres of a 15-year-old forest cut or equivalent to 9.4 million liters of diesel and GHG emissions of about 24,350 tons CO₂eq.</p> <p>Currently, each industrial unit plans to establish its own steam boilers unit. Typically, these small boilers consume a lot of fuel, have high maintenance costs and downtime, emit significant quantities of pollutants, and are a safety hazard. Design limitations of small-scale boilers prevent them from efficiently responding to fluctuating</p>	

¹⁶ See [Updated NDC Uganda.pdf \(mwe.go.ug\)](#)

load demands. These inefficient operations increased fuel consumption by 50% and consequently GHG emissions by 50%.

There are no interventions previously undertaken to facilitate the adoption of renewable energy and improve energy efficiency in steam generation within Soroti Industrial Park. However, the use of low-cost renewable energy alternatives (agro-residues) like bagasse, rice husks, sunflower husk, cassava peeling have been successfully used in generation of steam on industrial scale especially in paper and pulp, textile, sugar, dairy industries Uganda. The successful utilization of Agro-residues (renewable energy) on industrial scale in Uganda demonstrates huge potential to replicate use of agro-residues to meet steam demand for Soroti Industrial and Business Park. The adoption of modern biomass energy technologies like community biomass-powered boilers provides opportunity to sustainably utilize biomass, especially agriculture residues thus facilitating transition to eco-industrial Park.

1.5 Problem Statement

Provide an explicit definition of the problem to be addressed in terms of challenges, constraints or gaps that the market or private sector cannot resolve and:

- (iii) Mention the likely causes of the problem both direct and indirect,**
- (iv) Give a brief insight of the likely consequences if no government intervention is made.**

Operational enterprises within Soroti Industrial and Business incur high costs to generate steam for their thermal processes. The technologies adopted use diesel as fuel and emits significant quantities of GHG emissions. The cost of fuel for steam generation in Soroti Industrial Park is estimated at USD 0.106 per kg. The cost of steam generation and associated emissions are high because each individual industry within Soroti Industrial Park must establish its own steam boilers. These small boilers have design limitations preventing them from efficiently responding to fluctuating load demands thus consuming a lot of fuel. Small boilers have high maintenance costs and downtime, emit significant quantities of pollutants due to inefficient combustion, and are a safety hazard.

If there are no interventions undertaken to facilitate switching to clean fuel alternatives and improving efficiency in steam generation with Soroti Industrial Park the thermal energy demand is projected to be 299,387 GJ per year, emitting about 24,350 tons CO₂ eq. this is equivalent to about 9.4 million Liters of diesel and USD 12.33 million of foreign exchange loss.

A biomass-powered centralized steam generation can provide a common solution to all these problems.

1.6 Relevance of the Project Idea

Justify the need for the proposed project by: (i) linking the project to the National Development Plan (NDP) strategic interventions by identifying the objective (s) that the proposed project is expected to contribute to; (ii) Linking the proposed project to Sector Investment Plan (SIP) objectives by describing the sector outcomes that the project is expected to impact.

The Uganda Vision 2040 aspires to pursue economic development and socioeconomic transformation premised on the principles of a green economy such as equity, environment sustainability, resource efficiency, climate change adaptation and mitigation, and inclusiveness.¹⁷

The green manufacturing strategy aims to enable a shift from a linear to a circular production system through the adoption of Resource Efficient and Cleaner Production, Industrial Symbiosis, and Eco-innovation.¹⁸

The National Determined Contribution (NDC) prioritizes switching energy consumption in the industrial sector from fossil fuel to biomass. This can lead to emission reductions of approximately 0.23 MtCO₂e by 2030¹⁹

Adoption of a biomass-powered shared steam generation system will improve steam generation efficiency contributing to sustainable utilization of biomass. The shared steam generation will lower the cost of steam generation this directly contribute to a reduction in production costs thus enhancing competitiveness of enterprises in Soroti Industrial Park. The technology will also facilitate the transition from fossil fuel use to

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¹⁸ see [Green Manufacturing Strategy – Ministry of Trade Industry and Cooperatives \(mtic.go.ug\)](https://mtic.go.ug/Green_Manufacturing_Strategy)

¹⁹ See [Updated NDC Uganda.pdf \(mwe.go.ug\)](https://mwe.go.ug/Updated_NDC_Uganda.pdf)

biomass reducing dependence on fossils and the associated GHG emissions. The construction and operation phase of the project will create green jobs, especially for people in the Teso region. This will not only contribute the Uganda Vision 2040 and NDC but also to Sustainable Development Goals (SDGs), especially SDG 7 on affordable and clean energy and SDG 12 on responsible consumption and production

Section 2: Technical Approach

2.1 Stakeholders

Identify the key stakeholders that are likely to be affected by the interventions including (i) Direct Beneficiaries (ii) Indirect Beneficiaries (iii) Project Affected Persons. Give a brief description of the likely impact of the project on the stakeholders.

- i. Soroti local government; the local government will get revenue in the form of taxes and license fees for the operation of a steam generation facility.
- ii. Local communities. The construction and operation of a shared steam generation and distribution system will create employment opportunities for the people of the Teso region.
- iii. Industries in Soroti Industrial and Business Park. The enterprises within Soroti Industrial Park will enjoy affordable clean energy information? about steam
- iv. Farmers: the farmers will get an additional revenue stream by selling agro-residues as biomass feedstock to steam boilers. The farmers can earn up to Ugx 500 per kilo of agro-residues

2.2 Project Outcomes

Define the project objectives in terms of the positive impact that the project is expected to have on the economy and key stakeholders.

The objective of the project is to reduce energy costs and the environmental load of individual enterprises within Soroti Industrial and Business Park by providing a renewable energy-powered, common steam generation and distribution facility. The anticipated benefits of the proposed concept include.

- i. Increased efficiency: Fuel-to-energy conversion improves because producing steam in bulk reduces the per-unit fuel consumption. This can achieve about a 25-30 percent reduction in energy demand consumption. Reduction in industrial air pollution by 65–70 percent, with better emissions control and the use of one-point monitoring.

The proposed project is a shared steam boiler. A shared/community boiler is a centralized steam generation system with a steam pipeline network within an industrial area that caters to the demand for steam generation of member industrial units. This will include a 50-ton/hr Modular on-demand steam boiler. The modular on-demand boiler will be adopted to address the challenge of varying steam demand. Modular systems are designed specifically to meet varying load demands. The modular-on demand will run on a series of biogas and biomass burners boiler operating co-currently to allow substitution of diesel with renewable energy. The steam generation system will be installed in phases starting with a 4-ton/hr modular and consequently series of 2-ton/hr modular in corresponding to the establishment of new industries. Complementary components will be installed on the boiler these include (i) An automated boiler fuel feed control system mechanism, and a proper emissions monitoring mechanism, (ii) The master controller monitors steam demand through a steam sensor at the header and utilizes sophisticated software to optimize the staging sequence of the boilers for the best overall system efficiency.

The use of renewable energy automated fuel control and emission monitoring systems will contribute reduction of GHG emissions.

Master controller will optimize steam generation to match steam demand improving overall steam generation efficiency and reducing cost of steam production

2.4 Coordination with other Government Agencies

Identify specific activities and issues for which you will need to coordinate the implementation of activities with other government agencies. List the relevant Government partner agencies and briefly describe their roles.

- iv. National Environment Management Authority will ensure that environmental and social impact assessment is carried, and the project meets the minimum requirements according the environment impact assessment regulation and ensure that during operation environment audits are carried in accordance with the Environment act.
- v. Uganda Investment Authority will issue an investor license for developing and operating of shared steam generation and distribution facility.
- vi. Ministry of Gender, Labor and Social Development will monitor project development to ensure that Construction, Electrical, Mechanical, and Installations meet the Safety requirements as provided for by the law
- vii. Ministry of Water and Environment will issue water abstraction and wastewater discharge permits.

Section 3: Estimated Project Cost and funding sources