

GREENING UGANDA'S URBANIZATION AND INDUSTRIALIZATION
Developing Material and Energy flow plan and Industrial Symbiosis
layout plan for Entebbe International Airport Free Zone Park

Submitted to



By

Twinomujuni Edson

CONSULTANT

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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 EIAFZ. The RECP assessment entailed carrying out material flow 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 zone, 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.

Based on the RECP assessment jointly carried out in collaboration with water and sanitation, and value chain analysis, the feasible sectors for EIAFZ are fruits and vegetables, meat (beef), cheese, and cut flowers. The established processing and handling capacity of the EIAFZ is indicated in the table below.

No	Feasible sectors/processes	Established production capacities
1	Fruits and Vegetables (conventional)	200
2	Fruits and vegetables (organic)	400
3	Meat (specialty)	200
4	Meat (Bulk packaging)	200
5	Cheese	4
6	Flower Cuttings	1560

In business as usual, the projected daily energy demand is about 4258.293 kWh. Fruits and vegetables will account for 60% of the total energy demand. The projected process water demand is estimated to be 3510 m³ per day. Through the implementation of Resource Efficient and Cleaner Production (RECP) measures and the adoption of industrial symbiosis synergies, the energy and water demand for EIAFZ can be reduced by 25 % and 30% respectively. This can be achieved through the implementation of the following Resource Efficient and Cleaner Production measures. (i) Use of low-pressure foam and/or gel instead of water to clean walls, floors and/or equipment surfaces, (ii) Fitting of cleaning hoses with hand-operated triggers, (iii) High-pressure cleaning(pressures ranging from 15 bar to 150 bar), (iv) Use of correct number and position of nozzles, (v) Segregation of water streams, (vi) Optimization of chemical dosing and water use in cleaning-in-place, (vii) Closed-circuit cooling, (viii) installation of a shared capacitor bank, Voltage stabilizer and change over switch (ix) Use of a centralized compressed air system, and (x) Use of efficient lighting systems. Furthermore, the adoption of identified RECP measures and industrial symbiosis synergies has the potential to reduce GHG emissions of Entebbe Free Zones Industrial Park by 577.65 tCO₂ per year.

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1. Background

1.1. Mission Itinerary

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 partnered with the European Union (EU) as part of the EU inclusive green economy uptake programme (GreenUP). At present, it delivers a project titled “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 is the primary expert for Resource Efficiency and Cleaner Production deliverables with supervision from the GGGI Industrial Officer and Team Leader.

2. Methodology

2.3. Stakeholder Identification and Consultations

The consultant carried out a stakeholder analysis to identify the key stakeholders that may influence or be impacted by the sustainable industrialization in the target areas (see annex 3). Stakeholder consultations aimed at ensuring that the proposed sustainability options are in the interest of stakeholders and beneficiaries. The consultant engaged with the 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 the annex 4). Data collected was analysed to inform proposed green projects for Entebbe Free Zones Park.

2.4. 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. This approach helps to identify waste of natural resources and other materials in a defined system that would otherwise go unnoticed in conventional economic monitoring systems. Furthermore MFA 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 EIAFZ 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,

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

- 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 using a methodology adopted from 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.

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

iv. Equation 1

Since EIAFZ is under construction phase, data used in the toolkit was obtained from operational enterprises in Uganda with similar process operations as the potential sectors. Additional data was obtained from published resource use and environment performance indicators of the target sectors.

Data and information obtained from material and energy 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.

$$\text{Pollution load} = K \sum_{i=1}^n C_i Q_i \Delta t$$

$$\text{GHG reduction} = \sum_j^n F_j E_j$$

$$\text{Water Demand} = \sum_p^n W_p O_p$$

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

Key

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

2.5. 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 wellbeing of workers and local communities.

To identify RECP options for the feasible sectors. The consultant engaged the technical team of operational manufacturing enterprises in Uganda with similar process operations as feasible sectors for EIAFZ to identify successfully adopted RECP options. Furthermore, the proposed RECP measures were informed published best available practices and technologies. ²

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

2.6. 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.

In order to develop an industrial symbiosis layout plan, the consultant undertook 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).

3. Findings from Field Assessments

3.1. Material and Energy Flow of Target Sectors

A material flow analysis was carried for Entebbe Free Zones Park to identify feasible sectors/process, Resource Efficient and Cleaner Production (RECP) options for improving resource productivity, mitigating waste, and manage material resources as strategies to facilitate the creation of eco-industrial park.

3.1.1. Fish Sector

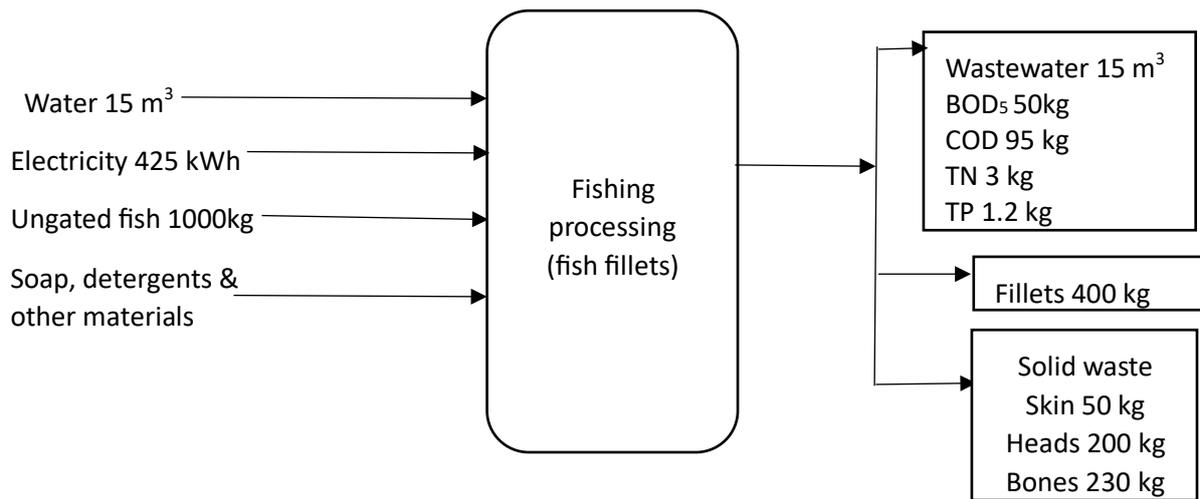
Fish fillet processing begins with pretreatment, which involves the removal of ice, washing, grading according to size, and de-heading. Fish is then scaled before further processing. The next step in the process is filleting, which is generally done by mechanical filleting machines however, in most companies in Uganda it's manually done with hands and knives. In the trimming department, pin bones are removed, and operators inspect the fillets, removing defects and any parts that are of inferior quality. Depending on the final product, the fillets may be cut into portions according to weight or divided into parts such as loin, tail, and belly flap. As a final step before packaging, the fillets are inspected to ensure they meet product standards. Fresh products are packaged in boxes with ice, the ice is separated from the products by a layer of plastic.

Material and energy flow in fish processing in Uganda.

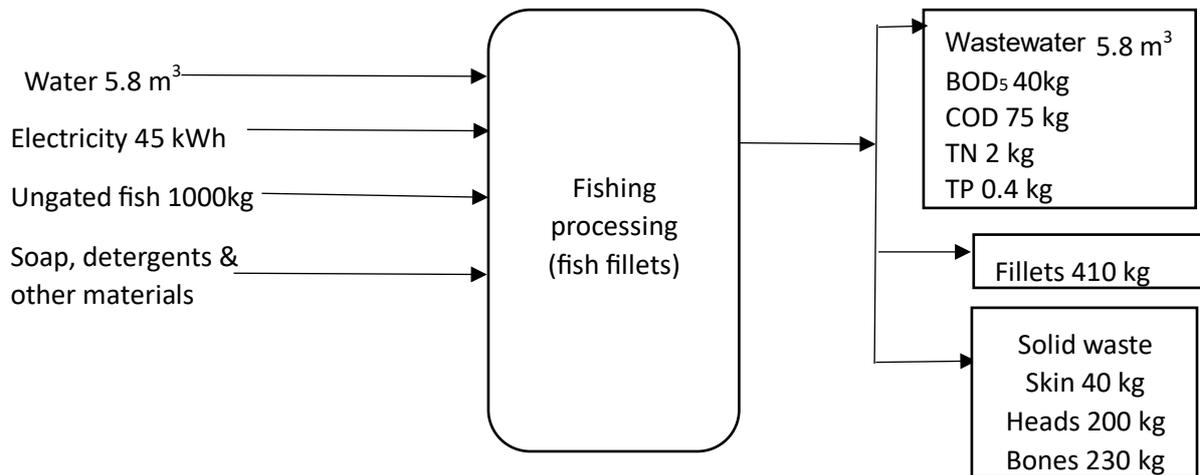
The average global water use in fish processing is about 8 m³ per ton of fish. According to the Uganda Cleaner Production Centre (UCPC), water use in fish processing ranges from 5.8 to 15 m³ per ton of raw fish. The large volumes of water consumption in fish factories in Uganda are due to manual processing including scaling, beheading, and filleting. About 50% of raw fish ends up as bi-products (heads, bones, and skin) and waste (blood and offal). The inefficient use of water is also attributed to the use of continuous running taps, and leakages. In 2011, energy consumption in fish processing factories in Uganda ranged from 175 to 425 kWh per ton of fish. Through the implementation of Resource Efficient and Cleaner Production (RECP) energy consumption was reduced to as low as 45kWh per ton of fish processed.

Material flow analysis of fish processing (business as usual scenario)

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 \(warwick.ac.uk\)](#)



Material flow analysis of fish processing (Best available techniques -scenario)



According to Food and Agriculture Organization (FAO), the space requirement for processing one ton of fish per hour is about 2560 meters squared. Therefore, the available space at Entebbe Freezones can handle a maximum production capacity of about 300kg /h or 4.8 tons per day. Assuming a fishing processing factory of 4.8 tons of fish per day is anchored at Entebbe Free zone the material flow of the fish factory will be as follows.

Table 1 Material and energy flow of a 4.8 tons per day fish processing factory (Business-As-Usual scenario)

Input			Output					
Fish (Nile perch)	Water	Energy (electrical)	wastewater	BOD ₅	COD	TN	TP	Solid waste (skin, heads and bones)
4.8 tons of fish	72 m ³	2,040 kWh	72 m ²	240kg	456kg	14.4kg	5.8kg	2.3 tons

Table 2: Material and energy flow of a 4.8 tons per day fish processing factory (Best Available Techniques scenario)

Input			Output					
Fish (Nile perch)	Water	Energy (electrical)	wastewater	BOD ₅	COD	TN	TP	Solid waste (skin, heads, and bones)
4.8 tons of fish	27.84 m ³	216 kWh	27.84 m ³	192 kg	360kg	9.6kg	1.92kg	2.25 tons

Environmental Risk of fish processing

Water consumption in the fish processing industry and the production of highly polluted wastewater are of great concern worldwide. Water consumed during fish processing becomes wastewater immediately. From the above material flow analysis fish processing (fillet) generates large volumes of wastewater with high loads of organic matter which includes fats, scraps of flesh, blood, and soluble substances (accounting for high BOD and COD loads), as well as detergents and other cleaning agents (accounting for high total phosphates and Nitrogen). The COD load of wastewater in Uganda from fish processing can be as high as 6 000 mg/l.

Fish processing Opportunities

While fish fillet processing is reported to be water-intensive and generates large volumes of wastewater with high organic load, the alternative method of fish smoking is more water-efficient and results in lower volumes of wastewater. This presents an opportunity to consider the production of smoked fish. However, fish smoking is associated with the emission of volatile Organic Compounds, Dust, carbon monoxide, polycyclic aromatic hydrocarbons, organic acids, acrolein, acetaldehyde, formaldehyde, and nitrogen oxides.

To address the environmental concerns, EIAFZ can explore the adoption of a Purified Smoke method. The Purified Smoke method involves treatment of smoke in the liquid phase for cleaning purposes (e.g. to remove undesired and harmful substances such as tar and ashes). Using compressed air, the purified smoke is afterward regenerated as smoke in a closed circuit and applied through the air to the goods to be smoked. Purified smoke is carried out in enclosed smoking chambers, thus no emissions into the air are generated. The production process of the pre-cleaned primary smoke condensate and the smoking process in a closed system together led to resource preservation and conservation of the environment. When compared to conventional smoked goods, purified smoke has the potential to reduce water consumption by 92 %, CO₂ emissions by 83%, wastewater by 83 %, and cleaning detergent consumption by 68 %.⁴

In conclusion, handling large volumes of wastewater associated with fish fillet processing would require a lot of space to accommodate a wastewater treatment plant. Given the size of EIAFZ (about 5 acres), the available space can hardly accommodate a large wastewater treatment plant. High pollution load of wastewater from fish fillet processing makes it difficult to harness symbiosis opportunity of channelling industrial wastewater to municipal wastewater treatment facility. Furthermore, operating an onsite wastewater treatment facility poses challenges of bad odour making it not compatible with trade house vicinity. For these reasons it's not technically feasible to anchor fish fillet process in a limited space at EIAFZ. However, from RECP point of view its technically feasible to anchor fish smoking at EIAFZ however, the value chain analysis disqualified it for the time being till airfreight export demand rises.

3.1.2. Dairy Sector

The dairy sector in Uganda mainly produces products with short shelf life, such as yogurts, and ice cream and products with longer shelf life, such as UHT, butter, milk powders, and cheese.

The dairy processing factories are among the water intensive process in manufacturing sector in Uganda. Water consumption in dairy processing is mainly associated with cleaning operations, other factors affecting water consumption in dairy processing include characteristics of CIP programs and maintenance of leaks. Discussion with the General Manager of Santos Foods Ltd reveals that water

⁴ Clean Smoke, Best available techniques for the smoking of food, 2018.

consumption in the production of cheese in Uganda ranges from 4.8 to 7.8 liters per liter of raw milk. According to water audit reports by the Ministry of Water and Environment (MWE) and Uganda Cleaner Production Centre water consumption in the production of market milk (UHT and Fresh milk) ranges from 2 to 8 liters of water per liter of raw milk. The Environment and Safety manager of GBK Dairy Products Ltd indicated that implementing Resource Efficient and Cleaner Production has enabled them to improve water use efficiency from 7.8 m³ per liter of processed milk to an average of 2 liters of water per liter of milk processed. Resource use and waste generation indicators of production process for dairy products are shown in the table 4. Over 95% of water consumed in dairy sector directly ends up in the waste stream generating large volumes of wastewater with high pollution load. Wastewater is the main environmental issue in the dairy sector. The wastewater from the dairy process majorly contains milk and milk products that have been lost from the process line, as well as detergents and acidic and caustic cleaning agents. The overall milk loss along the production is reported to range from 4% to 10% while product loss during packaging and storage can be as high as 3%. Data from a dairy factory in Mbarara shows that product loss range from 0.2–1 %. These milk losses occur during cleaning; spills during the startup, shutdown, or changeover of pasteurization units; or from accidental spills. Product losses to wastewater contribute greatly to the BOD, COD, nitrogen, and phosphorus content. The COD load in dairy processing effluents can be as high as 23,000 mg/L, in Uganda the COD load in dairy processing factory is reported to be as high as 60,000 mg/l. Cleaning-in-place (CIP) is the most common cleaning procedure used in the industrial production of dairy industry. The CIP uses acidic (Nitric acid) and alkali (Sodium Hydroxide), the use of these chemicals' accounts for the low or high PH of wastewater from dairy processing facilities.

Table 3: Cleaning solutions used in CIP

Products	Consumption of cleaning agents (kg/t processed milk)	
	NaOH 100%	HNO ₃ 100%
Yoghurt	0.2-10	0.2-5
Cheese	0.4-5.4	0.6-3.8
Milk Powder	0.4-5.4	0.8-2.5

The dairy sector is one of the most energy-intensive sectors. In Uganda, the dairy sector majorly uses electricity and steam to process its products. About 70% of dairy processing factories use biomass to generate steam while the rest uses diesel or furnace oil.⁵ Electricity used in the dairy sector is sourced from the national grid and diesel generators are used as a backup power source.

Table 4: Material and energy flow of dairy products processing

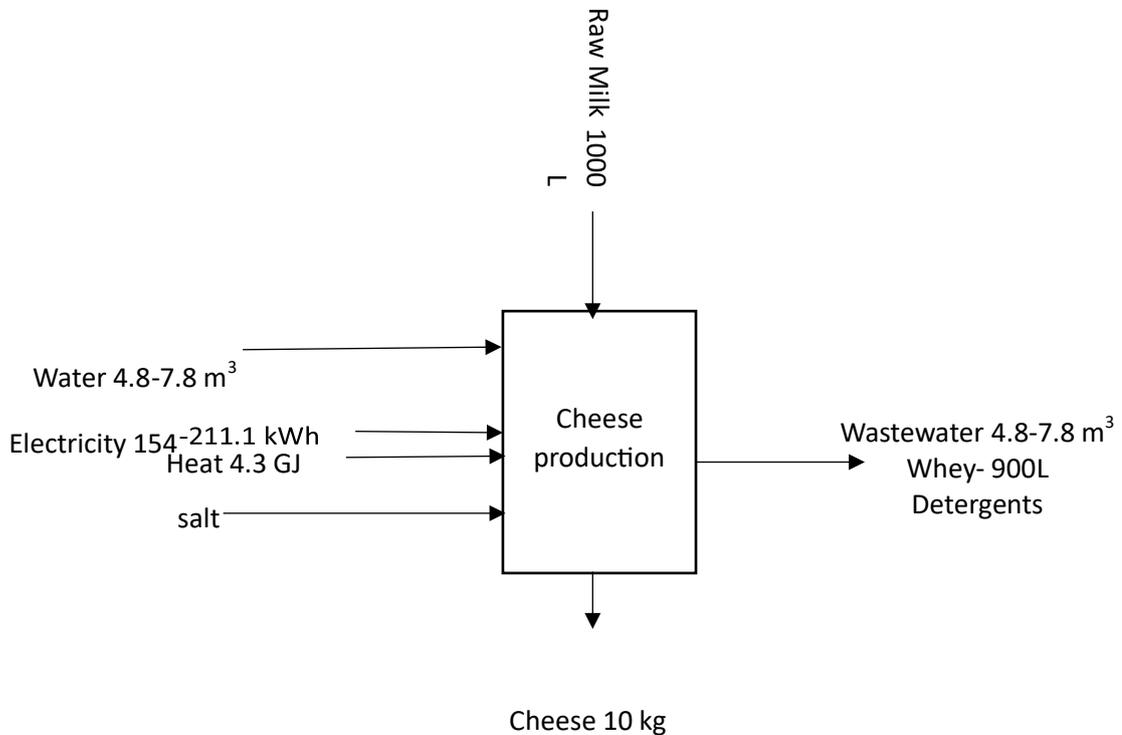
Type of milk product processed	Electrical energy in kWh per ton of raw milk	Thermal Energy in GJ per ton of raw milk	Water consumption in m ³ per ton of raw milk	Milk loss %	Wastewater in m ³ /ton of raw milk
Market milk	55.54-152.7	0.46-0.9	0.33–12.61	2.6-10	0.8-11
Yogurt	55.54-364.3		1.91–17.23	2.6-10	2-12
Butter	200.54-382.7	0.46-0.9	3–14		2–14
Ghee	270.54-452.7	0.46-0.9	3–14		2–14
Ice Cream	130-640	0.46-0.9	2–12.61		0.8-11
Cheese	154-211.1	4.34	0.24–10	0.3-2	0.75-3.5

⁵ Ministry of Trade, Industry, and Cooperatives 2018, Energy Assessment Report, Demand-side Management of Energy use in MSMEs in Uganda, Switch Africa Green Project.

Milk Powder	249.9- 397.1	20.60	0.50–4.27	0.86-4	1-3.5
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Material flow analysis of cheese

From discussion with production manager Sanatos Foods Ltd water consumption at the factory ranges from 4.8 to 7.8 liters of water per liter of raw milk. To process one kilogram of cheese, about 10-13 liters of raw milk are used generating about 9 liters of whey. Whey that is generated at the factory is collected in the storage tank and sold to animal farmers as feed.



Environment risks and opportunities associated with cheese processing.

The major environmental issue associated with the cheese-making process is the disposal of whey. This provides an industrial symbiosis opportunity for the recovery of the valuable high-grade protein from cheese whey. Currently its technically and economically feasible to recover protein from whey using ultrafiltration (UF), followed by spray drying of the protein. However, this option requires high initial capital investment. Currently, cheese factories in Uganda sell whey to animal farmers. The advantage of this whey management alternative is that there are no capital costs required. Cheese packaging generates solid waste, including discarded cuts and small pieces of cheese, and damaged packaging material. These of cuts can be blended with whey and sold to framers. Cheese storage is largely associated with GHG emissions from refrigerants, especially Chlorofluorocarbon (CFC) and Hydrofluoroolefin refrigerant gases (CFC). However, this can be minimized by substituting CFC with carbon dioxide. Carbon dioxide is a natural refrigerant with low global warming potential (compared to CFCs) and zero ozone depletion potential.

Table 5 Resource Efficient and Cleaner Production Measure for Cheese Production

RECP options	Technical description	Environment and social benefits Economic benefits

Minimization of the generation of acid whey	Acid whey is separated after curd formation. If acid whey is discharged to a WWTP, it may cause low pH levels. To prevent this, spillages are avoided by draining the top or platform of the salting vats. In addition, whey can be processed quickly so less acid whey is produced due to lactic acid formation.	Reduced wastewater pollution. Reduced wastewater treatments costs
Recovery and use of whey	Whey is recovered (if necessary, using collection tanks) and used, e.g. to produce As animal feeds. Recovery whey for animal feeds is no/less capital investment option for managing whey in cheese processing facilities. This is option widely used in cheese processing facilities in Uganda.	Reduce pollution loading of a cheese processing factory
Salt management - Handling of brine in cheese production	Integrated salt management in cheese production for reduction of salt in wastewater. This can involve: <ul style="list-style-type: none"> i. Extension of time for brine draining. ii. Installation of conductivity meters with alarms in transition wells of the WWTP. The alarm allows operators to check and take action in those cheese installations where the high salt content in wastewater originates. iii. Less salt discharge from the CIP of the brining system to the WWTP as the frequency of CIP can be changed, e.g. from one to two weeks. 	Reduction of chloride in wastewater 0.05 tones of salt per tone of produced cheese.

Generally, cheese processing generates less volume of wastewater compared to other dairy products. This makes cheese production the most technically feasible dairy processing option to be anchored at EIAFZ. However, through adoption of RECP, water demand and wastewater generation of ice cream, butter/ghee, yogurt, and UHT milk processing can be reduced to about 2 m³ per ton of product. This makes ice cream, butter/ghee, yogurt, and UHT milk processing potentially feasible to fit in limited space at EIAFZ. Much as adoption of RECP makes ice cream, butter/ghee, yogurt, and UHT milk processing potentially feasible, the value chain analysis didn't identify companies interested in exporting such products using freights.

3.1.3. Fruits and Vegetables

The fruits and vegetable processing industries may be described as consisting of two segments: fresh packing and processing. Packaging of fresh-cut fruits and vegetables involves gathering crops, sorting, cleaning, and packing them into boxes or bulk bins for shipment to the target market. Crops are cooled to preserve integrity and fumigated or treated to control insect infestation or microbial disease development. The unit operation involved in fresh fruit/vegetable processing in Uganda including inspection, sorting/trimming, washing, grading, and packing lines.

Water use and wastewater generation in Fruits and Vegetable fresh pack can be as high as 16 m³ per ton of the products. The large volume of water used and wastewater generation in the processing of fresh fruits and vegetables is associated with removing soil from fruits/vegetables, cleaning, rinsing, and cooling fruits, and vegetables, as well as cleaning different machinery and surfaces in the processing plants. These washing and sanitation operations are a major concern in reducing the total water and chemical consumption within the fruits and vegetables sector.

According to field assessments, processing of Fruits and Vegetable (organic and inorganic) in Uganda, applies a basic cleaning and disinfection approach that involves the use of only potable water to remove

dirt, pesticide, and residue reduction of microbial load. This is followed by grading according to size and packaging for shipping. There is no data that was shared on utility use and wastewater generation however, globally the reported resource use and wastewater indicators for the fruits and vegetable (fresh cuts) sector are shown in Table 5 below.

Table 6 Resource productivity indicator in fresh-cut fruits and vegetables

Raw material		Energy consumption GJ/ton	Water consumption m ³ /ton	Wastewater generation m ² /ton
Vegetables	Peas, beans, spinach, potatoes, asparagus, maize and lentils	20–65 kWheq	3 –11	3 –11
	Olives, cabbage, artichokes, mushrooms, onions, peppers, carrots cucumbers and		2.2–8	2.2–8
Fruits	Berries, pineapple, watermelon, mangoes,	20–65 kWheq	5-16	5-16

The environment Risks and opportunity.

Washing/disinfection, among all the processing steps, is identified as the most critical one, due to its crucial impact on the safety and quality of products and the environmental sustainability of the whole process. Washing of fruit and vegetables requires large quantities of water to remove chemical residues (i.e., pesticides, fertilizers). The freshwater used to clean fruit and vegetables during processing becomes wastewater. The cleaning and disinfection process results in chemicals like chlorine or ozone ending up in the wastewater streams thus increasing the COD. In the fruit/vegetable fresh-cut industry, pollution of wastewater is mainly linked to the high organic load and the presence of Disinfection By-Products (DBPs) associated with the use of chlorine. The most widespread approach for disinfection of process washing water is based on the use of chlorine, which is generally applied as a liquid, in the form of sodium hypochlorite (NaOCl) or calcium hypochlorite [Ca(OCl)₂] solution, or as a gas, in the form of chlorine (Cl₂) or chlorine dioxide (ClO₂).

To prevent the problem of Disinfection By-products (DBPs) associated with use of chlorine and its compound, it recommended that fruits at Vegetables at EIAFZ use Ozone as a disinfectant. Ozone is becoming an increasingly popular alternative to chlorine for water disinfection. Ozone provides comparable disinfection power to chlorine. Ozone treatments have the benefit of forming fewer undesirable by-products than chlorine treatments, such as trihalomethane, chloroform, and other dangerous compounds. Ozone is faster acting than chlorine and allows for adequate disinfection with short-term contact with the produces. The use of ozone does require an additional capital investment to install an on-site ozone generating equipment. Because of the instability of the compound ozone must be generated on-site, requiring investment in ozone-generating equipment. These generators create ozone through the action of a high energy source (UV light or corona discharge), splitting oxygen molecules that then recombine to form ozone. Small-scale ozone-generating units are available for a few thousand dollars.

Table 7: Typical wastewater characteristics for fresh-cut vegetable processing

No	Parameter	values
1	TS	4600–18,900mg/l
2	BOD	400-1700mg/l
3	COD	4,400–5,900mg/l
4	Total N	120–360mg/l
5	Total P	30–58mg/l
6	E. coli	3.1–3.7 log cfu (100 ml) ⁻¹
7	Coliform bacteria	4.9–6.5 log cfu (100 ml) ⁻¹
8	Faecal coliforms	2.3–5.5 log cfu (100 ml) ⁻¹

Fresh fruits and vegetable processing generates large volumes of wastewater with high pollution load as indicated in table 7. Fruits washing accounts for over 90% of water demand and wastewater generation while sorting accounts for the largest percentage of solid waste generation. To eliminate the risks associated treating large volumes of wastewater (with high pollution) and large volumes of solid waste. It's recommended that fruits and vegetables rinsing, packaging and cold storage be anchored at EIAFA while other processing including sorting pre-cleaning and washing be handled outside EIAFZ. The Fruits and vegetables enterprises at EIAFZ are advised to use ozone as a disinfectant at eliminated formation of DBPs.

3.1.4. Meat Processing

The meat (fresh cuts) industry in Uganda largely uses two methods: the bone-in method and the muscle boning method. In the bone-in method, the cut is trimmed off some fats and then vacuum-packaged and transported to a retail store. The vacuum packaging provides an anaerobic atmosphere and is then refrigerated to extend the shelf-life of the product. The advantage of using the bone-in method is that the process generated less solid waste (fat and bone). According to the production manager of Kajuma Agro Company Limited, the solid waste generated using the bone-in method is estimated to range from 12% to 20% of the carcass initial weight (cattle). In the muscle-boning method, the cut is trimmed off bones, and fats. The advantage of the muscle-boning method is the removal of the bones and fats that would otherwise take up packaging and storage space. However, this method generates large volumes of solid waste (fats and bones) estimated to range from 32% to 48% of the carcass initial weight (cattle).

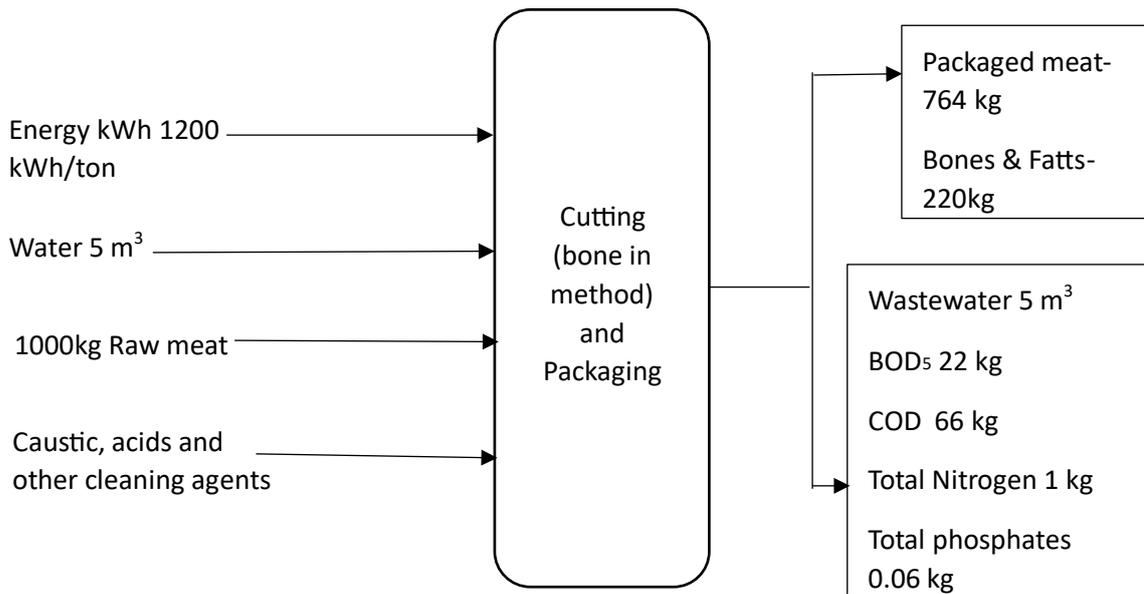
Data from UCPC show that fresh cuts production water consumption is about 3–5 m³ /ton (excludes slaughterhouse operations). However, according to the production manager of Kajuma Agro-Company Ltd Limited 2 Liters of water is used for every kilogram of meat packed. The water demand for Kajuma is relatively low because the company outsources slaughterhouse services, and its equipment is new and well-maintained.

Thermal energy, in the form of hot water, is used for cleaning and sterilizing. Electricity is used for the operation of machinery and for refrigeration, ventilation, lighting, and the production of compressed air. Like water consumption, the use of energy for refrigeration and sterilization is important for ensuring keeping good quality meat products.

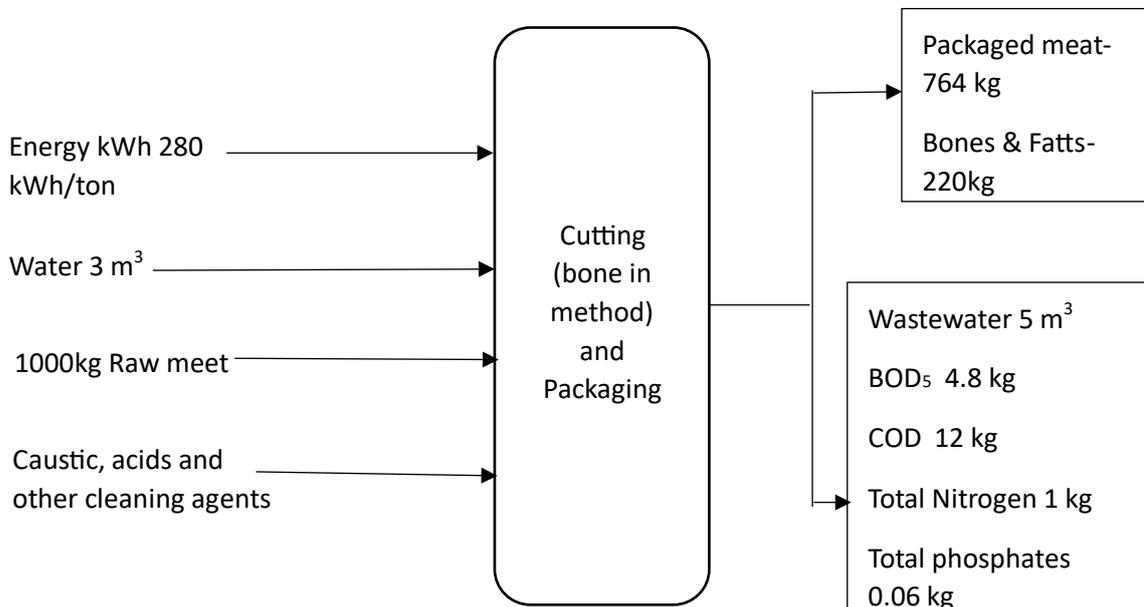
Table 7 Resource Use Indicators in Meat Processing

No	Parameter	Units
1	Water m ³ /ton	4-20
2	Energy kWh/ton	280-1200
3	BOD ₅ kg/ton	4.8-22

Material flow for meat processing (excluding slaughterhouse process) business-as-usual scenario.



Material flow for meat processing (excluding slaughterhouse process) best available techniques scenario.



Environmental risk of meat processing

One of the most pressing environmental issues associated with meat processing is the large volumes of effluent. Effluent from meat processing plants contains blood, fat, manure, undigested stomach contents, high levels of fat, fluctuations in pH due to the presence of caustic and acidic cleaning agents, and high levels of nitrogen and phosphorus as shown in Table 8 below. In meat processing, the abattoir/slaughterhouse accounts for over 60% of effluent generated, since over 95% of the water used in slaughterhouses is discharged as effluent. For this reason, the slaughterhouses stage will be operated outside the Entebbe Free Zone.

Table 8 Wastewater parameter for effluents discharged from slaughterhouse.

Parameter	Pollutant load in kg/ton of carcass
COD	12–66
Suspended solids	4–18
Total nitrogen	1–3
Total phosphorus	0.06–0.5

Carcass washing can be a significant source of water waste and effluent contamination. In manual operations, there is a tendency for operators to use more water than is necessary. In contrast, in automated carcass washing units' sprays are activated only when a side of meat is in the washing cabinet. The amount of water used can be set to the minimum required. Splitting and cutting are generally undertaken with little water. However large amounts of hot water is required for the cleaning and sterilization of knives and equipment (saws, trays, gambrels, hooks, rails etc).

Table 9 Wastewater parameter of effluent from meat cutting and packaging.

No	Wastewater parameter	unit
1	COD mg/l	1000-3500
2	BOD ₅ mg/l	600-200
3	Total Nitrogen mg/l	50-200
4	Total phosphorus mg/l	15-50

Material flow analysis identifies slaughterhouse operations as the most water and wastewater intensive stage of meat processing. Companies that outsource slaughterhouses services like Kajuma Agro-processing consume less water and generates low volume of wastewater. Given space limitations at EIAFZ, its therefore recommended the meat processing enterprises at EIAFZ outsource slaughterhouse services and only cutting, packaging and cold storages operations be anchored at the EIAFZ for the meat sector. This will eliminate risks associated with treatment large volumes of wastewater from beef/meat processing within in a limited space.

3.1.5. Floriculture Sector

The water footprint per stem (cut flower) varies from 7 to 13 liters. If we assume an average flower stem weighs about 25 grams, its blue water footprint would be about 6 liters/stem. The grey water (wastewater) footprint is about 3 liters/stem. The wastewater has high pollution load due to use of several chemicals during cultivation. Chemicals are used in floriculture for various purposes, such as:

- ii. Plant growth regulators: These are substances that modify the growth and development of plants, such as flowering time, branching, height, and quality. Some examples are ethylene, gibberellins, cytokinin's, and auxins.
- iii. Pesticides: These are substances that prevent or control pests, such as insects, fungi, bacteria, weeds, and rodents. Some examples are glyphosate, imidacloprid, etridiazole, and pyrethroids.
- iv. Fertilizers: These are substances that provide nutrients to plants, such as nitrogen, phosphorus, potassium, calcium, magnesium, and micronutrients. Some examples are urea, ammonium nitrate, superphosphate, and potassium chloride.

The most water and chemical intensive stage of cut flower production is the cultivation stage. Chemicals used at the cultivation stage of flowers end up as residual chemicals in waste during the processing of flower cutting. This makes effluent and solid waste from cut flower processing toxic.

Table 9 cut flower wastewater (typical) pollution parameters.

No	Wastewater parameters	mg/l
1	Total dissolved solutes (TDS)	357
2	Biochemical oxygen demand (BOD)	138
3	Chemical oxygen demand (COD)	569
4	Total nitrogen (TN)	5.1
6	Total phosphorous (TP)	5.1

Adopted from Kenyatta University Department of Zoological Sciences⁶

Some drawbacks associated with wastewater containing chemical residues from cut flower farm include.

- ii. Environmental impact: Chemicals can contaminate soil, water, air, and biodiversity. Chemicals can also contribute to climate change by emitting greenhouse gases.
- ii. Human health impact: Chemicals can pose risks to workers and consumers who handle or inhale them. Chemicals can cause acute or chronic effects, such as irritation, allergy, poisoning, cancer, or reproductive disorders.

In order to eliminated risks associated with residual toxic chemicals in wastewater from cut flower production. It's recommended that flower farms carryout all process operations that are responsible for residual chemicals at their farms. For these reasons only cut flower bulk packaging and cold storages operation are feasible to be anchored at EIAFZ.

3.2. Identification of Priority Sectors for EIAFZ

Key constraints for EIAFZ are the vicinity of Lake Victoria and the very small space which translated into limited space for sanitation infrastructures in the park, restrictions on processes as described in 2022 mission report, to which this mission brought the actual calculations to specify the maximum volumes per sector that could be handled. The initial broad sectors selection was obtained and validated as a result of 2022 mission. It considered a range of criteria including government priorities, stakeholders' interest, rapid value chain analysis and unique selling points considerations. The pre-selected sectors included Fruits and Vegetables, Meat, Fish, Dairy and Floriculture. The 2023 mission aimed at confirming the feasibility of the preselected sectors and stakeholder interest and went down to specifying subsectors or even processes/products that would best meet the performance criteria.

Using information from material flow analysis, a logic tree/decision support system (see Greening Uganda's Urbanization and Industrialization summary report) was applied to identify the feasible sector

⁶ [Treatment of flower farm wastewater effluents using constructed wetlands in lake Naivasha, Kenya | Semantic Scholar](#)

or processes. The feasible sectors include Fruits and Vegetables, Fish, Beef, Dairy, and Floriculture as described below.

Fruits and Vegetables: During the processing of fruits and vegetables, washing accounts for over 90% of water demand and wastewater generation while sorting generates the largest percentage of solid waste generation. To eliminate the risks associated with treating large volumes of wastewater (with high pollution) and large volumes of solid waste, it's recommended that fruits and vegetable rinsing, packaging, and cold storage be anchored at EIAFA while other processing including sorting pre-cleaning and washing be handled outside EIAFZ.

Meat/beef: Material flow analysis identifies slaughterhouse operations as the most water and wastewater intensive stage of meat processing. Given space limitations at EIAFZ, its therefore recommended the beef processing enterprises at EIAFZ outsource slaughterhouse services and only cutting, packaging and cold storage operations be anchored at the EIAFZ.

Dairy: Generally, cheese processing generates less volume of wastewater compared to processing other dairy products. This makes cheese production the most technically feasible dairy processing option to be anchored at EIAFZ. However, through adoption of RECP, water demand and wastewater generation of ice cream, butter/ghee, yogurt, and UHT milk processing can be reduced to about 2 m³ per ton of product. This makes ice cream, butter/ghee, yogurt and UHT milk processing potentially feasible to fit in limited space at EIAFZ. Much as adoption of RECP makes ice cream, butter/ghee, yogurt and UHT milk processing potentially feasible options, the value chain expert didn't identify companies interested in exporting such products using freight.

Fish: Handling large volumes of wastewater associated with fish fillet processing would require a lot of space to accommodate a wastewater treatment plant. Given the size of EIAFZ (about 5 acres), the available space can hardly accommodate a large wastewater treatment plant. The high pollution load of wastewater from fish fillet processing makes it difficult to harness the symbiosis opportunity of channeling industrial wastewater to municipal wastewater treatment facilities. Furthermore, operating an onsite wastewater treatment facility poses challenges of bad odor making it not compatible with trade house vicinity. For these reasons it's not technically feasible to anchor fish fillet process in a limited space at EIAFZ. From RECP point of view it's technically feasible to anchor fish smoking at EIAFZ however, the value chain analysis disqualified it for the time being till airfreight export demand rises.

Flowers: Cut flower production is a chemical intensive process and emits effluent with residual (toxic) chemicals. In order to eliminated risks associated with the management of residual toxic chemicals in wastewater. It is recommended that flower farms carry out all process operations that are responsible for release of residual chemicals at their farms. For these reasons only bulk packing and cold storages operation are technically feasible to be anchored at EIAFZ.

Table 10 Feasible unit/process operation of the selected sectors

No	Selected sector	Feasible unit/process operation
1	Fruits and Vegetables	Final rinsing, packing and cold storage
2	Meat	Cutting, packaging and cold storage
3	Dairy	Cheese (all unit operation)
4	Flowers (floriculture)	Packaging and cold storage

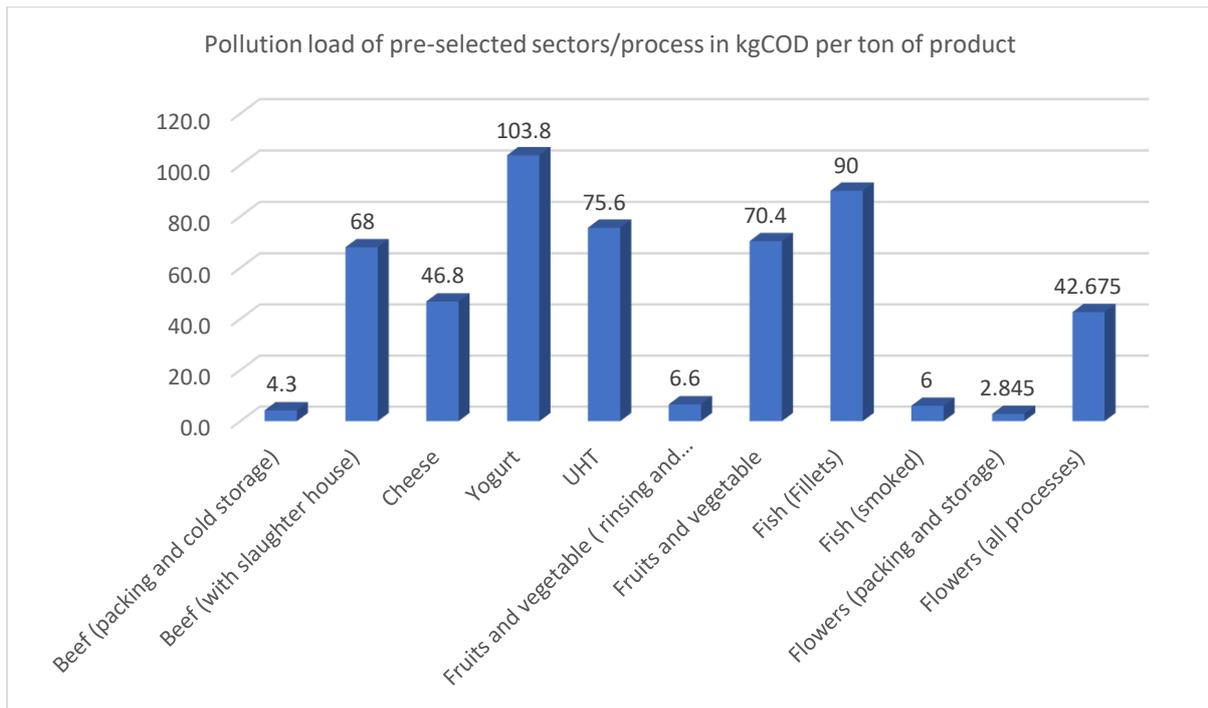


Figure 1 Pollution load of pre-selected sectors/process in kg COD per ton of product

3.3. Energy and Water Demand for EIAFZ

The maximum daily production capacity of EIAFZ is estimated to be a high as 600 ton of fruits and vegetables, 400 tons of meat, 4 tons of cheese and 1560 tons flower cuttings.

The projected business-as-usual daily energy and water demand for target sectors of Entebbe Free Zone Park is calculated to be 4260.70 kWh and 1405.0 m³ respectively. The water and energy demand are relatively high compared to values reported when the best available techniques are adopted. This provides an opportunity for implementation of RECP to improve energy and water efficiency and minimize pollution loading.

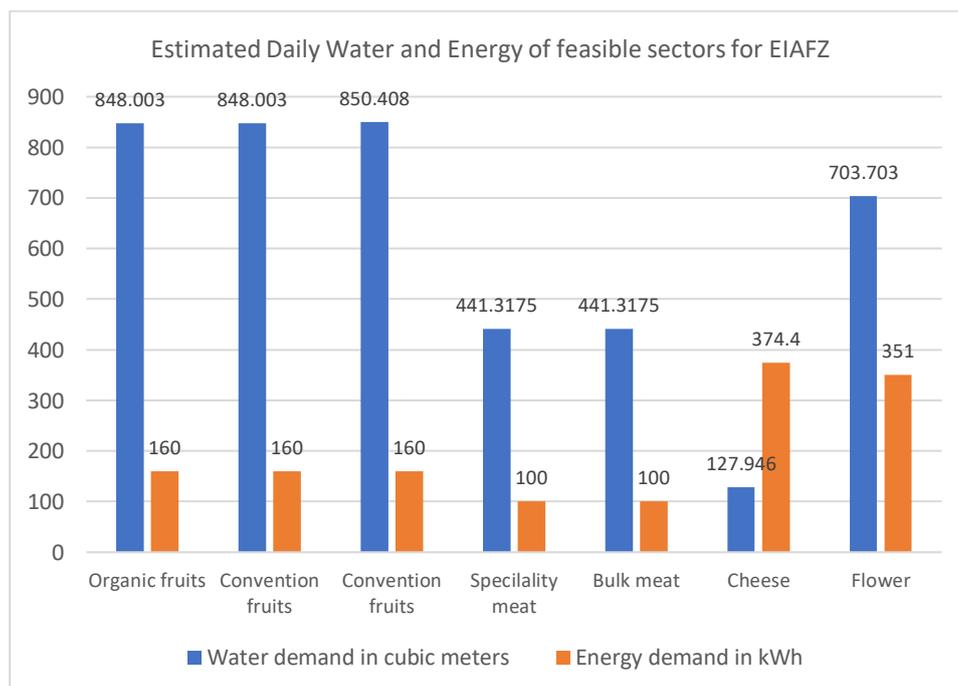


Figure 2 Estimated Daily Water and Energy of feasible sectors for EIAFZ

Fruits and vegetables will account for 34% of total water demand followed by flower (25%) and cheese (27%). Therefore, to significantly reduce water consumption and pollution loading of EIAFZ particular attention should be given to fruits and Vegetables, cheese, and flower processing.

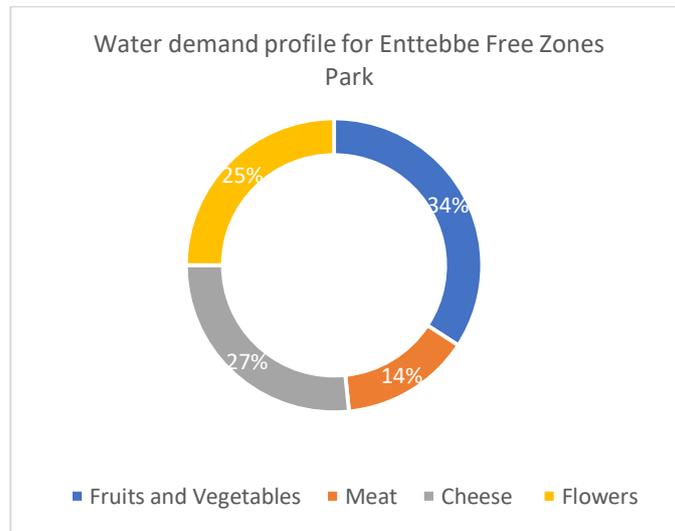


Figure 3 Water demand profile for Enttebbe Free Zones Park

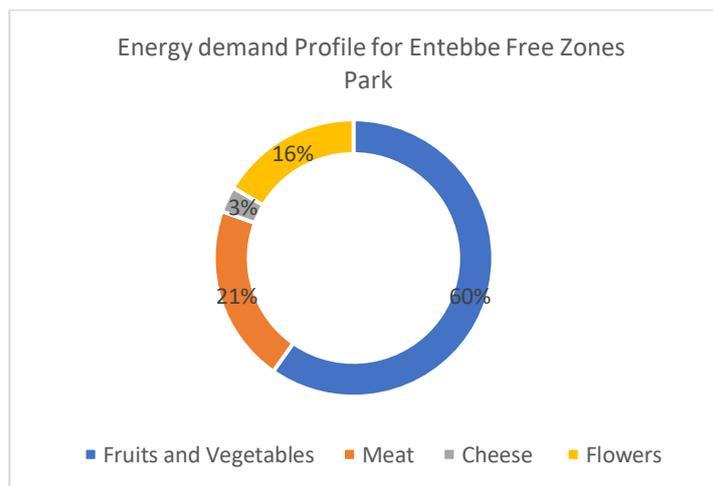


Figure 4 Energy demand Profile for Enttebbe Free Zones Park

3.4. Resource Efficient and Cleaner Production Measures

Adoption of RECP provides an opportunity for EIAFZ to improve energy and water productivity while at the same time minimizing pollution loading to land, water, and air. It's estimated that adoption of RECP measures will reduce energy and water consumption by 1065.17kWh and 351.35 m³ respectively per day. This translated annual energy and water savings of 332,333.04 kWh and 109621.2 m³. The annual energy saving will result in a GHG emissions reduction of 206.05 tCO₂eq.

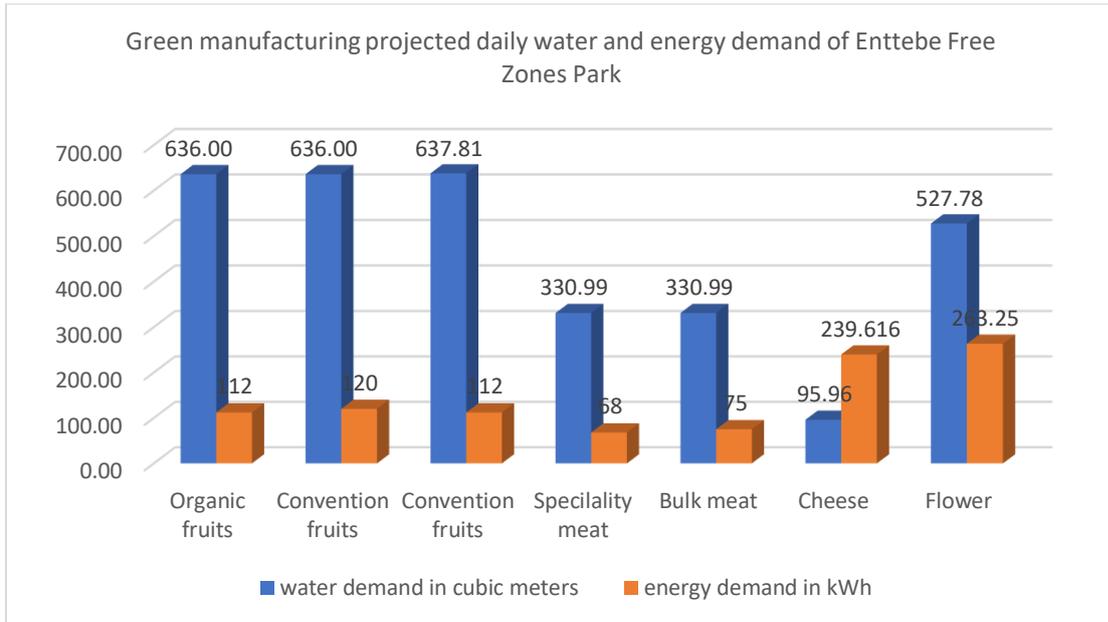


Figure 5 Green manufacturing projected daily water and energy demand of Entebbe Free Zones Park

3.5. Proposed Resource Efficient and Cleaner Production techniques and technologies

No	Resource Efficient and Cleaner Production option	Technical description	Benefits (environment, economic and social)
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. Centralised systems supply pre-mixed cleaning solutions and pressurised water from a central unit and during cleaning they automatically change between foam spreading and rinsing. Working with Eco-lab as a service provider, Crown Beverages and Uganda breweries have successfully used low pressure foam/gel as option to reduce water demand and wastewater generation.	Reduced 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 in this case are 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. Hand operated triggers are widely used in food and beverages industries in Uganda. For example, GBK Dairy Products Ltd and lakeside dairy in Mbarara	The time the hose was running was 8 h/day before installation and 4 h/day afterwards. For a water cost of USD 21/m ³ , an annual water cost saving of USD 4 987 was calculated. An annual energy saving of 919 GJ has also been calculated.

		adopted use of hand operated triggers as demand side water management strategy.	
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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 considered to be 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.
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5	<p>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 have fitted on steam lines, cleaning systems and material transfer lines.</p>	<p>Flow measurement and control techniques can reduce material waste and wastewater generation in FDM 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. Nile Breweries uses automated control devices to optimizes process operation and minimizes waste generations as results of overflows.</p>	<p>four times the design requirement. 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 m³/year, corresponding to 7.5 % of the site's mains water consumption. Water and waste water costs fell and there was reduced energy consumption and wear of the vacuum pumps. At the chicken processing installation, the introduction of flow regulators cost less than GBP 1 000 and resulted in water savings worth over GBP 10 000/year. At the fish processing installation, the 40 % reduction in water use saved GBP 2 500/year and gave a payback period of 5 weeks.</p>
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7	<p>Segregation of water streams; Water streams that do not need treatment (e.g. uncontaminated cooling water or uncontaminated run-off water) are segregated from waste water that has to undergo treatment, thus enabling uncontaminated water recycling.</p>	<p>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 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</p>	<p>Segregation of waste water 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 waste water treatment (e.g. water-holding capacity, energy consumption), whether on site, at a MWWTP or a combination of both. Waste water separation/segregation systems can be installed efficiently at new installations</p>
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8	<p>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.</p>	<p>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. Dairy industries in Uganda including Pearl dairies, Jessa Farm and Lakeside dairy invested in modern CIP that allow optimization of chemical dosing to improve chemical productivity and minimize water use and pollution loading of wastewater.</p>	<p>Within a six-year implementation of CIP optimization (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</p>
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9	Green Cooling. Use of refrigerants without ozone depletion potential and with low global warming potential	Prevention of emissions of substances that deplete the ozone layer or have a high global warming potential by using alternative refrigerants, such as water, carbon dioxide or ammonia. Much as, no success stories on use of natural refrigerants reported in Uganda, natural refrigerants technologies are commercially available and have been successfully implemented in Africa especially in south Africa and Kenya.	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
10	Use of ozone as a disinfectant	Ozone is becoming an increasingly popular alternative to chlorine for water disinfection. Ozone provides comparable disinfection power to chlorine The use of ozone does require an additional capital investment to install an on-site ozone-generating equipment. Because of the instability of the compound ozone must be generated on-site, requiring investment in ozone-generating equipment. These generators create ozone through the action of a high energy source (UV light or corona discharge), splitting oxygen molecules that then recombine to form ozone. Small-scale ozone-generating units are available for a few thousand dollars.	Ozone treatments have the benefit of forming fewer undesirable by-products than chlorine treatments, such as trihalomethane, chloroform, and other dangerous compounds. Ozone is faster acting than chlorine and allows for adequate disinfection with short-term contact with the produces.

3.6. Proposed Industrial Symbiosis and RECP Infrastructure

Recommended RECP infrastructures	Description and benefits
Voltage Stabilizer	<p>Usually, the power transmission and distribution in Uganda is characterized by power surges and voltage drops. This would require a voltage stabilizer to safeguard the equipment against power surges.</p> <p>This is important because fluctuations in voltage can cause damage to the equipment and machinery, leading to costly repairs or replacements. Voltage stabilizers help to maintain the quality of power supply by regulating the fluctuating input voltage before it could be fed to the load (or equipment which is sensitive to voltage variations) . other benefits of voltage stabilizer include</p> <ul style="list-style-type: none"> • To protect your appliances and electronics from voltage fluctuations that can cause damage or reduce their lifespan. • To ensure a consistent and optimal performance of your equipment, especially those with motors, such as refrigerators, air conditioners, and pumps. • To save energy and reduce electricity bills by avoiding over-voltage or under-voltage situations. • To prevent accidents and fire hazards caused by short circuits or overheating of wires and devices
Capacitor bank	<p>The majority of the industrial loads are of inductive nature and require a certain proportion of reactive power for them to function. Capacitor banks are used in industry to provide reactive power to inductive loads. Capacitor banks act as a source of local reactive power and thus less reactive power flows through the line. Capacitor banks are also used for various purposes, such as power factor correction, harmonic filtering, and transient suppression. In summary, capacitor banks can help improve the efficiency of electrical systems by reducing the circulating current caused by inductive loads within a circuit, decreasing energy costs, extending the life span of electrical systems, compensating reactive power to steady voltage fluctuations within a power system, and improving system efficiency.</p>
Centralized cooling with parallel compressor racks system for the cold rooms	<p>The compressor racks system works based on the cold room loading. If there is low loading in the cold room, one compressor runs; when more loading is inside the cold room, two or three compressors run. It is easy and flexible to maintain because each compressor can work independently, so one compressor not working will not impact other compressors' working and can be repaired when other compressors are working.</p> <p>The recommended refrigerant is R744 (carbon dioxide). This is because Carbon dioxide is non-flammable offering a safe and non-toxic industrial solution, allowing electrical panels to be in the same room as the plant saving on installation costs. Furthermore, CO₂ doesn't require regular compressor overhaul saving on maintenance costs. R744 refrigerant (CO₂) is also compatible with copper and k65</p>

	<p>pipes this reduces the installation cost as no requirements for welding as well as eliminates corrosion risks. Alternatively, R1234yf (2,3,3,3-Tetrafluoroprop-1-ene)) can be considered. R1234yf has a low global warming potential of less than 4 and zero ozone depletion potential</p>
<p>Automatic change-over switch</p>	<p>Handling perishables products requires reliable power and an automatic change-over switch eliminates the time lag to switch to a power backup or stand-by system. Installing an automatic changeover switch improves:</p> <ul style="list-style-type: none"> i Convenience: An automatic changeover switch saves you from the hassle of frequent manual line changes. It can be catastrophic to deal with a manual generator hookup, particularly in the dark. ii Safety: A transfer switch that has been properly installed protects your home or business. Improper ties mean that when power is restored, the electrical current from the generator will short circuit with utility line current . iii Reliability: An automatic changeover switch ensures that your home or business has uninterrupted power supply during a power outage .
<p>Power Back up (Solar-diesel generator hybrid system)</p>	<p>The power is required to provide reliable power in case of power interruptions or load-shedding. The solar diesel hybrid with minimise emission compared to convention diesel generator systems.</p>
<p>Chemical leasing</p>	<p>To optimize the use of water and chemicals instead of buying chemicals the Freezone should work with chemical suppliers like Eco-lab to pay for the services chemicals do instead of buy quantities of chemicals. Promote responsible cleaning-in the place.</p>
<p>A centralized air compressor system</p>	<p>A centralized system has better energy productivity and will provide lower overall costs than a decentralized system as illustrated below.</p> <ul style="list-style-type: none"> • Lower Costs: In general, a centralized compressor system will require less equipment. Further, the installation of distribution piping costs less than installing smaller compressor units throughout the facility. • Easier Logistics: Only a single area needs to be addressed for issues such as noise reduction. • Easier Monitoring: Only one system needs to be monitored, rather than several smaller ones.
<p>Automated external solar lightning.</p>	<p>External lightning can be activated by movement detectors and powered by solar cells.</p>
<p>Fire security and disaster risk management</p>	<p>Fire detectors and fire rescue equipment need to be available in strategic locations, intervention modalities established with the Aviation Authority and contingency plans (multi-risk) need to be developed, including simulations and training.</p>



Figure 6 three phase industrial AC automatic voltage stablizer

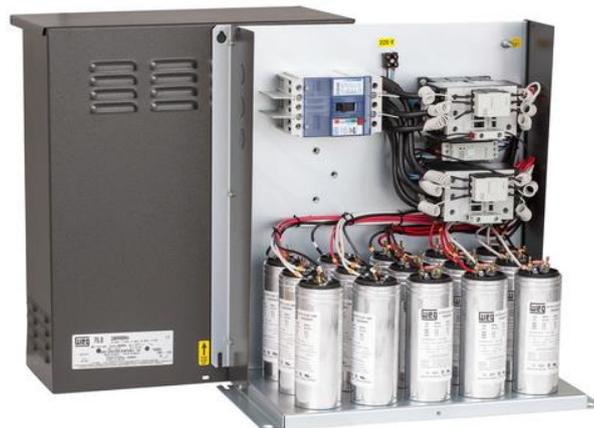


Figure 7 Industrial capacitor bank



Figure 8 Demand response centralized compressed air system.

3.7. GHG Emissions Reduction Potential

Implementation of RECP and industrial symbiosis synergies has the potential to reduce GHG emissions of Entebbe Free Zone Park as shown in table below.⁷

Table 11 GHG emission reduction potential of Entebbe Free Zones Park

No	Item	GHG emission reduction potential
1	RECP Measures	206.05 tCO ₂ eq per year
2	Centralized refrigeration compressor racks	371.6 tCO ₂ eq per year

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 and GHG emissions are projected to exceed 4258.293 kWh GJ, and 3510 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 Entebbe International Airport Free Zone 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 (UFZA) and private sector are empowered to make well-informed choices about technical RECP options. It is recommended that UFZA 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 for power supply and stabilizer

Table 12 Concept note improve power quality for EIAFZ through the installation of a power stabiliser, Capacitor bank, and Automatic Change Over Switch.

Project Summary	
Sector	Energy

⁷ The GHG emissions reduction potential was calculated using the national grid emission factor for Uganda. The basis calculation is potential energy savings from RECP and Industrial symbiosis measures.

Project Title	Improving Power Quality through the installation of a Power Stabilizer, Capacitor Bank, and Automatic Change Over Switch
Project Duration (Financial Years)	1 year
Estimated Project Cost	176785.7
Officer Responsible	Industrial Officer GGGI
Date of Submission	15 th November 2023

Section 1: Project Background

1.1 Situation analysis

Entebbe Free Zones Park has access to the national grid and plans to source all its electrical power from it. However, most of the electricity networks in Uganda at present are experiencing frequent interruptions and power cuts due to maintenance challenges and demand load variations. While recently installed additional generating capacity may have somewhat alleviated the situation, the occurrence of a poor power quality crisis in the long term remains a clear possibility. This is because the base case peak demand growth scenario shows further supply shortages from 2020 onwards. When power demand outstrips supply, it gives rise to large voltage swings, surges, and power outages in the supply.

Entebbe Free Zones Park will anchor enterprises processing various produce likely ranging from dairy, fruits, vegetables, beef, and flowers. The processing and storage equipment and machinery of such enterprises require a supply that is maintained within certain voltage variation limits. Too low voltage and the equipment will malfunction, too high voltage and the equipment could be seriously damaged. Interruptions of electricity power grid increase the vulnerability of the cold-chain facility at EIAFZ to spoilage thus increasing food loss and

Furthermore, the processing and storage machinery especially rotating machinery (compressors, motors) require reactive power to operate. The demand for reactive power lowers the 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. Enterprises whose power factor falls below 0.9 are penalized and incur charges for reactive power. For example, enterprises with peak demand above 500KVA can incur a reactive charge of over USD 6,575 per year.

Over the past 20 years, the Ministry of Energy and Mineral Development (MEMD) has implemented various initiatives, some of which specifically target industries. However, the goal of promoting industrial energy efficiency as a standard practice has not been achieved so far due to factors such as limited technical know-how, challenges in securing capital for power system investments, and a lack of standard practices among manufacturing companies.

1.2 Problem Statement

Entebbe Free Zone Park plans to source electrical power from the national grid. However, the national grid is known to experience transmission and distribution loss and vandalism contributing to unreliable power. Power quality is also reported to be characterized by low power factor, harmonic distortion, voltage variation, and power interruptions. Voltage fluctuations and power interruptions occur due to variations in electricity demand and failures of transmission and distribution lines.

The target sectors for Entebbe Industrial Park include Beef, Dairy, Fruits, Vegetables, and Flowers. The productivity of these sectors is dependent on electricity, a slight destabilization or disruption to the power quality (voltage deviation) can significantly damage the products creating waste. The power interruption increases the vulnerability of cold storage facilities at EIAFZ resulting in food losses and waste. Furthermore, Power interruptions often result in production interruption, loss of production time, and, in some instances, equipment damage. In some cases, it results in frequent power outages, which result in increased fossil fuel energy consumption. For example, milk losses associated with power interruptions in the dairy processing enterprise

can be as high as 30% of the production batch. In cases where enterprises switch to diesel generators, the power cost increases from 12.3 cents to 30.2 cents per kWh.

The costs of equipment repair or replacement, damaged materials, production output loss, labor loss, and restarts increase the production cost and reduce the profitability of enterprises. This makes SMEs vulnerable to unreliable power supply and frequent power interruption.

Furthermore, bank loans for SMEs are generally available at interest rates of 18 to 22 percent with short payback periods. With no financial incentives in place, small and medium-sized enterprises (SMEs) find it difficult to invest in energy-efficient technologies (like capacitor banks, and power stabilizers).

1.3 Relevance of the Project Idea

The National Development Plan 2020/21 - 2024/25 (NDPIII) recognizes sustainable (reliable, affordable, and clean) energy as a key instrument critical for economic growth, poverty reduction, as well as the social and cultural transformation of society. NDP III aims at Increasing grid/power reliability to 90 percent.⁸

The National Determined Contribution 2022 identifies improving industrial energy efficiency as one of the key mitigation actions under the energy sector to contribute to a reduction in GHG emissions. It's estimated that improving industrial energy efficiency can result in emission reductions of approximately 0.26 MtCO₂e by 2030.⁹

Energy efficiency is widely seen as a cost-effective way to reduce greenhouse gas emissions and to ensure access to energy for all. In Uganda, where the ambition is to mitigate climate change and meet energy access goals, improving energy efficiency (by improving the demand-side distribution system) can play an important role in reducing the cost of delivering modern energy services as well as exposure to energy price volatility, while also improving the long-term sustainability of energy supply. Industrial energy efficiency is seen to be relevant not only to meeting energy and climate mitigation goals but also to delivering benefits to industries. Installation of a Power stabilizer, capacitor bank, and automatic change-over switch at Entebbe Free Zone Park will improve power system reliability, thus reducing the use of standby generator power by reducing technical losses, and the overall generation cost. This will improve the energy efficiency of industries within Entebbe Free Zone Park thus reducing their operational and maintenance costs.

Section 2: Technical Approach

2.1 Stakeholders

- i. Uganda Free Zone Authority; improved power quality and reliability will contribute to improved quality of agro-produces for export thus enhancing capacity for exporting agro-processing enterprises
- ii. Tenant industries of Entebbe Free Zones Authority. The projects will eliminate costs associated with unreliable power enhancing the productivity and competitiveness of agro-processing enterprises.

2.2 Project Outcomes

The objective is to improve power quality and stability and compensate for reactive power to contribute to the electrical power reliability for Entebbe Free Zones Park.

- I. The project will result in reactive power compensation by maintaining a power factor above 0.9.
- II. Improved power quality supply voltage will be kept within acceptable limits of $\pm 5\%$.

2.3 Proposed Project Interventions

The proposed project will involve the installation of a 550kVA voltage stabilizer, a 351.4 kVAr capacitor bank, and an automatic change-over switch. The installation Power stabilizer, capacity bank, and automatic change-over switch will be in a global/centralized installation to ensure a collective voltage stabilizing and power factor correction for all SMEs with the Entebbe Free Zone Park.

⁸ See [NDPIII-Finale_Companded.pdf \(npa.go.ug\)](#)

⁹ See [Updated NDC_Uganda.pdf \(mwe.go.ug\)](#)

Installing a power stabilizer will ensure that the voltage supplied to the electrical equipment is stable and within the required range. The power stabilizers also reduce electricity bills by reducing the amount of energy wasted due to voltage fluctuations. Maintaining good quality voltages eliminates downtime associated with power surges and improves productivity (especially for sensitive equipment like cold rooms).

Installing a capacity bank will provide an economical and reliable approach to reduce losses and improve overall power quality. In summary, capacitor banks can help improve the efficiency of electrical systems by reducing the circulating current caused by inductive loads within a circuit, decreasing energy costs, extending the life span of electrical systems, compensating reactive power, and improving system efficiency.

Installing a power stabilizer, capacitor bank, and automatic change-over switch will therefore improve power quality and stability and compensate for reactive power which will improve the energy efficiency of industries within Entebbe Free Zone Park thus enhancing their competitiveness and profitability.

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 Ministry of Energy and Mineral Development will provide overall project oversight and monitor the progress of project implementation.
- ii. Electricity Regulatory Authority to 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.
- iii. Uganda Electricity Distribution Company will take the lead in the extension of the electricity distribution system to Entebbe Free Zone Authority.
- iv. 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.

Section 3: Estimated Project Cost and funding sources

5.2. Annex 2 Concept note for cold storage services.

Table 13 Concept Note EIAP cold storage.

Project title: Entebbe Free Zone cold storage	Estimated. project cost: (in current USD)
Location: Entebbe Free Zone	Estimated duration: 10 years
Project objective (outcomes): <ul style="list-style-type: none"> • To improve the quality and quantity of exports through shared cold storage facilities 	Potential beneficiaries (target groups) <ul style="list-style-type: none"> • Farmers, Exporters
	Stakeholders involved

- HortiFresh,

Context/problem statement:

The Government of Uganda, recognizing the pivotal role of the "real economy" in fostering economic growth, has emphasized investment in sectors like agriculture for import substitution and export promotion. Growth in agricultural exports has multifaceted benefits such as high welfare effects because of the numbers involved in such agricultural export-oriented value chains, food security and nutrition. In line with this vision, the National Development Plan (NDP III) places significant emphasis on increasing agricultural exports. Despite these aspirations, the volume and value of exports remain below their potential, posing a challenge to Uganda's economic objectives.

The global demand for agricultural products is on the rise, driven by factors like globalization, urbanization, and improved interconnectivity. Uganda, with internal developments like the establishment of Uganda Airlines stands at the threshold of increased export potential. Targeting stable high-income markets, such as the European Union, and expanding to regions like the Middle East and emerging markets in China and the USA, offers strategic avenues for growth in agricultural exports. Initiatives like the development of free zones and associated infrastructure further position Uganda to capitalize on these opportunities.

However, Uganda faces persistent challenges of rejected goods by importing countries, often attributed to poor handling during export. This stems from inadequate infrastructure and suboptimal transportation systems. Cold storage emerges as a critical factor, especially for perishable agro produce, as evidenced by 100 interceptions in 2022. Inadequate cold storage infrastructure results in rapid deterioration, causing significant losses in quantity and quality, spoilage, and contamination. Export companies, especially small and medium enterprises (SMEs), face challenges with insufficient cold storage facilities, frequent power cuts leading to power surges that compromise the quality of produce.

Current handling services lack the necessary cold rooms to accommodate the growing number of companies entering the export business. Some aspiring export companies are deterred due to the absence of adequate cooling facilities. The considerable investment required for establishing cold storage facilities underscores the importance of exploring shared services, particularly crucial for the success of small and medium export enterprises, the primary focus of government-led export growth efforts. The development of a cold chain facility at Entebbe Free Zone is an important strategy to ensure the inclusion and success of small and medium export companies and in addressing a critical gap in Uganda's export ecosystem.

Project description

The cold storage is planned for four important commodities: fruits and vegetables, flowers, cheese, and meat. The commodities are the priority sectors earmarked by the Government to spur growth through exports. Storage at the Entebbe Free Zone is important as the commodities await to be exported. The export companies that use the cold room facilities benefit from standard temperature and storage conditions that meet the requirements for the commodities stored and other associated services such as washing/cleaning services, fumigation services, packaging services, efficient loading and off-loading of commodities to be stored etc. For cheese production, some processing activities will be accommodated at the facility to allow innovation for competitiveness in the cheese industry.

The storage period can be shorter, for temporally storage (between 3-24 hours) awaiting to be loaded to the cargo or could be longer but within one week before they are exported. For fruits and vegetables, the cold rooms cater for two categories of commodities, the organic and conventional. Organic products are separated from conventional products as a regulatory requirement, meeting consumer expectations, ensuring product integrity and preserving distinctiveness of organic products on the market. Other commodities (cheese, flowers and meat) are conventionally produced and thus do not require separation of the cold rooms within the commodity group.

For fruits and vegetables, it is expected that several exporters may require the cold room services unlike for other products where a few companies may require cold storage. The fruits and vegetable exporters already operate under the umbrella organisation, HortiFresh. With this structure in place, the exporters can agree on schedule for usage, cleanliness standards and maintenance costs. The export companies are expected to pay a fee that

is commensurate to the space they will use for cold storage. This implies that export companies need to be definite on how much space they need to use.

Expected outcomes

Reduction in post-harvest losses is a crucial benefit attributed to the availability of cold storage services. These losses are mitigated both at the farmer level and during the export process. At the farmer level, increased access to export companies translates to reduced post-harvest losses, addressing the common issue of surplus produce without a market. This is particularly significant for fruits and vegetables, where farmers, especially during peak production seasons, often experience losses exceeding 80% due to inadequate market outlets.

The presence of cold storage facilities contributes to a significant reduction in spoilage and related interceptions resulting from poor quality caused by exposure to sunlight. The existing growth and the anticipated future expansion in exports are currently underserved by handling services. Cold storage becomes instrumental in maintaining product quality throughout the export journey. This not only ensures the integrity of the exported goods but also aligns with international quality standards, reducing the likelihood of interceptions and rejections by importing countries.

Opening of the global market for non-traditional exports especially for meat and cheese. These commodities are easily crowded out in an already strained cold services offered by the handling facilities.

Efficiency in energy use since several export companies utilise the common cold storage services. The overall energy consumption is reduced and ultimately reducing carbon emissions.

Benefit to the small export companies and those at the start up stage. The smaller volumes produced by these companies can be accommodated at the Entebbe Free zone. This will overall spur growth in the exports from Uganda. Specifically, the innovation will enable small flower export firms and the cheese and fruit and vegetables to use the shared facility and enter the global export market.

Technical specifications/services to be provided within the project and potential providers:

Equipment and Services:

Cold storage of Fruits and Vegetables will require three cold rooms, each cold room will have inner dimensions of 24m X 12m X 4 m. The desired storage condition for most fruits and vegetables ranges from 4-15 °C. Each cold room will have a cooling capacity of 35.26kW (this includes transmission, infiltration, deforesting, goods cooling, goods respiration, and others).

Cold storage of meat will require two cold rooms, each cold room will have inner dimensions of 24m X 8m X 4m. the optimum storage temperature for meat ranges from -1 to 0 °C maintaining these conditions each cold room will have a cooling capacity of 18.35 kW.

Cold storage of flowers will require two cold rooms, each cold room will have inner dimensions of 24m X 10m X 4m. The desired storage temperature for flower cutting ranges between 0-2 °C. Therefore, each cold room will have a cooling capacity of 14.63kW.

Cold storage of cheese will require four cold rooms, each cold room will have inner dimensions of 5m X 4m X 3.6m. The desired storage and maturation temperature of cheese range from 5 to 12 °C. Therefore, each cold room will have a cooling capacity of 1.33kW

The loading dock is required to ease the handling and transfer of pallets to and from cold stores and transport vehicles. Therefore, the entrance to cold storage should be designed/provided with loading/ unloading docks that match the dimensions of selected trucks for transportation. For trucks usually, it's recommended to provide a loading dock with a height of about 1.40 m.

All cold rooms at Entebbe Free Zones Park will be connected to one centralised refrigeration system with a total cooling load capacity of 177.58 kW. The recommended refrigeration technology is a compressor rack system. Compared to the single compressors, the compressor rack is safer, more power-saving, and easier to maintain and install. Compressor racks system works based on the cold room loading. If there is low loading in the cold room, one compressor runs; when more loading is inside the cold room, two or three compressors run. It is easy and flexible to maintain because each compressor can work independently, so one compressor not working will not impact other compressors' working and can be repaired when other compressors are working.

The recommended refrigerant is R744 (carbon dioxide). This is because Carbon dioxide is non-flammable offering a safe and non-toxic industrial solution, allowing electrical panels to be in the same room as the plant saving on installation costs. Furthermore, CO₂ doesn't require regular compressor overhaul saving on maintenance costs. R744 refrigerant (CO₂) is also compatible with copper and k65 pipes this reduces the installation cost as no requirements for welding as well as eliminates corrosion risks. Alternatively, R1234yf (2,3,3,3-Tetrafluoroprop-1-ene) can be considered. R1234yf has a low global warming potential of less than 4 and zero ozone depletion potential.

In a business-as-usual scenario, the cooling load demand is determined to be about 215.25 kW, and through improved design of insulation of cold rooms the cooling load can be reduced to 177.58 kW. Furthermore, the adoption of green technology like can reduce compressor running hours from 18.5 per day to about 12 hours per day. Such innovation combined improved insulation of cold room with can reduce annual energy demand from 1,453,476 kWh to 777,800 kWh. This can reduce GHG emissions by 371.6 tons CO₂eq per year.

Management model:

The cold storage services will be provided by the private company whose services will be supervised by the Uganda Free Zone Authority. The export companies that use the shared services are expected to pay for the space used for cold storage on a monthly basis.

3.1 Project Cost (Annualised Costed work plan)

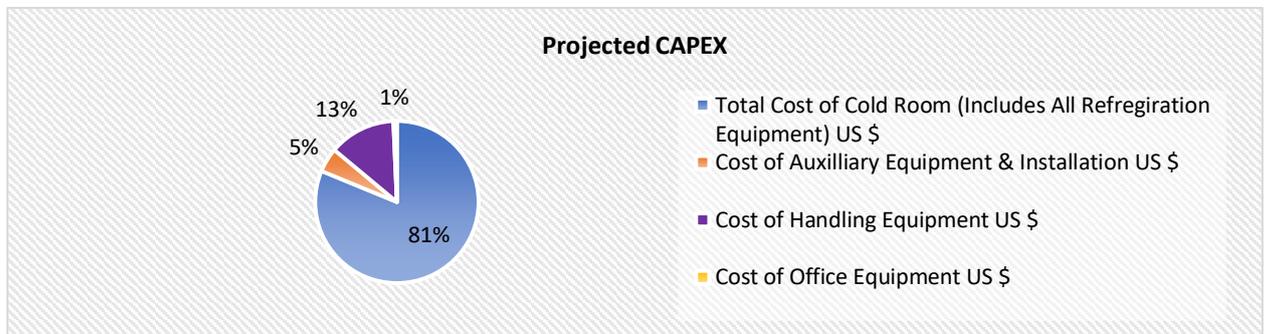
Give an estimate of the total project cost and disaggregate by year for each output/component or intervention described in 2.3 above. The project period should correspond to the period it takes to have the physical infrastructure in place and ready to be operated.

The Project involves setting up cold stores for the following products, with their respective capacities and average maximum total capacities throughout the year.

Product	Cold Store Capacity (MT)	Avg. Max. Total Capacity During the Year (MT)
Floriculture Products	9.9	2,185.7
Cheese Products	2.2	83.0
Fresh Fruits & Vegetables	31.1	9,329.0
Meat	57.6	2,131.3
Total	100.9	13,729.0

	Year 1	Total cost
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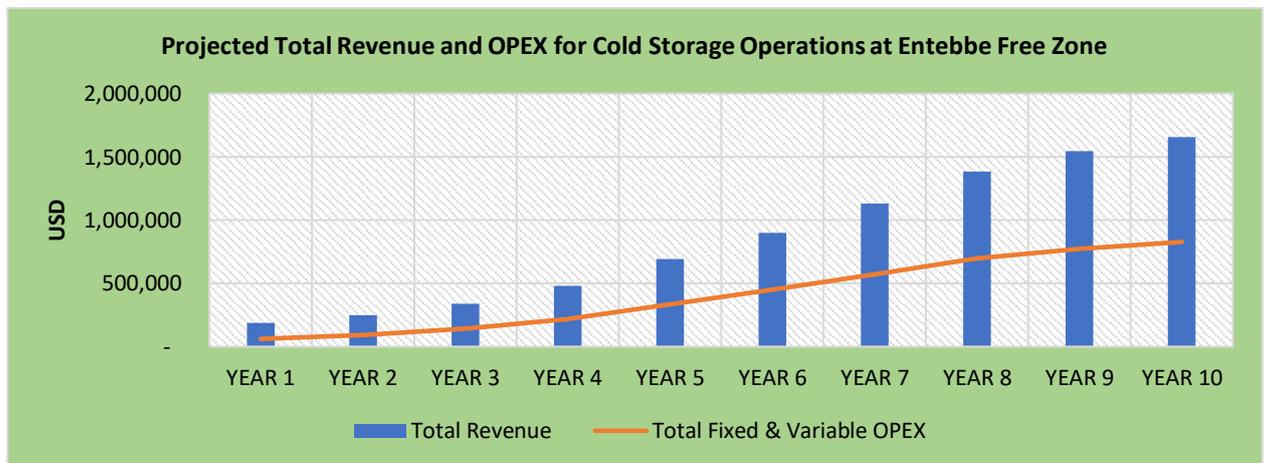
Cold Rooms (Including all Refrigeration Equipment)	145,941	145,941
Auxiliary Equipment & Installation	8,732	8,732
Handling Equipment	23,700	23,700
Office Equipment	1,247	1,247
Total Cost	179,620	179,620

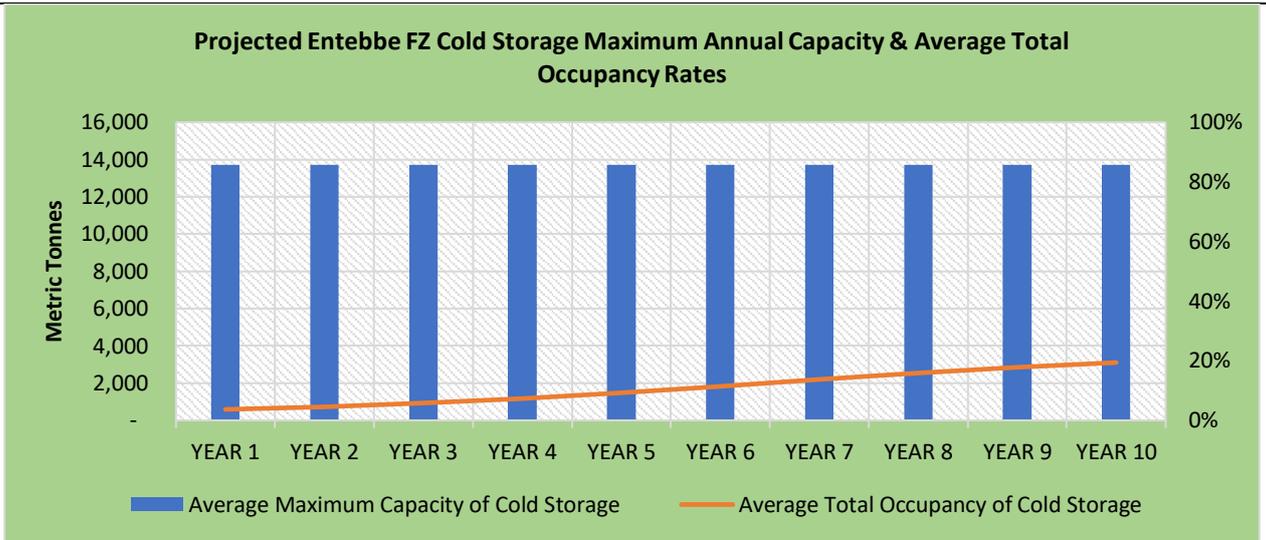


3.2 Projected Revenues

The cold storage is expected to operate on a pay-as-you-store model, with companies paying an hourly or daily fee per kilogram of produce stored. In this model, revenues are projected to grow from USD 69,706 to USD 1,364,710 in 10 years.

This is based on average total occupancy rising from 3.7% to 19.4% over the same period, as shown in the figures below.



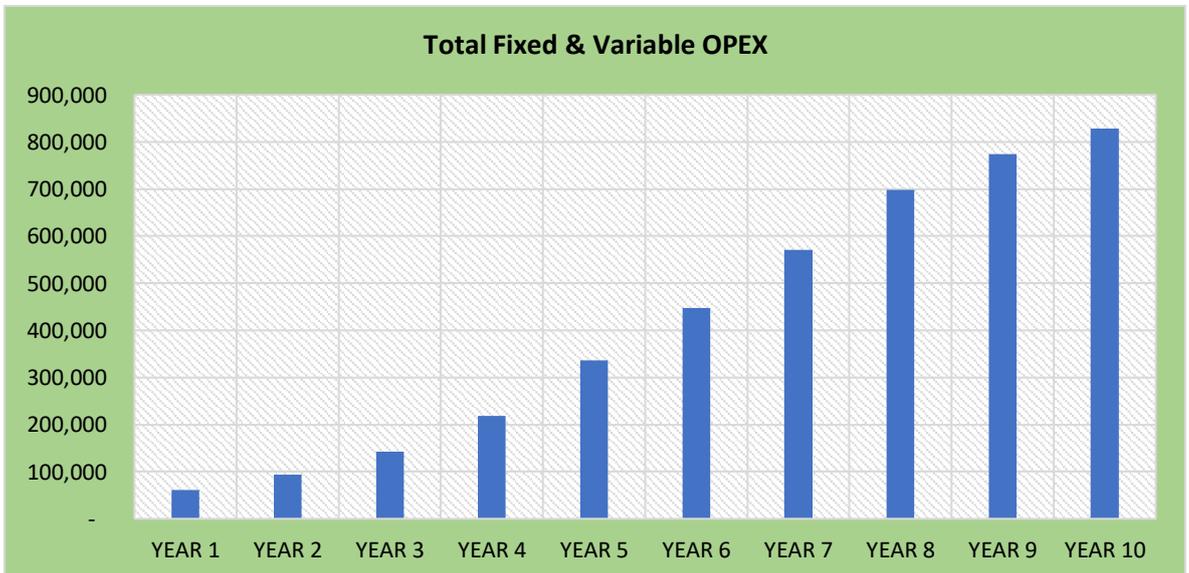


3.3 Projected Operating Expenditures (OPEX)

The operating expenses considered in this analysis include:

- Electricity;
- Staff and labour;
- Servicing and maintenance; and
- Water.

Total annual OPEX is expected to grow from USD 60,897 to USD 827,768 over the 10-year projection period, as shown in the figure below.



3.4 Project Performance Metrics

NPV

US \$

1,199,280

IRR	%	2755%	
Return on Investment (ROI)	%	1382%	
Breakeven Period	Years	4	

5.3. Annex 3: Concept note for logistics optimization.

Table 14 Developing and Implementing a Traffic and Logistics Optimization System at Entebbe Free Zone

Project Summary	
Sector	Logistics
Project Title	Developing and Implementing a Traffic and Logistics Optimization System at Entebbe Free Zone
Project Duration (Financial Years)	One (1) Year
Estimated Project Cost	USD 125,000
Officer Responsible	Senior Industrial Officer Global Green Growth Institute Uganda Office
Date of Submission	15 th November 2023

Section 1: Project Background

1.4 Situation analysis

The Entebbe Free Zone (FZ) is an industrial park and free zone that is currently under construction on the shores of Lake Victoria, right next to Entebbe International Airport. It sits on five (5) acres and comprises of seven (7) production units, each covering an area of around 760m² (i.e., about 26% of the land). The team of consultants commissioned by the Global Green Growth Institute (GGGI) to propose green ways of developing Entebbe FZ, especially given its low environmental bearing capacity that arises from:

- i. Proximity to Lake Victoria;
- ii. Proximity to Entebbe International Airport;
- iii. Proximity to Entebbe Municipality; and
- iv. Small area of land.

In addition, Section 47 of the Free Zones Act, 2014 requires that goods produced in a Free Zone be restricted to exports, except in special instances. Section 4 of the same law requires that the goods produced or stored in the Free Zone not harm the environment.

The Team has proposed the following sectors to be housed at the FZ:

- i. Dairy, especially the processing, packaging, and storage of both soft and hard cheese, ice cream, and ghee/clarified butter;
- ii. The washing, packaging, and storage of fresh fruits and vegetables, including mangoes, pineapples, bananas, peppers, and sweet potatoes;
- iii. Trimming, packaging, and storage of flowers;

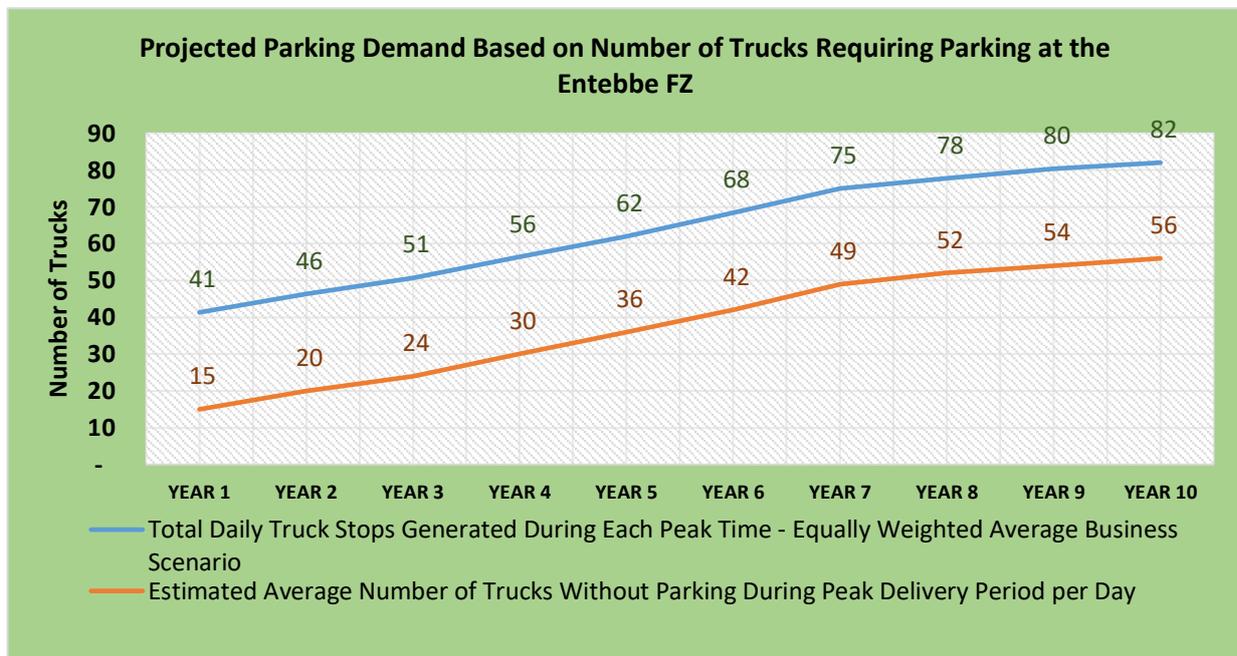
- iv. Bulk packaging and storage of meat, including full, half, and quarter carcasses and special individual cuts; and
- v. Possibly, processing fish waste into Omega 3 oil and packaging into both bottles and capsules.

1.5 Problem Statement

Given that Entebbe FZ sits on a small area of land, the space available for truck parking as drivers wait to unload deliveries for processing, packaging, or storage, or wait to load goods for export is only about 300m². In the Business as Usual (BAU) scenario, there is no traffic and logistics optimization system and companies decide how to schedule their deliveries or disbursements. In such an instance, industrial truck delivery patterns show that there most companies will choose to schedule for the same times which will form a peak delivery and disbursement period during the day.

From the projected number of trucks waiting to make deliveries or to load goods for export in the BAU scenario¹⁰, the projected truck parking demand, based on number of trucks, hours of parking required, and required parking space, both within the FZ and within the community surrounding the FZ is as follows;

i. Truck parking demand based on number of trucks seeking parking.

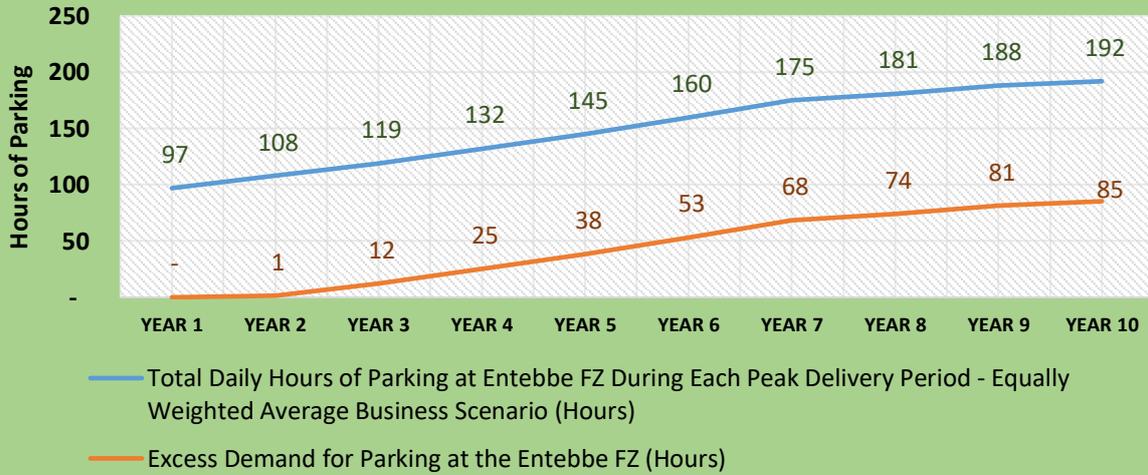


The number of trucks needing parking during the peak parking time per day, grows from 41 in the 1st year to 82 in the 10th year. Given the limited truck parking space available, this results in 15 trucks waiting without parking per day in the 1st year, which grows to 56 in the 10th year.

ii. Truck parking demand based on the time required for parking;

¹⁰ Assumes a worst case scenario of only 1 4-hour peak parking period per day

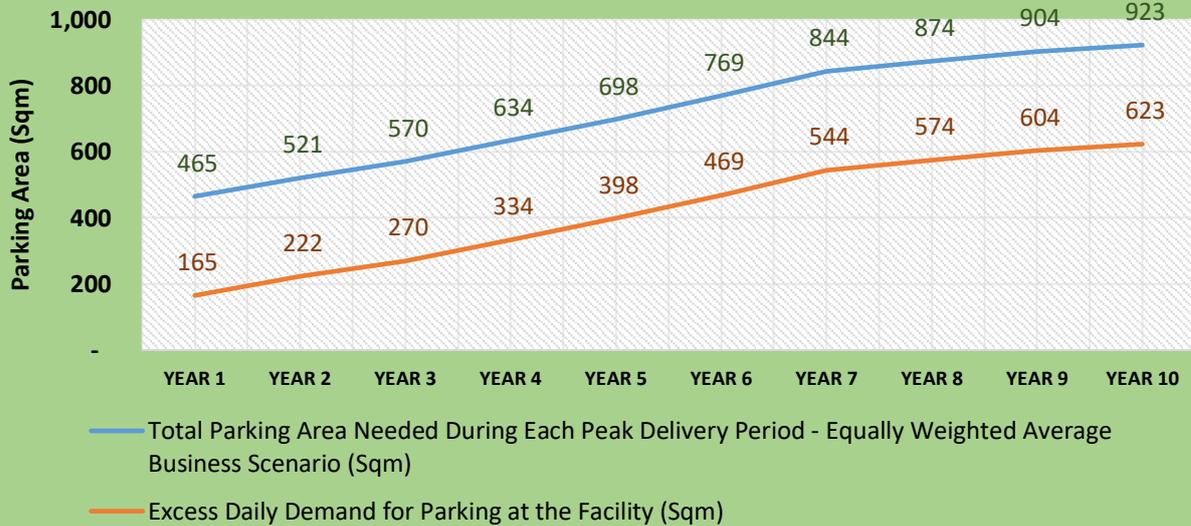
Projected Parking Demand Based on Hours of Parking Required by Trucks Arriving at the Facility During Peak Parking Times



Given that there are few truck parking spaces, and the peak delivery time is short, the average daily total amount of time drivers waste while waiting for parking space is projected to grow from 1 hour in the 1st year to 85 hours in the 10th year.

iii. Truck parking demand based on the space required for parking;

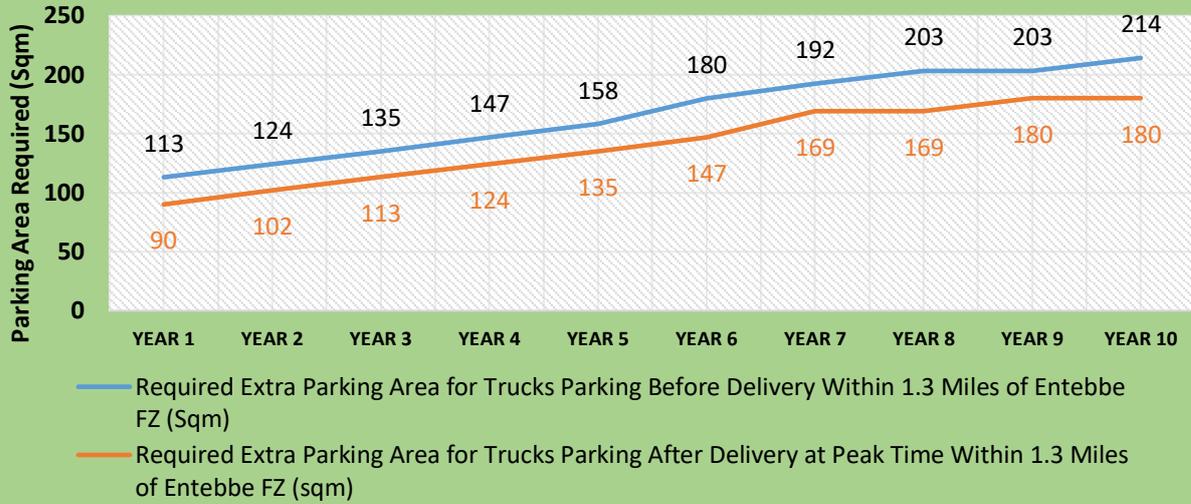
Projected Parking Demand Based on Area Needed to Accomodate all Trucks Requiring Parking at the Entebbe EIP & FZ



Given that the available space for truck parking is only 300m², the daily total amount of extra parking space required by truck drivers is expected to grow from 165m² in the 1st year to 623m² in the 10th year.

iv. Truck parking demand based on the space required for parking within the community surrounding Entebbe FZ;

**Projected Extra Truck Parking Space Required Within 1.3 Miles of Entebbe
EIP & FZ**



Section 2: Technical Approach

2.1 Stakeholders

No	Project Beneficially	Project impact
1	Entebbe Free Zone	The Project would enable the FZ to operate smoothly without the interruptions caused by congestion of trucks crowding around the parking area and along the access roads.
2	Entebbe Municipality	The Project would allow the Municipality to enjoy the benefits of a fully operational free zone without disturbance caused by a situation where many trucks are arriving in the Municipality at the same time and needing extra space for parking both before and after deliveries.
3	Truck Drivers	The Project would schedule trips which would save drivers the time usually spent waiting for parking.
4	Uganda Free Zones Authority (UFZA) & Uganda Investment Authority (UIA)	The Project could be replicated by UFZA and UIA in other free zones and industrial parks under their jurisdiction without incurring significant capital expenses due to their ownership of the system.

2.2 Project Outcomes

The impact of the Project can be seen in the projected truck parking demand metrics, as shown in the figures below.

- i. Truck parking demand based on number of trucks seeking parking.**

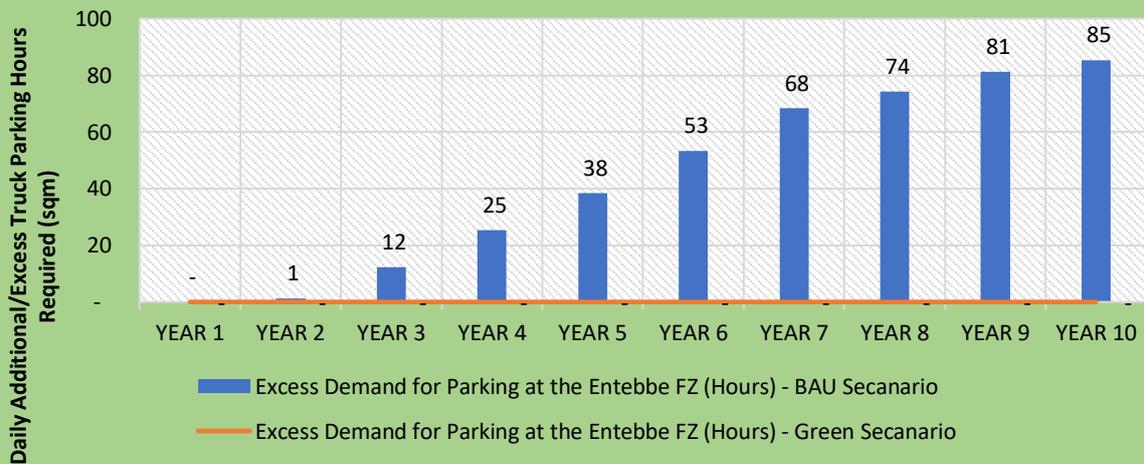
Comparing Projected Peak Parking Demand at Entebbe FZ in the BAU & Green Scenarios



In the Green scenario where the traffic and logistics optimization system is implemented, the number of trucks seeking parking at any one time is kept stable, rising from 3 in the 1st year to 5 in the 10th year.

ii. Truck parking demand based on the time required for parking;

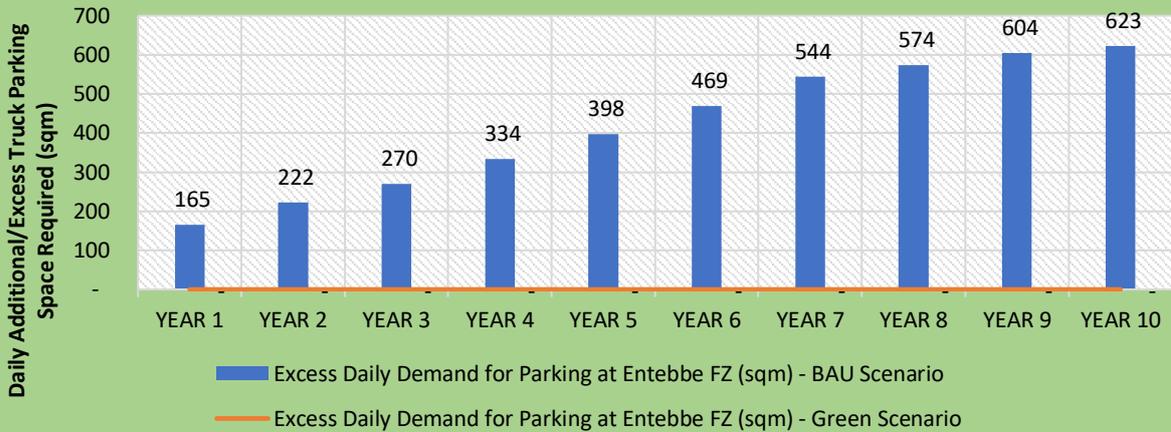
Comparing Projected Excess Demand for Parking Hours at Entebbe FZ in the BAU & Green Scenarios



The effect of implementing the Project is that it will schedule the truck arrivals within a longer period in the day thereby allowing the available daily total truck parking time at Entebbe FZ to be sufficient.

iii. Truck parking demand based on the space required for parking;

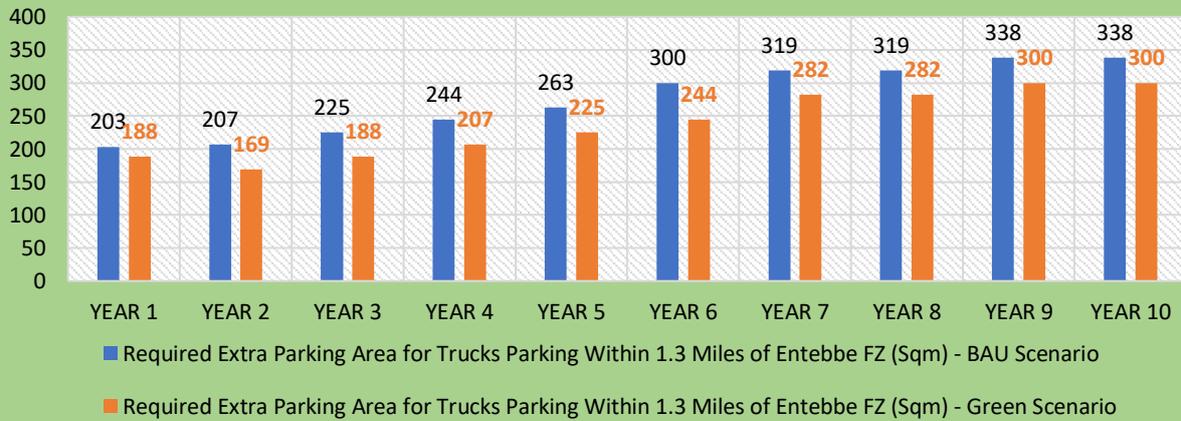
Comparing Projected Excess Demand for Parking Space at Entebbe FZ in the BAU & Green Scenarios



The effect of implementing the Project is that it will schedule the truck arrivals within a longer period in the day, such that the available parking space is sufficient.

iv. Truck parking demand based on the space required for parking within the community surrounding Entebbe FZ;

Comparing Projected Excess Demand for Parking Space Within Entebbe in the BAU & Green Scenarios



The Project will save the Entebbe Municipality an average of 37m² per day in extra parking space required for truck drivers making a stop before and after their deliveries. Over the 10-year period, this will amount to 2.9 acres of land.

2.3 Proposed Project Interventions

To address the problem of limited space at Entebbe Free Zone, the goal of the traffic and logistics optimization system will be to shorten:

- i. Vehicle turnover;

- ii. Waiting time before loading – time measured from the moment the vehicle arrives at the parking lot till it is moved to the loading ramp and ready to be loaded;
- iii. Loading time – time between arrival at/departure from the loading ramp;
- iv. Waiting time after loading;
- v. Time spent at warehouses/storage area as well as duration of individual activities performed in those warehouses document processing after loading; and
- vi. Sanitization of the trucks to avoid contamination.

To achieve this, the strategy is to develop and adopt the use of a space calculator for logistics. An appropriate technology solution for space-optimization improves storage layout and goods stacking and reduces time spent picking products/items from the shelves by improved slotting. In addition, it can help to deliver more tonnage in fewer trucks and containers, reduce time on load planning, and minimize delivery delays thanks to decreased manual processes. Fast offloading and loading will minimize the time spent in the parking lot and therefore allow more cars to move in, park, and off/upload in the defined time frame.

The system shall be managed by a management and technical team, supported by support staff who shall help to load or offload goods on or off trucks, at a fee.

2.4 Coordination with other Government Agencies

The development and implementation of this Project is envisaged to require the participation of only UFZA and UIA, along with a competent systems development team.

Section 3: Estimated Project Cost and funding sources

3.1 Project Cost (Annualised Costed work plan)

Give an estimate of the total project cost and disaggregate by year for each output/component or intervention described in 2.3 above. The project period should correspond to the period it takes to have the physical infrastructure in place and ready to be operated.

	Year 1	Total cost
Developing Testing & Installing System	USD 125,000	USD 125,000
Purchase of Computers and Data and Office Equipment	USD 12,500	USD 12,500
Total Cost	USD 137,500	USD 137,500

3.2 Projected Revenues & Operating Expenditures (OPEX)

The system is expected to generate revenues from 2 sources:

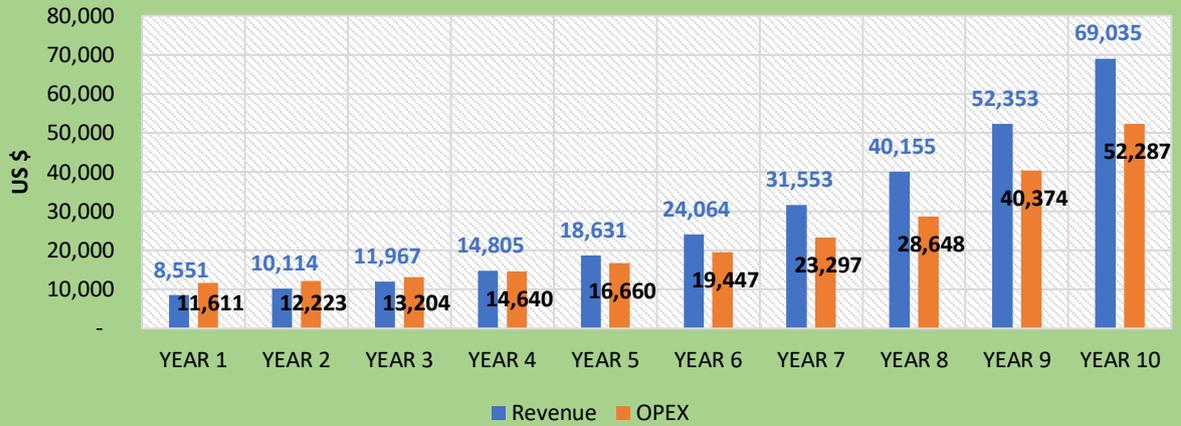
- i. An hourly truck parking fee, set to start at an average of US \$0.25/hour; and
- ii. A loading and offloading fee, set to start at an average of US \$ 1.35/tonne.

The system's OPEX is expected to include:

- Salaries;
- Internet and other utilities;
- IT maintenance.

The figure below shows the projected growth of the Revenues and OPEX.

Projected Revenues & OPEX for the Traffic & Logistics Optimization System at Entebbe FZ



3.4 Project Performance Metrics

Financial Viability Assessment Results

Total Initial CAPEX	USD	125,000
Unlevered Net Present Value	USD	(159,536)
Unlevered IRR	%	0.057%
Unlevered Breakeven Period	Years	DOES NOT BREAKEVEN
Unlevered ROI	%	-76.67%

Economic Cost-Benefit Analysis Results

Discounted costs	USD	240,618
Discounted benefit	USD	46,562

Economic NPV	<i>USD</i>	(194,056)
Benefit Cost Ratio (BCR)		0.19
Green Growth Outcomes		
Net Economic Benefits	<i>USD</i>	(159,536)
Net Environmental Benefits	<i>USD</i>	572,738
Net Social Benefits	<i>USD</i>	8,999,568
Cumulative Reduction in Land Required for Truck Parking Within the Community	<i>Acres</i>	2.86