Zero emissions systems in food processing industry

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Abstract

The food processing industry is part of an interlinked group of sectors. It plays an important role in the economic development of every country. However, a strongly growing food processing industry greatly magnifies the problems of waste management, pushing the management of waste (solid, gas and liquid) as well as pollution to the forefront of environmental challenges. While concepts to minimize, reuse and recycle wastes proposed have not solved thoroughly the negative effects on environment and human population, zero emissions concepts have arisen. It implies the optimization through an integrated system of processes and requires the industries to redesign manufacturing processes to efficiently use both raw material within the process and waste towards the aim of sustainability. It means that utilization of waste can be brought to at sustainable levels in closed loop processes, bearing the phenomenon of the industrial metabolism.

This paper starts with an outlook on zero emissions systems and continues with principals of these concepts. Following this, a zero emissions agricultural industrial system (AIZES) for the food processing industry will be displayed, emphasizing on the utilization of all by products as process inputs in anaerobic digestion processes. The model permits an identification of opportunities for reducing environmental impact at process level and driving the system toward sustainability through zero emissions concepts. A case study, focusing on the Pineapple processing industry, will be used to illustrate the application of the aggregated material input-output model. The case study will also represent energy and material balances, inputs and outputs, calculations on the economic feasibility of AIZES as well as discussions of case study. The research can lay out a promising path to adapt to environmentally friendly issues through alternative use of fossil fuels, chemical fertilizers, zero emissions and reducing Greenhouse Effect gases.

***Key-words**:* Energy, zero emissions, waste, food industry, pineapple.

1. Introduction

The food processing industry is a part of a complex and interlinked group of sectors. It has been an important industrial activity, which has gained significant economic influence in many countries. The industry is divided into two sectors including manufacturing and services; and four activities including processing, packaging, flavors & additives, and storage & handling. Most food products must be transported, warehoused, and sold, hence its industrial impacts are felt on many other sectors, for instance transportation, wholesale, retail trade, construction or consumption network.

The food processing industry requires agricultural raw materials; derived primarily from crops, plants, and fresh fruits; as process input materials. Output for those processes are food products and huge amounts of waste (solid, gas and liquid). Unfortunately the amount of waste could be a serious environmental pollution sources regarding sanitary environmental issues. For example, food waste has been 17,500ton/day and wastewater of 80,000ton/day generated from food industry in China [1], 12,000ton/day of food waste and liquid waste of 110,000ton/day from food processing industry in Japan [2], and 16,000ton/day for food waste in Vietnam [3]. If waste treatment and waste management methods have not been applied thoroughly, the negative effects on the environment and human will be very serious, especially the negative effects of odors, leachate, and spreading of pathogens at open-landfill sites. This waste amount, however, has a great potential for the generation of gaseous energy carriers. It can serve as input material for fermentation in anaerobic digestion.

From an environmental perspective, the elimination of waste represents the ultimate solution to pollution problems that threaten ecosystems at global, national and local levels. In addition, full use of raw materials, accompanied by a shift towards renewable sources, means that utilization of by-products can be brought back to sustainable levels in closed-loop process, called zero emissions systems.

2. Outlook on zero emissions systems

2.1. What is a zero emissions system?

The term 'emissions' is normally associated with vehicles and other combustion based machinery for transport (over land, sea, air, rail) and for other uses (agricultural, mobile power generation, motor, etc) which contribute heavily to global warming and pollution. A definition regarding 'emissions' in the area of vehicle and mobile machinery defined by Michael P. Walsh that '*Zero emission refers to an engine, motor, or other energy source which emits no waste products pollutes the environment or disrupts the climate*' [4]. It implies that a zero-emissions vehicle produces no emissions or pollution when stationary or operating. Emissions of concern in this case include particulates, hydrocarbons, carbon monoxide and various oxides of nitrogen. Although not considered an emission by this definition, carbon dioxide is one of the most important greenhouse gas implicated in global warming scenario.

In the subject of agro-based industrial production processes, ***there is no formal definition of a zero emission agro-based industrial system***, even more than fifteen years after the concept of zero emissions was initiated in 1991 by Gunter Pauli. This means that ideally a definition of zero emissions agro-based industrial system seems to be necessary to point out in this paper.

A leading remark regarding 'emissions' themselves was for instance made by Mickael Planasch in the Conference on Environmental management in Poland in 2006.

''Emissions that pass the defined system boundary in a Zero Emissions system must neither interfere with ecological nor social requirements''

To define what a zero emissions agro-based industrial system is, we start with a definition of 'zero'. 'Zero' in this case means 'no'. Emissions, in this case, approach to waste in the form of solid waste (municipal, agricultural, and hazardous waste), liquid waste (wastewater), and gasses. It also implies 'zero' requires the concentration of every compound in emissions to be below its detection sensitivity limit. So, the meaning of zero emissions is expressed regarding 'no solid waste, no wastewater, no gases to contribute greenhouse gasses, no energy losses. But in addition waste should be used as process input materials in a closed-loop of the production, in this way emissions are considered as an unexpected part of production processes. We can make a definition of a zero emission agro-based industrial system that:

'A *zero emissions agro-based industrial system is a system in which industry and agriculture corporate to produce the products serving important social or industrial needs but no longer generate harmful emissions to human and the environment'.*

2.2. The concepts of a zero emissions system

There have been many discussions on the progress of treatment methods to protect the environment towards the aim of 'sustainability'. Starting from end of pipe treatment, the issue moved into waste prevention, waste minimization, eco-efficiency, design for the environment, cleaner Production, zero defects, and then approached Zero emissions. By disposing waste to landfill we bury many useful resources and preventing ongoing use of the material in the case of the ecosystems. Although these materials can be remade, this requires large amounts of energy, and the consumption of more resources. A process to achieve a higher level in waste management is throughout both cleaner production and waste minimization. Waste can be managed by prevention, reuse, composting, recycling, or clean production, and bio-products production via new technologies (bio-refinery, cellulose fermentation, plasma gasification, etc). At this time when we think 'using everything, no wastes left', we are thinking about a zero emissions system. A foundation of zero emission is provided by viewing an industrial production as a metabolism, which stands for the whole integrated collection of physical processes that convert raw materials and energy, plus labor, into finished products and wastes in a (more or less) steady state condition.

In 1991 Gunter Pauli launched the idea of a zero waste aim for industrial production through the clustering of activities at his detergent factory in Belgium [5]. The term 'zero waste' for industry was imitated from 1994 as the Japanese took the concept of zero waste to Japan and the developing world [6]. From this time the concept of zero waste is influenced by the idea of 'zero defects' in manufacturing. Perspective totally a zero emissions industrial system offers the aspirational goal to achieve zero discharge, zero waste, and zero atmospheric damage.

The concept of zero emissions offers a positive alternative to input materials for the development of healthy and environmentally benign products and product systems. It can be an innovative system of sustainable industry development, where reduction, minimization and utilization of waste remain. In the process, zero emissions techniques offer a bridge between the specific innovations occurring in cleaner production and the attainment of an industrial system supplying human needs within constraints of global and local carrying capacity.

Zero emissions strategies shows a shift from the traditional industrial model towards the integrated systems in which everything is reused, recycled or recovered. Zero emissions system concepts envisage all industrial outputs from the process being used as input process materials or converted into value added inputs for other processes, to maximize resource consumptions and to increase eco-efficiency simultaneously. In this way, the production process is reorganized into a loop cluster which emulates as an industrial metabolism of the sustainable cycles found in nature. Also by this way, waste and by products are fully matched with the input requirements of any other process. A perfectly integrated process management produces no waste. This technique requires analysis tool known as the input and output approach such as material, energy, input-output balances in all production processes.

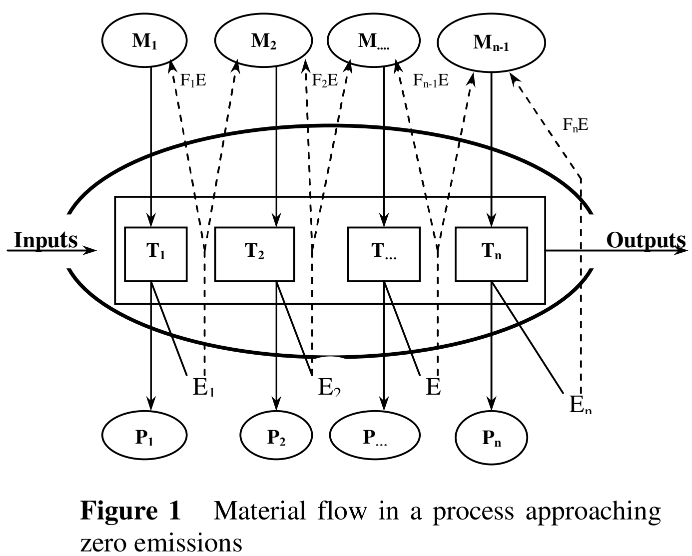

Figure 1 Material flow in a process approaching zero emissions

However, like the other methods gone from end of pipe, 3R's, waste prevention, eco-efficiency, waste minimization, and cleaner production, zero emissions also has strengths as well as limited aspects. Its strength is that it moves and clusters waste (solid, liquid, gas) together and then use process outputs as inputs in an integrated system that eliminates all inefficiencies. The limited aspect of the application of zero emissions system is that zero emission defines as zero output from a process except for one desired product is not possible according laws of nature. Chemical reactions, for instance, do not reach exactly 100% yield and waste through heat emissions is inevitable [7]. Another limited aspect is that if a food production process has small-scale production capacity, waste quantity generated is not inherently high enough to make a zero emissions production economically feasible.

We can see that zero emissions system focuses on the whole lifecycle of products including the production, design, waste reduction, waste reuse, recycling, and process redesign. It can be an innovative system of sustainable industry development, where reduction, minimization and utilization of waste remain. Because of this, zero emission approach does not only represent conversion and use of process outputs as inputs for other processes but also an increase in eco-efficiency and elimination of waste as well. If we consider to the mathematical formula in the production process, we can see input material I_{a1} and I_{b1} are adopted to produce the main product, it is still M_1, by products are B_1 therefore formula will be:

$$I_{a1} + I_{b1} \longrightarrow M_1 + B_1 \qquad (8)$$

But when zero emissions techniques are applied in the production, by-products or waste is not B_1 any more. It will be a new product because B_1 is used for another process and converted into B_2, the reaction is written as follows:

$$I_{a1} + I_{b1} \longrightarrow M_1 + B_2 \qquad (8\text{-}1)$$

In (8-1) we can see that changing input materials from I_{a1} and I_{b1} to I_{a2} and I_{b2}, the environmentally undesirable by-products B_1 might be changed into B_2. If input material is feasible, process will become:

$$I_{a2} + I_{b2} \longrightarrow M_2 + W/B_2 \qquad (8\text{-}2)$$

In the process II, input material will be changed because it is replaced by waste/by-products, used for the production activities. At this time by products generated being reused in a new process, the reaction is written as (8-3):

$$I_{a2} + W/B_1 \longrightarrow M_2 + W/B_2 \qquad (8\text{-}3)$$

The result of new process will be new products useful for human activities, leading towards sustainability. By this way, the inter-connection between waste and materials in the new processes could be written as:

$$I_{an} + W/B_{n-1} \longrightarrow M_n + W/B_n \quad (n = 2,3,4...,n) \quad (8\text{-}4)$$

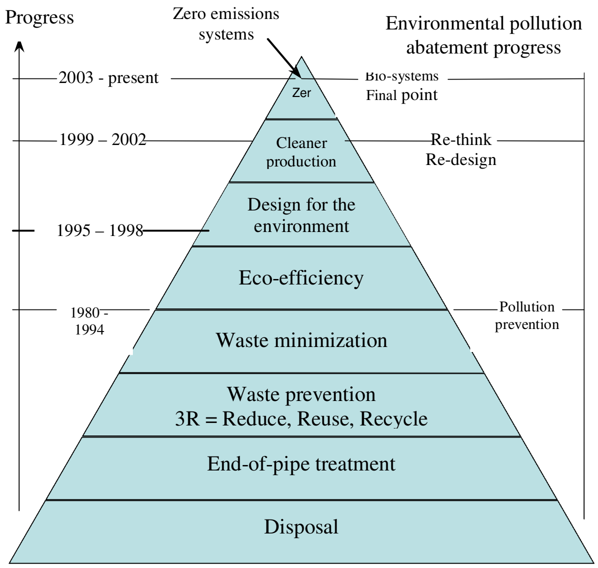

Figure 2 Zero emission in hierarchy environmental protection progress

2.3. Vision for zero emissions systems

From a system viewpoint, the sun provides the energy for the earth, which drives the photosynthesis processes, this processes order atoms and molecules to higher value such as forest and food products. Dead matter is processed by microbes in the soil to become food for the next cycle except coal, wood, and fossil fuel. It means natural cycles function without producing waste. Waste existent in this production process will serve as a resource for other processes of live. This can be expressed similarly by the equation 'waste or emissions = food'. A zero emissions system approach is employed when returning 'residual products' as inputs to further processes in industrial closed loop systems. This may involve redesigning both products and processes in order to eliminate hazardous properties that make either of them unusable and unmanageable. Also, all of the input production factors are completely used up. The factors are either utilized in the final products or become value added raw materials for the industries. As the final goal is to have the total input volume equal the total production volume, the ultimate objective is for industries to generate no waste products whatsoever. As well, it contributes to energy conservation by using the waste heat generated during recycling processes to provide heating and hot water, and by producing solid fuel and other energy from the compression and combustion of refuse. Under this concept, zero emissions systems represent an increase in eco-efficiency and elimination of waste as well.

The defined zero emissions agro-based industrial system boundaries can enclose a private company, a cluster of companies, or a region certainly. From a holistic point of view, zero emissions technique is not a stand-alone technique. It must be implemented in context of existing environmental techniques and technologies such as Cleaner Production, Eco-efficiency, Pollution Prevention, Upsizing, Industrial Ecology, Design for the Environment, Green Chemistry, Integrated Bio-Systems etc, and combine the strengths of all waste management methods. Through materials and energy has to be sourced to a much greater extent from renewable resources. This will adapt to the beneficial economic and environmentally traits in ecosystem clusters which advocate the use of all waste and to convert it into additional products through value added processes. In addition, every substance in the production has a detection sensitivity limit below which it can not be controlled, but the implementation of zero emission techniques to production processes requires the creation of safe products to limit environmental negative impacts to a minimum.

For business, AIZES can mean greater competitiveness and represents a continuation of its inevitable drive towards efficiency. From a perspective of industrial progress we may conceive that the first productivity of labor and capital in the industrial revolution, and in today's major shift come the productivity of raw materials – to be producing more from less. Zero Emissions can therefore be understood as a new standard of efficiency and integration. Shortly 'zero emissions' is a completely new approach to a sustainable and resource efficient economic development.

AIZES also promotes a shift in society as a whole. It is widely recognized that production and consumption are tightly intertwined activities. Thus, to truly achieve AIZES, it is necessary to consider the larger societal system within which industrial activities take place. Achieving zero emissions at a societal level includes addressing such issues as urban and regional planning, consumption patterns, energy conservation, upstream industrial clustering, the reuse and recycling of products, and the interactions of these activities with the local industrial production base. Also, AIZES envisages all industrial inputs being used in final products or converted into value-added inputs for other industries or processes. In this way, industries are reorganized into clusters such that each industry's wastes or by products are fully matched with the input requirements of another industry, and the integrated whole produces no waste of any kind. This technique should be based on the well-established economic analysis tool known as input/output method. By this way, AIZES strategies consider the entire life-cycle of products, processes and systems in the context of a comprehensive system of interactions with nature and search for efficiencies at all stages. It also offers a chance that waste can be prevented through designs based on the full life cycle of the product. Instead waste should, like any residues of processes, be thought of as potential inputs for starting new processes. The opportunities for reduced costs and reduced negative environmental impacts will be possible. Under this way, AIZES strategy leads to look for efficiencies in the use of materials, energy and human resources to achieve a sustainable future, extreme efficiency in the use of all resources, and in order to meet the needs of human. The strength of AIZES concept is, it moves and clusters waste together, and then uses process outputs as inputs. In the process, zero emissions systems offer a bridge between the specific innovations occurring in cleaner production and the attainment of an industrial system supplying human needs within the constraint of global and local carrying capacity. The limited aspect of the application of AIZES is that zero output from a process except for desired products is not possible according to laws of nature.

3. The principals of a zero emissions agro-based industrial system

Like the other methods of pollution prevention, AIZES should have the principals which lead to a more environmentally benign industry design where industrial clusters imitate nature, eliminate waste and pollution, and are more productive than conventional models.

There is no formal principal of a zero emission agro-based industrial system, even the idea of zero emissions initiated more than fifteen years ago. We have present 7 principals of AIZES distilled from a diverse set of practices and emerging research. These can be viewed as imperatives or directives that address alternative input materials, processes improvement, waste management, producing and reusing of renewable energy and materials, production process control.

Prevention waste

This principle poses that it is better to prevent waste than to treat or clean up waste after it is formed. This is due to spending time for waste treatment, treatment technologies as well as costs for treatment. In an industrial production process waste prevention is definitely considered as the first principle in management of material flow. Many research shown that regardless of the scale, using benign and safe materials in the production is always going to be beneficial and costs of disposal of solid waste and hazardous materials usually exceed reuse costs per volume. At manufacturing scale, the costs to remain within legal emission levels and the associated costs to monitor and document these levels become quite high. So, realization of principle 1 '*prevention waste*' makes environmentally sensitive sound production.

Less harmful materials and synthesis

The second principle of AIZES suggested is *less harmful materials and synthesis*. This principle proposes wherever practicable, synthetic methodologies should be designed to use and generate substances or materials that possess less harmful, hazardous, and toxic properties. In addition, the materials, chemicals, or compounds should be digestible to avoid creating the persistent pollutions, compounds, and materials. Especially, manufacturing and engineering procedures ensure that the contamination from these processes do not appear in the final product. The products in AIZES are products which should be made by bio-synthesis. Increase output (products) and less input (raw materials) is encouraged in this principal. Re-engineering production to minimize waste, create new products, or use innovative materials which are less toxic and more recyclable should be reached.

Energy efficiency

Energy requirements recognized for their environmental and economic impacts should be minimized. Normally, physical or chemical reactivity is obviously governed by the laws of thermodynamics, mass, and kinetics. Every transformation requires an input of energy to overcome the activation energy of the transition state in the process. Energy inputs can amount to a substantial component of the overall environmental footprint of a transformation. New transformations must be designed to work within more readily accessible energy limits to assure energy efficiency. Or, pollution reduction has been achieved through using of clean technologies and avoiding usage of fossil fuel of course.

Reuse, Recycle and Renewable feedstock

This would ameliorate waste generated in the area which is waste-intensive. A major opportunity in AIZES to reduce the amount of waste generated is focusing on reuse and recycles. The negative impacts on the environment and the costs for waste treatment will be less. Moreover, a raw material should be renewable rather than depleting wherever technically and economically practicable. The chemical industry's reliance on petroleum should be addressed. The timeline for depletion might be debatable. Nevertheless, long-term sustainable alternatives should be identified. Agricultural-based resources offer an alternative as the isolation and purification technologies improve such as bio-ethanol (bio-fuel), chemicals (lactic acid, amino acid, acid amine, etc), bio-products (organic products), and degradable products which are extracted or produced from biomass through a natural fermentation process or reaction in bio-catalysts, bio-degradation, photo-synthesis, and bio-digestions. Not only are the products made from renewable or agricultural-based resources, but they are also capable of being completely recycled or even composted after use. Certainly this principle tends to drive down manufacturing costs and is the elimination of unnecessary intermediate products and finished harmful products.

Waste-based economy

This principle is based on a material and energy balance method which should be designed to maximize the incorporation of all materials and energy used in the process into the final product. Under this way, the process should be designed within the framework of make the product at whatever the cost. In addition, waste must be used back for a new process to improve the profitability. At process level output material of the transformation is an actual increase in non-incorporated materials into the final product therefore we must do an accurate calculation of waste usage in the new process. If for instance an existing reaction provides a 70 - 80% yield together the amount of by-products, usage of waste in a new process must lead to by a significantly higher yield and more environmentally responsible.

Design products to degrade after use

The finished products should be designed in a way that at the end of their function they do not persist in the environment. Particularly their chemical compounds should be broken down into the innocuous degradation products. A natural rule, the earth's natural environment is full of ecological cycles where the waste of one process becomes a feedstock of another. Before our needs required for durable and stable materials such as plastic materials, however these materials enter a non-degradable cycle. Nowadays we are dealing with their negative characteristics, for example plastic materials in landfill. Most of plastic materials are non-degradable materials. Regardless they are landfilled for more than 20 years, the non-degradable ability of plastic materials seems taking very long time. Therefore we must better understand these cycles and incorporate them into the design of future materials. Design the finished products in AIZES should be focused on the production of materials which has the ability of being broken down innocuously after use. Hence its accumulation will not longer be able to persist in the environment. The implications for use of a genetically modified plant should certainly be considered for this.

Real time analysis for pollution prevention

The requirement of this principal implies that analytical techniques to prevent pollution must be developed in the real-time because of the relation of dynamic reaction and the inter-influences in the process. Certainly these applied analysis techniques will be different depending on the type of enterprises such as small-sale, medium-scale, or large-scale manufacturing processes. In particular, analytical methodologies need to be further developed to allow for real time, in-process monitoring, and control prior to the formation of waste and hazardous substances. If better, more responsive monitors can be designed. Then the use of ‘just in time’ techniques can be employed that will minimize the environmental toll. Also there is a need to improve analytical techniques to consume less material and energy. Quantitative determinations of contaminants and pollutants in the environment are important aspects of analytical techniques certainly.

4. Case study on zero emissions in the pineapple processing industry

4.1. Canned pineapple production process

There are many operations during pineapple production processes. It is principally divided into five stages including input material, preliminary processing, primary processing, filling, and product stages (Figure 3).

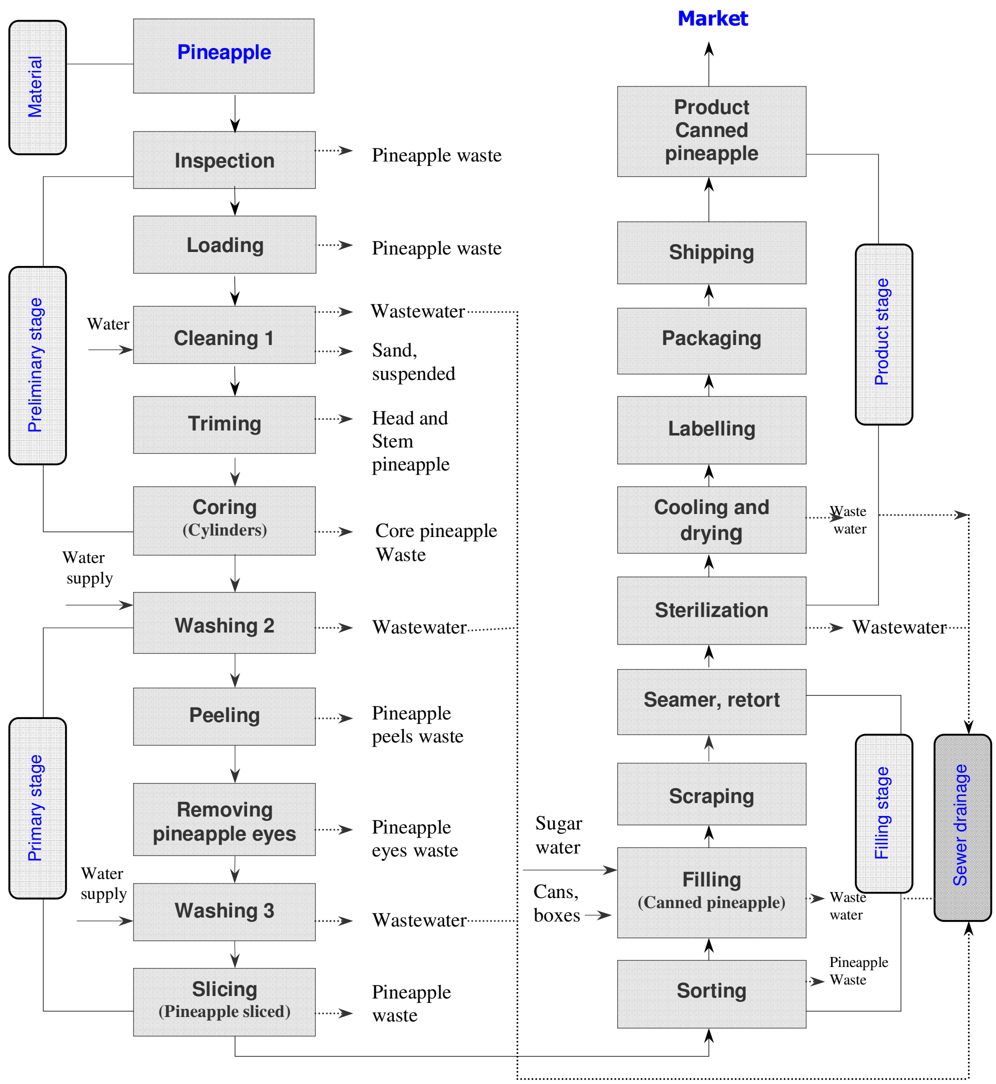

Figure 3 Flowchart considered for canned pineapple production processes

Material: Pineapple fruits which are used for production activities consist of Queen, Cayenne, and Spanish pineapples. This kind of pineapple has a diameter within 75-90cm and a water percentage of 72 -88%, sugar percentage of 8 - 18.8%, protein, mineral, acid citric, acid tartaric, and vitamin [8].

Preliminary stage: the pineapple is washed in the basins in this operation. Here pineapple is only used for the process when it is separated from material presenting some sort of defect (trimming and coring). The selection is carried out on a conveyor belt with the speed of 0.12-0.15m/s. The core is cut from the center of pineapple while also removing both ends and core at a rate of 15-20fruit/min.

Primary stage: this stage consists of five operations including washing 2, peeling, removing pineapple, washing 3, and slicing. Continuously, slicing is entailed to slice pineapple. After coring, pineapple is washed twice in basins, where water is also replaced continuously. Peeling is included in this stage. It is an operation that allows for better presentation of pineapple. The pineapple eyes are removed by workers. Blanching is also an employed operation in the pineapple production processes.

Product stage: Sterilization is applied in this process operation. Sterilization consists of a thermal treatment that is higher than pasteurization during processing, microorganisms that can cause spoilage are destroyed by heat. The cans holding sliced pineapple are processed in hot-water cookers at 100°C, and 10 – 15min duration time. The products are quickly cooled to prevent overcooking to preserve sensory, color and steel erosion.

4.2. The method of AIZES

A method towards a zero emissions industrial ecosystem is established having three basic steps. The methodology starts with analyzing the material and energy flows that run through the industrial systems and partly end up in wastes, followed by analyzing various possibilities to prevent the generation of wastes in the second step. The third step concentrates on identifying, analyzing and designing potential offsite recovery and reuse options. It also entails the identification of remaining wastes in this step to treat follow a reasonable method toward zero emissions.

Analyzing material and energy flows: is important for an identification of sources of by products/waste, excessive materials, and energy consumption in the production. This analysis concentrates to determine the type as well as amount of by products, waste, materials, and energy used in the production units. It is started by going through the whole production process to obtain an overview on where inputs are processed and where by products or waste are generated. Materials and energy balances for input-output is also done in this step. Material and energy balance contributes to the understanding of the relative importance of different causes of waste generation, energy consumption as well as the costs used in the production.

The possibilities to prevent waste: this step is based on the step of analyzing material and energy flow. It implies that data analyzed can be used for appropriate possibilities to prevent and minimize waste generation. Waste prevention concentrated at preventing wastes from being generated. Waste minimization aims at dealing with minimizing waste that have been generated by a producer based on the information of the quantity, characteristics, waste handling methods, etc. Depending on the specific process circumstances and the socio-economic conditions several alternatives for prevention and minimization of waste generation are usually combined to come to an optimum set of option for waste prevention. The assessment of individual and combinations of options should result in an integration of various alternatives into a practical and feasible model. The feasible options are often selected based on criteria of environmental regulations and issues, available technology, product quality, economic efficiency, etc.

Identifying, analyzing and designing potential offsite recovery and reuse options: reusing, recycling, and recovery by products are considered in this step. By products will be reused as process inputs for the other processes to reach the aim of 'zero waste'. Waste treatment will also be done in this step of course. The treatment certainly depends on characteristics and the amount of waste, environmental standards or pollution reduction requirements, available treatment technologies, etc.

4.3. Input and output analysis in AIZES

The AIZES model is introduced on a case study of canned pineapple production processes at Food and Vegetable frozen Company in Thoi an commune in Vietnam (COFIDEC). The processing plant produces 4.300tons of canned pineapple products each year. To serve for the production activities the company used the high amount of fossil oil for the boilers. In this case study the potential of the utilization of agricultural residues has been examined through the biogas experiments.

A chain route of pineapple production processes originates continuously from raw material, preliminary, primary, secondary to final product processors for consumer market. Production activities require input materials for the process, including pineapple fruits, water, sugar, chemicals, and energy. AIZES model starts from the analysis of the amount of pineapple waste generated during the production. The material flow model is simulated in Figure 4. Wastewater which is discharged from the pineapple production is treated in wastewater treatment plant. The product of the digestion is fertilizer; it could be used as plant fertilizer for agriculture. Biogas, which is also a product of the digestion, can be used directly as gasification for lighting and boilers demand in the factory.

Non-waste: In the AIZES model pineapple waste generated from the production is collected, gathered, and then put into digester in anaerobic digestion for biogas production. Digester is obtained from pineapple waste, livestock manure, sludge from the wastewater treatment plant, and residues from the factory. There is 520kg of waste generated when 1 ton of pineapple fruit is processed.

*Water and non-wastewater: w*ater consumption to process of 1ton pineapple fruits is approximately

22-25m^3. It is used for all processes; relevant from cleaning, washing, processing, sterilization, cooling, washing the cans, washing the floor, and equipments after each shift. Water is mainly supplied from the local well, pumped of 350m^3/day for the pineapple production. Wastewater is discharged as much as approximately 350m^3/day to be collected from the pineapple production processes and then piped directly to the wastewater treatment system. A part of wastewater after treatment is used to mix the substrates in the digester for biogas production. The wastewater treatment system uses a combination of physical, biological and chemical treatment methods, to remove suspended solids, organic matters, and bacteria. Treated water meets to the industrial standard B discharged [9] and used back as water for irrigation system in agriculture or satisfied for pouring plant.

Energy demand: Electricity powers all stages of processing including conveyer transport, peeling, trimming, coring, removing pineapple eyes, slicing, filling, seamier, retort, and sterilization. Organic waste which is actually thrown frequently into landfills is collected and used as input material for digester in anaerobic digestion. the food industry uses energy for food preservation, safe and convenient packaging, and storage. Food preservation is dependent on strict temperature controls. Proper storage is also energy dependent. Freezing and drying are the most crucial methods of food storage. Freezing operations require a large portion of electricity used by industries.

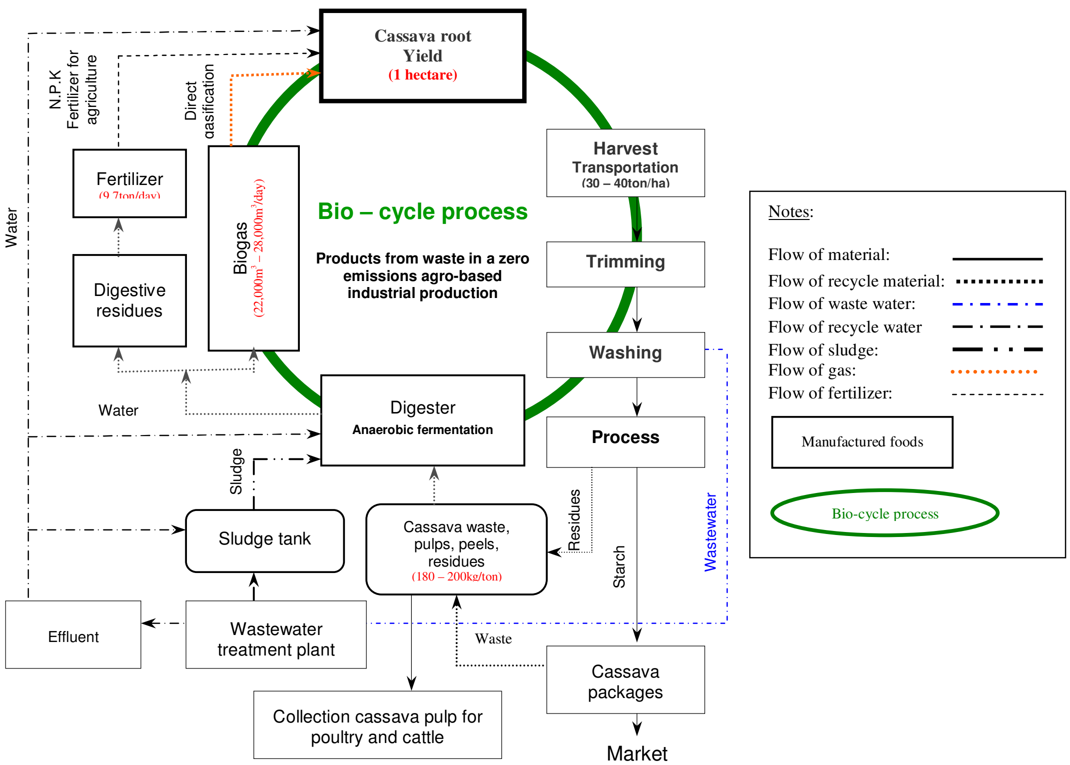

Figure 4 Zero emissions pineapple canned processing industry

Outputs: *Fertilizer and biogas*: corresponding to input materials of production capacity, outputs from sectors of the canned pineapple production were waste (solid and liquid), odors, and air-polluted exhausts. However, the effects on the environment and human population by exhausts from the process were not serious. The compositions of solid waste consist of waste from COFIDEC (7.2ton/day) and the others (23.0ton.day). In AIZES model, the system outperforms its design goals by a significant margin, for instance all waste from the pineapple production process is used as input substrates, or the use of treated wastewater as supply water for mixing substrates (waste and manure) in anaerobic digestion. Biogas conversion was efficient through the experiments regarding pineapple substrate was very high and the methane was generating more than anticipated (value was 79.55%) [10]. If it is possible, inside the factory the gas is combusted in oil boilers, which transfers the thermal energy to oil-carrying media inside the combustion chamber, for instance the boiler for sugar water or sterilization. The avoided cost for external energy supply are an efficient part of business – rationale for implementing the AIZES in this case. The sludge from fermentation can be used as plant fertilizer. That offers cost savings in company owned or plantings or market potential for external use.

4.4. Material and energy balances

Material balances are fundamental to control production processes, particularly in the control of product yields. The calculation of material balances is based on material, waste, wastewater and energy in the process. Material balance in this case study is formulated according to the law of conservation of mass. The basic formula is:

$$Mass_{in} = Mass_{out} + Mass_{stored} + Mass_{lost}$$

Raw materials = products + wastes + stored materials + losses

$$\Sigma m_R = \Sigma m_p + \Sigma m_w + \Sigma m_s + \Sigma m_L$$

In which:

$\Sigma m_R = m_{R1} + m_{R2} + m_{R3} + ... + m_{Rn}$: Total raw materials
$\Sigma m_P = m_{P1} + m_{P2} + m_{P3} + ... + m_{Pn}$: Total products
$\Sigma m_w = m_{w1} + m_{w2} + m_{w3} + ... + m_{wn}$: Total wastes
$\Sigma m_s = m_{s1} + m_{s2} + m_{s3} + ... + m_{sn}$: Total stored products
$\Sigma m_P = m_{L1} + m_{L2} + m_{L3} + ... + m_{Ln}$: Total losses are unidentified materials.

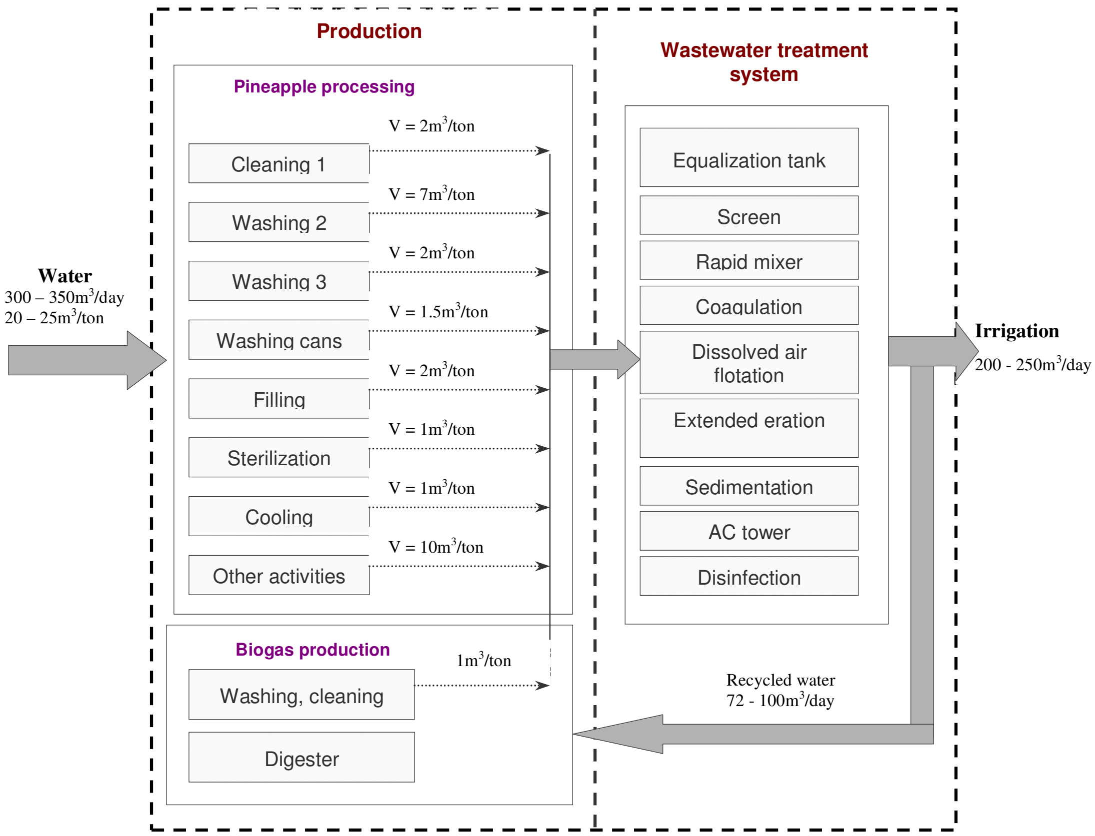

Figure 5 Flowchart considered for material balances in AIZES

Material balances: on AIZES are calculated for *mass-in* and *mass-out* in the pineapple production processes, simulated in Figure 5.

Mass in

Water = $\Sigma m_{Water} = m_{cleaning\ 1} + m_{washing\ 2} + m_{washing\ 3} + m_{wahing\ can} + m_{filling} + m_{sterilization} + m_{cooling}$

Basic $1m^3$ of water = 1000kg

Water consumption for all process and cleaning equipment and tools : $\Sigma m_{Water} + m_{others} = 350m^3/day$

Chlorine: $\Sigma m_{Cl} = m_{cl,W.W.T.P} + m_{Cl,process} =$ 300kg/year

Pineapple waste = 7.26 - 30ton/day

Calcium hydroxide: $m_{Ca(OH)2,\ process}$ = 40ton/year

Sodium hydroxide: $m_{process} + m_{WWTP}$ = 200ton/year.

Total waste = $\Sigma m_R + \Sigma m_{others}$ = 25 - 30ton/day

Mass out

Pineapple waste = $\Sigma m_{whead} + m_{wcore} + m_{wpeel} + m_{weyes}$

Pineapple waste = Σm_R = 0.185 x 12 + 0.045 x 12 + 0.24 x 12 + 0.125 x12 = 7.3ton/day

Water for digester = Σm_{mixing}= 72- 100m^3/day

Wastewater = $\Sigma m_{Water} = m_{cleaning1} + m_{washing2} + m_{washing} + m_{wahing\ can} + m_{sterilization} + m_{cooling} + m_{others}$

Total wastewater = Σm_{Water} = 350m^3/day

Total substrate loading: $\Sigma m_{Rloading}$ = 22ton/day

Fertilizer = 30% x $m_{digestate\ residue}$

Fertilizer mass = 0.30x (72+22 + 7.2) = 30.5ton/day.

Energy balances

Energy balances are normally not simple because they can be inter-converted, for instance mechanical energy to heat energy, but overall the quantities must be balanced. As mass conserved, energy coming into a unit operation on pineapple production can be balanced by energy coming out (electricity) and energy stored (thermal energy). In the factory, energy usage can be split up into various forms. For instance, electrical energy is used for power in the process and lighting. FO used for boilers, which generate stem for heating of sugar water in the filling stage. Besides, energy usage is used for the cooling tower and cooling the water supply system and for compressing air.

$Energy_{in} = Energy_{stroed} + Energy_{out}$

Where:

$Energy_{stored} = \Sigma E_E + \Sigma E_S$

$Energy_{out} = \Sigma E_L + \Sigma E_P$

ΣE_e: Total energy entering the process

ΣE_S: Total energy stored

ΣE_P Total energy leaving with the products

ΣE_L: Total energy lost to surroundings.

Then:

$\Sigma E_{In} = \Sigma E_e + \Sigma E_L + \Sigma E_s + \Sigma E_P$

Total energy entering for the process

$\Sigma E_e = E_{e1} + E_{e2} + E_{e3} + ... + E_{en} = E_{e\ cans} + E_{cleaning} + E_{trimming} + E_{coring} + E_{peeling} + E_{slicing} + E_{strilization} + E_{cooling}$

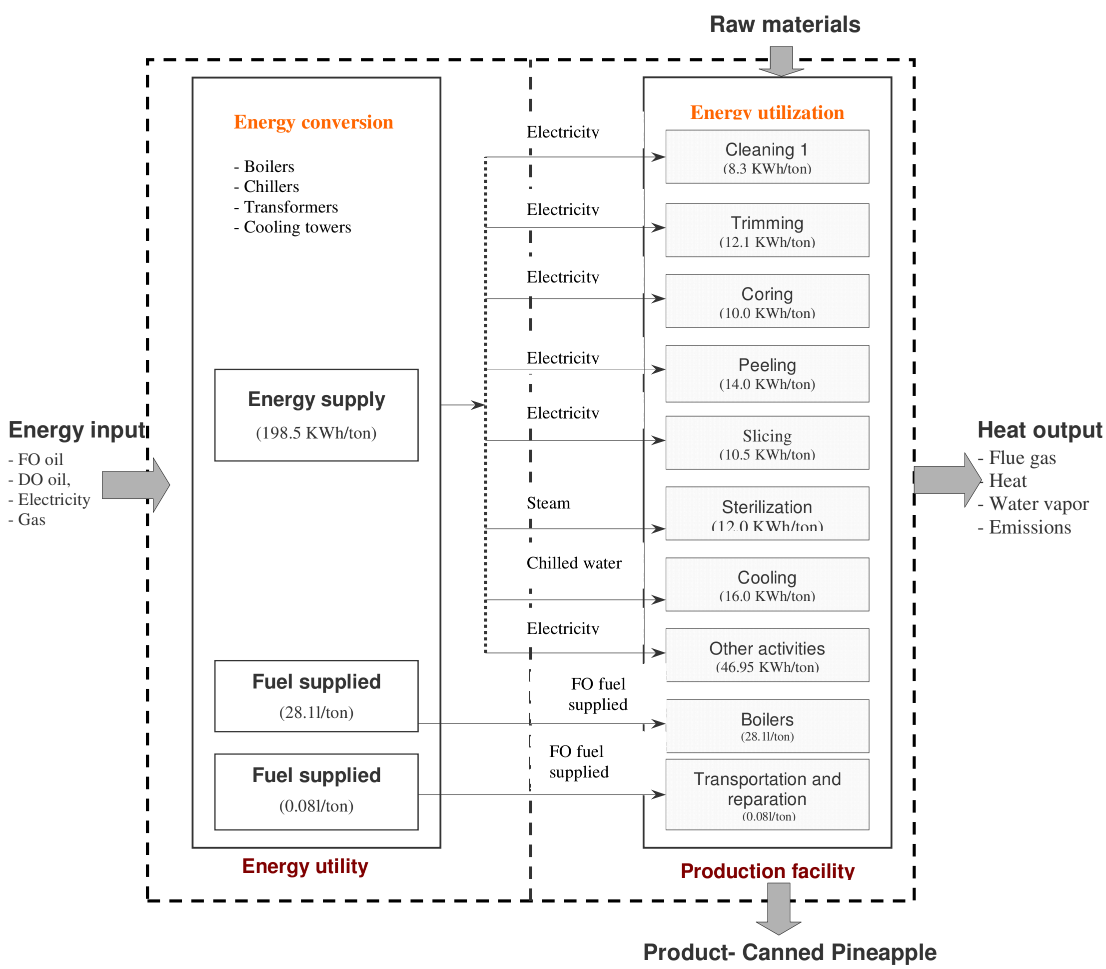

Figure 6 Flowchart considered for energy balance on canned pineapple production

Heat entering = heat in cans = weight of cans x tem. above datum x special heat

For pineapple process, an autoclave consists of 1500 cans. The weigh of each can is 80g. It is heated to an overall temperature of 100°C. And then it is cooled to 40°C before leaving the autoclave.

$E_{heat\ in\ caning}$ = 1500 x 0.08 x (100 – 40) x 0.5kJ/kg°C = $3.6.10^3$kJ

The volume of each box is 353g. Quantity of boxes used for 1ton of the fruit is 2833 boxes.

E_{ecans} = $E_{heat\ in\ caning}$ x 2833/1500 = $3.6.10^3$kJ x 2833/1500 = 6799.2KJ = 1.8kWh

Total energy entering = ΣE_R = 1.8 + 8.3 + 12.1 + 10.0 + 14.0 + 10.5 + 12.0 + 16.0 = 84.7KWh/ton

Total energy store

$E_s = E_{s1} + E_{s2} + E_{s3} + E_{sn} = E_{s\ 80tonnes} + E_{s\ 50tonnes} + E_{s\ primary\ frozen} + E_{sfrozen} + E_{s120tonne}$

Total energy stored = ΣE_s = (501.000 + 83.000 + 70.000+33.000+ 28.000)/(360x6480) = 110KWh/ton

Total energy leavings with products

$\Sigma E_P = E_{P1} + E_{P2} + E_{P3} \ldots + E_{Pn} = E_{P1} + E_{Plighting} + E_{Pother\ act.}$

$E_{lighting}$ = 108,000/360 x 6480 = 0.05KWh/ton

E_{Pother} =(202,000+475,000)/360x6480=0.29KWh/ton

ΣE_P = 0.05+0.29 = 0.34KWh/ton.

Total energy lost to surrounds

$\Sigma E_L = E_{L1} + E_{L2} + E_{L3} + E_{Ln} = E_{Lboilers} + E_{Lprocess}$

Radiation heat transfer losses at boiler:

$q_{1-2} = \varepsilon_1 \times A_1 \times (T_1^4 - T_2^4)$

Where:

ε_1 : emissivity, $\varepsilon_1 = 0.8$

A_1 : Surface area

T1: is temperature measured at the surface.

T2: is ambient temperature

$E_{Lboiler}$= 0.293x11.900/1000= 3.49kwh/ton

$E_{Lprocess}$ = 10% x 110 = 11kwh

Total energy to process each ton product:

$\Sigma E_{In} = \Sigma E_e + \Sigma E_L + \Sigma E_s + \Sigma E_P$

ΣE_{In} = 84.7 + 3.49 + 0.34 + 110.0 = 198.53kwh/ton.

4.5. Wastewater treatment system

Pineapple fruit processing operations generate substantial amount of wastewater that is characterized by high organic content, high strength chemical oxygen demand (BOD: 12,000mg/l), bio-chemical oxygen demand (COD: 5,000mg/l), total suspended (TS: 385mg/l), temperature of 30 - 45°C.

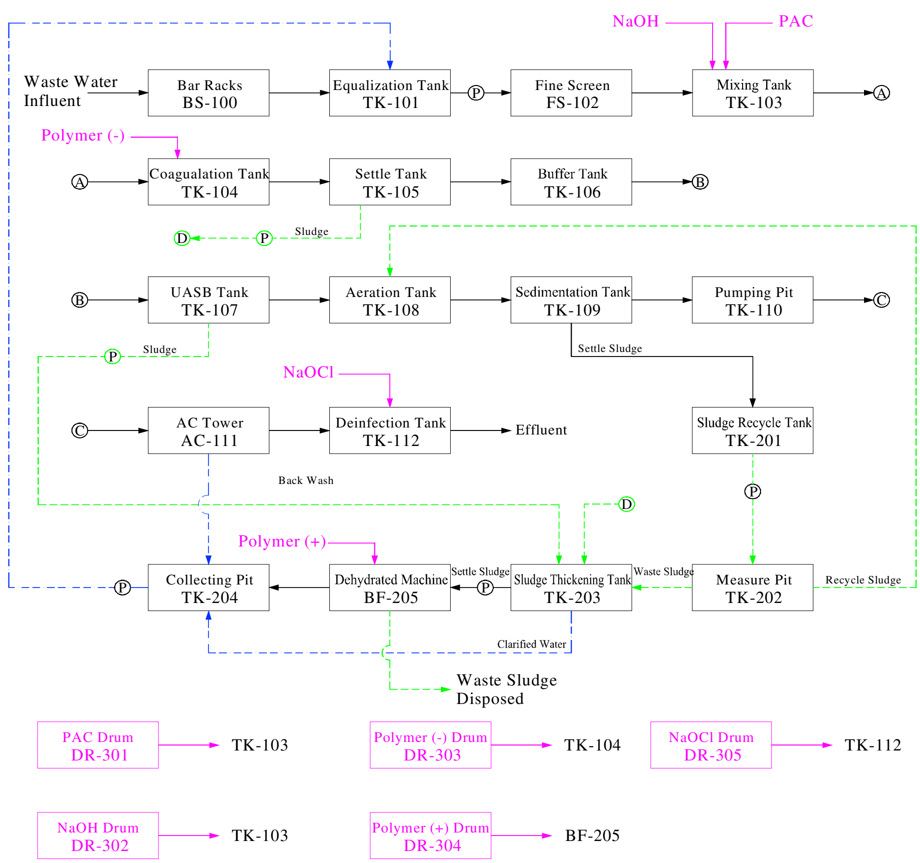

Figure 7 Bock diagram of pineapple wastewater treatment system

A physical treatment method is applied first to remove coarse, debris and solid contaminants by letting the wastewater flow through bar rack. Then the wastewater flows into equalization tank to control hydraulic velocity, or flow rate through a wastewater treatment system. Wastewater is then pumped into the mixing tank and the coagulation tank to increase the removal of solids because with the addition of specific chemicals, solids become heavier than water gravity and will settle down.

Aeration tank can be considered as biological phase in the wastewater treatment system to remove up to 90 percent of organic matter in the wastewater. Sedimentation tank is also called settling tank, a vessel in which solids settle out of water by gravity through pulling particles to the bottom of the tank. It is installed after aeration tank.

The UASB (up-flow anaerobic sludge blanket) and aeration tank can be considered as a biological phase in the system to remove up to 90 - 95% of the organic matter in the effluent. Then, the effluent flows to sedimentation tank. The sedimentation tank is also called settling tank, a vessel in which solids settle out of water by gravity through pulling particles to the bottom of the tank. It is installed after the aeration tank, see figure of block diagram 7.

Effluent from sedimentation tank is pumped into the activated carbon tower (AC) to pure the contaminant concentration through a bed of activated carbon, called a mass transfer zone. This ‘mass transfer zone’ is defined as the carbon bed depth reducing the contaminant concentration from the initial to the final level, at a given flow rate. Carbon is used as an adsorbent to remove a large variety of compounds from contaminated waters or toxic pollutants. The adsorption is a natural process by which molecules of a dissolved compound collect on and adhere to the surface of an adsorbent solid. Although the effluent is treated, it contains many types of human enteric organisms that are associated with various waterborne diseases.

Disinfection can selectively destruct the disease-causing organisms in the effluent. The disinfection contact tank and the associated chemical dosing facilities will be designed to meet the *E.coli* criteria of ≤ 1000/100mL (geometric mean). The chemical used to eliminate bacteria in disinfection tank is NaOCL. NaOCl is pumped from NaOCl drum to efficient tank, where bacteria and E. coli are eliminated. The effluent is channeled into a clean water reservoir with a volume of 450m^3/day and going to be used back as irrigation water for agriculture or plants in the company (350m^3/day) and 100m^3/day for digester, see figure 7. The calculation on tank and architecture of the citrus wastewater treatment system shows in the Table 1.

Table 1 Tank and architecture of the citrus waste water treatment system

Tank and architecture	Quantity	Dimension	Material
TK-101 EQ. Tank	1 Basin	7.0M (L) × 4.0M (W)× 3.0M (D)/ 2.5M(SWD)	RC+ Epoxy Coating
TK-103 Mixing Tank	1 Basin	2.0M (L) × 2.0M (W)× 1.5M (H)/ 1.5M(SWD)	RC+ Epoxy Coating
TK-104 Coagulation Tank	1 Basin	2.0M (L) × 1.5M (W)× 2.0M (H)/ 1.7M(SWD)	RC+ Epoxy Coating
TK-105 Settle Tank	1 Basin	3.0M (ψ) × 4.0M (D)/ 3.0M(SWD)	RC+ Epoxy Coating
TK-106 Buffer Tank	1 Basin	2.0M (L) × 1.5M (W)× 2.0M (D)/ 1.5M(SWD)	Reforce Conrete
TK-107 UASB Tank	1 Basin	4.0M (L) × 3.5M (W)× 4.0M (D)/ 5.0M(SWD)	Reforce Conrete
TK-108 Extended Aeration	1 Basin	5.5M (L) × 3.5M (W)× 4.5M (D)/ 4.0M(SWD)	Reforce Conrete
TK-109 Sedimentation tank	1 Basin	3.0M (ψ) × 3.0M (D)/ 3.0M(SWD)	Reforce Conrete
TK-110 Pumping Pit	1 Basin	1.5M (L) × 1.0M (W)× 4.0M (D)/ 4.0M(SWD)	Reforce Conrete
TK-112 Disinfection tank	1 Basin	2.0M (L) × 1.0M (W)× 2.0M (D)/ 1.5M(SWD)	Reforce Conrete
TK-202 Measure Pit	1 Basin	1.0M(L)×1.0M(W)×1.0M(D)/0.8M(SWD)	
TK-204 Collecting Pit	1 Basin	2.0M(L)×2.0M(W)×1.5M(D)/1.5M(SWD)	Reforce Conrete

Notes: L: the length, W: the width and D: dimension.
Source: Own calculation.

4.6. Anaerobic fermentation

The method introduced in this AIZES to examine is anaerobic fermentation. In the digestion progress, organic matter is digested in the absence of air to produce methane, carbon dioxide and other trace compound. A digester consists of a mixing tank, sludge tank, an engine generator set and liquid storage. The digester is an in-ground concrete tank. The thick of the tank is made by concrete and coated by epoxy. When gas production has ceased, the digester is emptied and refilled with a new batch of raw materials.

Retention time of fermentation is within 28 - 40 days. Digester is sealed from the inside to prevent biogas leakage and insulated to maintain temperature. The separated liquids will flow to the concrete storage by gravity, where a liquid is centrifuged, and then the liquid is used as fertilizer. PH value was 6.0 - 8.0. Biogas produced will be utilized as renewable energy. The biogas yield was 18,000m^3-24,000m^3/day. Biogas yield and methane content was very high, its maximum value was 79.5%. In the first week the amount biogas generation was slower but the yield was still released slowly until the end of fermentation phase. Gas of this quality can be used to generate electricity. It may be used as fuel for a boiler, heater, cooking, lighting, etc. Biogas volume was measured at the batch reactor headspace by using a system pressure gauge. The biogas in the reactors headspace was released under water to prevent any gas exchange between the reactor and the air. Digester is sealed from the inside to prevent biogas leakage and insulated to maintain temperature. The separated liquids will flow to the storage by gravity, where the liquid is centrifuged used as fertilizer. With production capacity from pineapple production, the amount of fertilizer is estimated approximately 30.5ton/day.

4.7. Economic considerations

A decision to implement or choose between one and other options is dependent on economic considerations, which includes both establishment costs, capital investment costs, and operation costs. However, from an environmental aspect, those costs must be compared to environmental issues although economic efficiency, monetary flow back and the possibilities of savings are put on the top. Economic calculations are described shortly in figure 9.

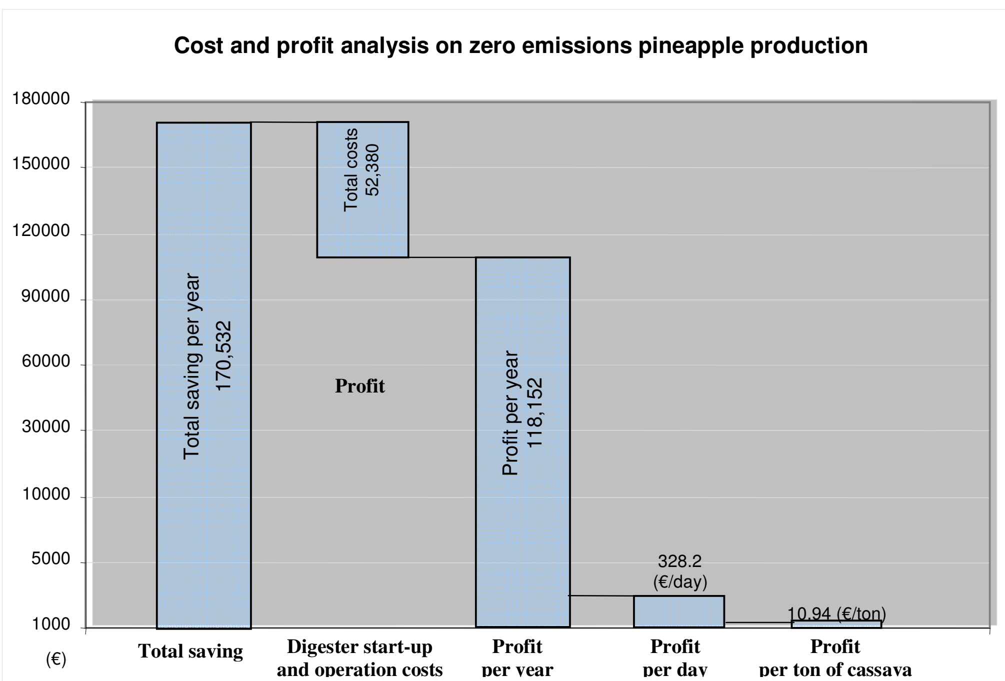

Figure 9 Cost and benefit analysis of zero emissions pineapple processing industry.

5. Discussions on zero emissions

5.1. Lessons we have learned from case study

Constraints and opportunities in approaching zero emissions systems

A lot of expectations are placed while the concept of zero emissions systems has arisen to approach 'no waste' in industrial production. Basically, the shift from zero emission concepts to the possibility of applying zero emission systems in reality necessitates a fundamental redesign of the process, the system of industrial material flows and the skills necessary for implementation. Nevertheless, the case studies have revealed several constraints hampering the application of zero emissions, waste exchange, and even approaching end-of-pipe treatment. However there are also opportunities to support a more sustainable development of processing and manufacturing industry. Discussions on constraints as well as opportunities, which can not be the same in all situations, will focus on three major aspects following:

- Management aspect: we can see that technical constraints can be pointed out by the absence of adequate technology and lack of willingness of producers to change the current techniques. Firstly it is hard for the producers to know how to apply zero emissions techniques, reuse and recycle options, and manage waste. This leads to the producers being to change the old current techniques although that technology is not adequate. It seems that it is not easy to show the urgency of employing development strategies in the factories or companies. Several economic and technological possibilities feasible for onsite and offsite reuse and recycling of byproducts have not been practiced. Concentrations of substances in the effluent from the existing processing, which are often higher than allowed according to the discharge standards give evidence that these companies do not pay attention nor know how to treat thoroughly. In addition the producers just consider their current production practice efficiently. They do not want to modify their operational habit, or have the prejudice implementing any changes in the processes because they think it takes too long and may affect the product quality, in particular in case of food processing. The required extra investment adds to their unwillingness to any change.

Practical experiences show that the lack of information dissemination also contributes to the technical constraint because not all producers is informed about the available technological possibilities to improve their efficiency and environmental performance. This limits the opportunities for producers to access new techniques to improve their production efficiency and environmental performance. Especially it is also difficult to convince the producers to carry out waste reduction and minimization activities due to limited number of practical demonstrations and full-scale applications of the laboratory studies. Finally, the lack of advanced equipment in the production process is causing high amount of waste generated. The lack of facilities for monitoring and continuous assessment of environmental performance is also a constraint, leading to improper implementation of environmental protection activities by several producers.

Although there are some technical constraints in an application of zero emissions, several opportunities can be found to overcome these technical constraints. Generally AIZES is a new approach. Waste management in AIZES approaches waste exchange in a closed loop. The successful application of zero emissions techniques can convince producers that it is not too difficult to improve their production efficiency in terms of technical modification as well as costs, or the availability of know-how on zero emissions. Another point is, in order to encourage producers to conduct auditing programs, provincial authorities need to give clear and specific guidance for environmental reports and material manifests so that producers have to carry out measurements and provide more detailed data on their production processes and waste generation. Under this way, environmental management authorities can compare and establish whether these production processes are operated efficiently and environmentally friendly, and advise them in conducting AIZES. More especially, growing foreign investments in industrial development might help Vietnam, generally developing countries, to modernize the industrial system and achieve more sustainable development.

- Economic aspect: the first economic constraints can be found by an absence of incentives from economic agencies, such as bank, insurance companies, and tax agencies, to apply pollution prevention measures. No tax exemption or tax reduction is applied for environmental investment by companies. But in developed countries such as Austria or Germany, there are many subsidies for green technologies. Insurance companies have only emerged recently and are mainly related to health insurance. Another point is that the consumers play no role yet in pushing food processing companies in

Vietnam to improve the quality of product and environment nor do they demand companies to acquire ISO certifications. None of the studied companies produces a product with an eco-label. If the companies can improve the role or requirement of consumers, such as products satisfy ISO, use clean technologies, etc, in the production and consumption, this will lead a significant contribution of environmentally sound waste management method as AIZES. In addition, lack of capital or financial assistance for investment in environmental measures remains a barrier for the implementation of zero emissions techniques, even also for end-of pipe treatment, particularly in the case of small- and medium-scale units.

Besides the constraints, several possible efforts can also be found to overcome, for example one of these are cleaner production demonstration projects that have recently been established (supported by UNIDO) in developing countries. Although cleaner production technology does still not eliminate waste, anyway it is one of positive methods to manage waste on the way to approach zero emissions. However under this way, it implies that environmental funds with a preferential interest rate for financing of investment in green technology will facilitate the implementation of environmental protection. Thus, companies are willing to borrow money from credit institutions for environmental investments. The developing countries can also learn from experiences from the developed countries in applying soft loans and tax benefit to make zero emissions more attractive. Additionally, foreign customers and consumers may push export product's companies to pay more attention to their environmental performance through acquiring ISO 9000 and ISO 14000 certification, etc. The companies confronted with financial limitations, could start with effective low cost and no-cost zero emissions measures that are easy to implement. The savings from these low- or no-cost solutions could be used to subsequently fund the applications of more costly options.

- Environmental policy: due to economic development progress existing environmental legislations mostly emphasize end-of-pipe solutions, especially in the developing worlds. The focus is more concentrated on treatment rather than orienting them to optimize their material flow within the production process, or paying attention to onsite and offsite reuse and recycling of by products. Waste management in food processing plants just tried to fulfill the requirements from the environmental authorities without paying proper attention to treatment efficiencies. Additionally, environmental regulations are not much incentive for investing for example in the application of AIZES models as well as waste exchange options.

Continually low resource pricing and absent pollution treatment fees are among the major regulatory constraints in encouraging the implementation for zero emissions and waste exchange. For instance the producers use underground water without fee charged therefore they are not interested in minimizing water loses. Moreover they do not have to pay for discharging their wastewater. Most of producers do not have a separate environmental management section, hence the except for selling of by products or reusing for other environmental improvement activities is hard to carry out. So for environmental pollution prevention as well as for approaching AIZES we need to establish financial incentives in the environmental regulation system to encourage the implementation of zero emissions and waste exchange practices. Also, setting a suitable waste treatment and disposal fee based on the unit of waste generated is necessary because this fee can push the producers to minimizing the generation of waste, both wastewater and solid waste. An additional effect can be given through an appropriateness pricing of natural resources, materials, the removal of subsidies for water and electricity supply, waste collection, and disposal service. The charging rates have to be determined of course. If too high charging rate will affect the economic performance and competitiveness of a business, and lead way to illegal disposal black-markets. On the other hand, too low charging rates will discourage producers to pay attention to environmental protection. Finally, we see that without continuous maintenance of environmental protection activities by the companies all attempts towards the aim of the production 'zero emissions' is meaningless.

- Public aspect: one factor that should be identified is public participation. A strong involvement from the public is considered a key catalyst for adoption of environmental-friendly production practices. In several cases environmental reforms are triggered by complaints from the local community. Usually, the overall level of environmental awareness of residents remains low, in particular regarding the long-term impacts cause by wastes. Only very limited attention is paid to the problem of waste disposal. For instance in Khiet tam village where villagers earn income through the use of wastewater from cassava production as fish feed or from recovered fibrous residues and pulp, the inhabitants do not complain about the discharge of wastewater, the company employs some members from the neighboring households therefore it remains rather unattractive to complain about environmental problems caused by this local production unit. It can be said that this is an overall phenomenon in developing and poor countries. Continuously the difficult access to environmental agencies is also limiting the role of the community. Community members mostly do not know their responsibilities hence they sometimes call upon social organization or the media to transfer their complaints to higher authorities. The absence of local and national independent non-governmental organizations working on pollution issues deprives citizens from a powerful source of support: the role of communities in detecting environmental pollution and changing behavior of the polluters. The communities should become more aware and better informed about the environment and environmental quality in their neighborhood. Moreover, the government can help in transportation environmental information as well as issues at schools and public media such as television, radio, newspaper, etc. This might be also widened by the opportunities for establishing local, national as well as international environmental NGOs. Also, the state environmental authorities should provide specific guidelines for citizens' complaints for environmental pollution.

Scale size, inadequacies, and disadvantages

We can see that food processing industry or food production units, in particular food production processes in developing countries, vary between small-scale in household with only 3-10 employees, medium-scale factories with about 10-30 employees, or large-scale factories with more than 30 employees. These production activities, from small-scale to large-scale, contribute to the deterioration of the environment due to improper discharge (solid waste, organic waste, and wastewater), disposal, and an un-hygienic generation of waste. The excessive generation of waste arises due to the following factors:

- Inefficient technology, inadequate processing, and inadequate reuse and recycling of materials;
- Lack of awareness as well as knowledge about waste management, wastewater treatment, and poor environmental regulation, enforcement, and environmental education; and
- Under-priced natural resources.

Additionally, failures in environmental management, in particular in developing countries are factors causing serious environmental pollution. It can be indicated by the following major points:

- State environmental management authorities;
- Environmental and economic agencies are not strict enough to encourage producers and production units improving their production efficiencies;
- Lack of finance as well as financial support from the government for waste treatment and management; and
- Research for improvements in the production and environmental protection is inadequate.

It is actually not easy to avoid the generation of organic waste in the production progress. Any industrial production generates waste, particularly in food processing industry. Food processing industry basically generates three types of waste, including (i) solid waste includes rejected raw material, residues in the production process, and packaging; (ii) wastewater results from process cooling, heating, and processing; and (iii) air pollutants from boilers and heaters. Principally the application of zero emissions methods can be successfully in small, medium, and large sized companies in minimization, reusing, and eliminating waste. However there are in practice several key differences as the technological options vary widely from the different scales of operation. Small firms or small companies obviously dispose of more limited financial and human resource available for environmental improvements than larger firms. Additionally, government institutions pay limited attention to the environmental performance of smaller industries and are more closely observing large-scale enterprises. This leads to the limitation in waste management as well as implementing waste exchange. But these limitations can overcome if co-operations between this small factories and medium factories are fastened. This does not only help solving a huge amount of waste generated but also solve the existing environmental problems in an economically and environmental friendly way. It can be done for example by the installation of a central plant which collects waste from many individual enterprises, municipal solid waste, or sludge from wastewater treatment system to be put together for the fermentation, composting, recycling of materials. Under this way, the group of food producing households or small-scale production processes can benefit from the collective offsite reuse and recycling of waste and from the available environmental services. Hence, waste will be easier and more efficient to collect, treat, and process. This promises costs for waste management and environmental services to get less, or training for workers and employees will be easier to be acquainted with new technologies or installations.

It seems feasible to approach the goal of zero emissions in food processing industry due to simple and easy analysis methods of materials and energy flow as well as its many advantages. However the disadvantage can also be realized from these case studies: waste from some group of enterprises can not match to each other's products for reuse or recycling, for example wrapping materials. Material flow network, which is often essential to reach the aim of zero emissions, can not be fixed to some enterprises. But anyway most organic waste or by products from food processing industry are suitable for a new production to produce biogas, fertilizers, livestock feed, animal feed, industrial grade alcohol, ethanol, and bio-products if resources to establish such plants are available.

Different parts of the word pose different challenges to approach zero emissions

We can see that inequitable development is the major cause for the emergence of the so-called developed and developing worlds. Although this trend has changed little over the last century, the gaps continue to increase between the rich and poor and more recently between those environmentally well-off and those not so. It poses that the developed countries have safer sanitation, cleaner production, and better waste disposal systems, while the developing countries are marked by polluted air, open-landfill sites, non-existent effluent treatment plants, and environmental polluting production.

In developed countries approaching zero emissions seems more easily. It can be available at the flip of a switch. This is due to two major factors including environmental legislation and the powerful sources of finance, while these factors seem being difficult to reach or unavailable in developing worlds. Although international financing institutions, such as the World Bank and regional development banks, have played an important role in this development, most growth has taken place through private sector investments. These investments have often, though not always, led to increased pollution loads and inefficient use of energy and natural resources. Besides this, the challenges have arisen in the third world related to the increasing population, expanding urban or cities, increasing and changing industrialization, and globalization in the attempts to promote economically viable domestic and international investments or decisions that are generally based on financial criteria.

Additionally environmental considerations in developing worlds often deal with emission standards only and they typically rely on an end-of-pipe approach to making changes in companies. These tools do not address the challenge of generating investment without depleting resources and burdening the environment any further. We can sum up in the industrial production progresses at in developing countries 30-70 percent of current industrial pollution is linked to wastes and inefficiency from the use of obsolete technology, inadequate knowledge, low level of environmental awareness, and poor enterprise management. After the 1990s more projects have been done in developing countries by UNEP and World Bank. Most of the installed industrial base and of the energy production capacity in Asia, Africa, and Latin America are new, depending on the industrial and economic development strategies of course. This presents an opportunity to avoid the costly waste management solutions that have burdened the industrialized world. Whether countries seize this opportunity depends greatly on the types of technologies they choose to adopt and the sufficient availability of appropriate financing and shill. The developing country today can make the transition from an agricultural to an industrial economy with much lower costs and with less environmental damage than today's developed countries did although achieving sustainable economic development on a global scale will require the judicious use of resources, technology, appropriate economic incentives and strategic policy planning at the local and national levels. Besides this, in the poor countries although the economic development can be changed to a better way, the industrial production process is still lack of modern technologies and clean technologies. Inadequate technologies, equipment, tools are challenges in the pathway to approaching zero emissions. Generally the basic differences to approach zero emissions of different parts of the world depend on region, fund, local authorities, training, and environmental issues.

5.2. Challenges and options of AIZES

Most definitions include both objective and subjective elements, AIZES is as well. We believe that this explains the widespread incompleteness and ambiguity that characterize most definitions of alternative industrial systems. An approach that we have found usefully is to define such industrial systems according to their proximity, along a spectrum, to a set of preferred goals. When the idea of a zero emissions system emerged in 1991, there are some ideas regarding 'zero emissions' to argue that it is simply unrealistic because it can be found that no matter how good we get at recycling and reducing our waste, there will always be something left over for which there is no reasonable way of dealing with except disposal. Also, critics argue that a zero emissions industrial system is impossible, how expensive it is? Certainly a lot of expectations as well as arguments are placed on a zero emissions system. By setting a goal of zero emissions we have made a decision as a community that waste is not acceptable. They must be rejected in a zero emissions system due to its reuse as well as recycling. In addition we must admit that catching technology and society changes we will find new ways of doing things that will get us closer and closer to the goal. This also implies that recovering resources can at least create jobs and boost the local economy. Moreover, recycling and resource recovery may create up to twenty times as many jobs compared to landfilling the waste, and the costs for treatment waste are automatically reduced in the production of course. Lastly, rationale to research on AIZES done, the opportunity to reach the goal is possible and can be innovative depending its application.

As a community we must look at all the options and decide on the best way to manage our emissions now and in the future. A zero emissions system is one option that is attracting more and more attention related to its advantages, but it is only the best option for a system in which industry and agriculture corporate. From practical viewpoint, business on waste by reuse and recycle is possible in AIZES models. Nonetheless, the fact that many firms in developing countries have limited technological and organizational capabilities may cause them to choose end-of-pipe solutions once the environmental challenges appear. This analysis focuses on the process of sustainable development, rather than on the state of sustainability. At the same time, more complex pollution prevention measures are harder to implement because they demand planning, design, production and marketing activities redefinition, as well as the corporate management reorganization, in order to include environmental concerns in each one of these stages. This tendency may be reinforced by the biases in the regulations, technology providers, etc., in favor of end-of-pipe technologies. But since developing countries economies, in particular many countries in Asian countries, are widely based on agriculture, significant potential for the implementation of AIZES is given.

5.3. The advantage of the application of zero emissions in the food processing industry

The shift from zero emission concepts to the possibility of applying zero emission systems in food processing in reality necessitates a fundamental design of the process, the system of industrial material flows, and the skills to apply.

We can summary that AIZES is a model in which industry, particularly the food industry, and agriculture cooperate. It will be suitable to be applied for the food processing industries which generate high amounts of both liquid and solid waste. Because AIZES operates based on food processing industry and other enterprises besides the main flows to make the products, it can use waste from food processing enterprises or by products as raw materials for the anaerobic fermentation. It can use livestock manure to feed biogas fermentation. Sludge from wastewater treatment plants can also be added for anaerobic fermentation. Biogas yield produced in the fermentation can burn back for the steam requirements and lighting during food production processes. Biogas could also be converted to the fired system, thus the boilers would have to use less fossil oils. This promises CO_2-free production and minimization of greenhouse effect gases. Also wastewater which is treated in wastewater treatment plants can be used to improve the fruit yields. However, the operation of AIZES will vary due to the diversity of food processing systems. This generalized model could be a foundation for governmental authorities, planers, policy makers and environmentalists in reforming existing industrial systems and establishing new industrial systems. Of course preliminary investment and establishment costs must be considered.

The zero emissions idea has arisen as the idea of environmental protection showing no longer a separate between add-on cost and the overall cost of the primary activity. It is thought to reduce the costs of inputs and outputs, such as materials and energy and the costs of waste generation. Because of this, an avoidance of waste generation - whether solid, liquid, gas, wasted energy, water, or other resources - is a way to save money in a zero emissions system. Application of zero emissions techniques can eliminate both the cost of treating waste, disposing of waste, and even the cost of the raw materials or services that would be wasted. Some of these benefits are considered as the major advantages of a zero emissions system including more efficient use of human and physical resources and increased recovery and recycling of materials. Some other advantages compared with the different waste management methods in environmental protection progress will be:

- Using by-products as inputs for new processes;
- Support fertilizer for agriculture;
- Support water for irrigation in agriculture;
- Producing biogas renewable energy;
- Reduce the negative effects on the environment and human on landfill waste; and
- To reduce Greenhouse effect gas.

Certainly each method of waste management as treatment in environmental protection progress has strengths and weaknesses. Therefore there will probably be a series of equally acceptable treatment options with different quality, economics and environmental performance for each stream. It implies that the selection of a suitable waste treatment and production technology is not a simple issue although a sensible environmental option. Treatments or production technologies need to minimize end-of-pipe interventions, to maximize the cleaner production thinking, and approach zero emissions state. The advantages can show the possibility to apply AIZES in consideration based on typical motivations such as social concern, intergenerational concern, formal position concern, and empowerment, and credibility although the difficulties in finance sources will be a problem especially in developing counties.

6. Conclusions

Outlooks on zero emissions, its application in food processing industry as well as discussions on the constraints and opportunities are at the heart of this article. Approaching zero emissions can open up numerous possibilities for conducting in food processing industries more efficiently.

Although pollution treatment technology plays a dominant role in the industry as a rational response to environmental regulations, it has still accrued the stresses on the environment because it can not solve the original environmental problems. Zero emission is a concept for the production, manufacturing, and consumption of goods and services toward a development that is sustainable and harmless to the environment. The zero emissions model positively defines the beneficial environmental, social, and economic traits. And it empowers waste to gain the status of a resource by establishing a coherent network of process chains.

The food industry is an important industry in the economic development of every country. However, the amount of by-products from food production is not low, if waste can be managed and used as input material for the process this can offer beneficial environmental and economic efficiencies; it does not only reduce the costs for waste treatment as well as the negative effects but also protect the environment. Moreover fermentation technology which can be applied in AIZES is not difficult to conduct. Digesters are already widely established. This means that the application of zero emissions techniques in the food industry will be possible; it is a promising path to adapt to issues environmentally friendly through alternative usage of fossil fuels, the use of chemical fertilizers, reduction of greenhouse effect gases, and minimize waste. Principally zero emissions techniques can apply to small-, medium-, and large-sized companies, but there are in practice several key differences as the technological options vary widely different scales of operation. Actually small firms or small companies obviously have very limited financial and human resources available for environmental improvements. In addition, government institutions pay limited attention to the environmental performance of smaller industries and are more closely observing large-scale enterprises. Because of this, bringing the food processing industrial sectors together in industrial bigger zones will offer bigger advantages at two sides. Firstly we can collect more by-products for reusing and recycling in environmentally friendly new production processes. Secondly waste management will be more concentrated, the costs for waste management and services will get less through economies of scale.

In conclusion it may be said that it is not easy to disseminate the concept of zero emissions. The dissemination of zero emissions concept is a challenging task, in particular in the developing worlds. Nevertheless, the potential benefits of such efforts are sufficient motivators for strengthening focused aid in development of adequate local capacity in zero emission production. Such activities would be great contributions to the aim of global sustainable development.

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