ZERO MUNICIPAL WASTE

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ABSTRACT

Improvements in determining the effects of municipal waste discharges have led to the adoption of stringent environmental laws, which define the degree of treatment necessary to protect the environment. Zero Waste is a philosophy, a strategy, and a set of practical tools seeking to eliminate waste, not manage it.Zero Waste means designing and managing products and processes to reduce the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them. Implementing Zero Waste will eliminate all discharges to land, water, or air that may be a threat to planetary, human, animal or plant health.The concept of Zero Waste (ZW) is considered as a way to improve efficiencies, reduce production waste and save money. Zero-Waste (ZW) is about making the best choice with our natural resources - from extraction to production to consumption to disposal. It involves a constant evaluation about our materials' choices and a strong commitment to eliminating waste, not just treating it. Zero Waste is emerging as a paradigm shift, a new, comprehensive socio-technical system that addresses our resource use from product design to disposal [1].

Zero Waste has an important impact on the management of energy flows in the economy. In the life cycle of most products the most energy intensive moments are in the extraction, production and use phase; hence from an energy point of view Zero Waste reduces emissions associated to extraction and production thanks to feeding-back most nutrients and resources back into the natural cycle –soils- or technical cycle -reuse and recycling. The emissions associated to the use phase are reduced with better product design and eco-innovation [2].

Zero Waste System is based on the development and operation of a processing municipal solid Waste. They understand how system can provide a significant enhancement to traditional anaerobic operations. The municipal solid waste stream is potentially recoverable in the form of biogas production. A comprehensive waste processing system creates value by saving disposal and transportation costs, and preparing the organic fraction for use in an energy recovery process. Waste-To-Energy (WTE) as a part of Zero Waste because WTEhas the most greenhouse gases (GHG) per fuel typeits emissions contain dangerous air pollutantsand compostingproduces only a fraction of the energy that can be saved through recycling [2].

Anaerobic digestion system for organic waste processing from municipal sourcessuited for the production of biogas from solid organic waste in a biological treatment operated by an activated sludge process. The Anaerobic digestion system can is designed to include biogas-processing technology for combined heat and power (CHP) generation for onsite use in saving the energy consumption for aeration mechanical system based on the amount of organic waste to be processed.Biogas generation is one of the most promising renewable energy sources in hot climates. Anaerobic digestion is one of the effective ways of generating biogas. Anaerobic digestion is also a reliable method forwastewater treatment and the digestion the effluent can be used as fertilizer to enhance the fertility of thesoil. As far as energy generation is concerned Zero Waste supports systems that operate at biological temperature and pressure, such as anaerobic digestion to produce biogas followed by composting of digestate in order to maximise benefits of turning organic matter back to soils [3].

Keywords: ZERO WASTE, WASTE-TO-ENERGY, ANAEROBIC DIGESTION, BIOGAS, COMBINED HEAT &POWER, ENERGY RECOVERY

1 INTRODUCTION

Improvements in determining the effects of municipal waste discharges have led to the adoption of stringent environmental laws, which define the degree of treatment necessary to protect the environment. As far as energy generation is concerned Zero Waste supports systems that operate at biological temperature and pressure, such as anaerobic digestion to produce biogas followed by composting of digestate in order to maximise benefits of turning organic matter back to soils. Zero Waste refers to waste management and planning approaches which emphasize waste prevention as opposed to end-of-pipe waste management [3].

Biogas technology is one of the most potential technologies of biomass and bioenergy as it is considered as a renewable sources of biomass and bioenergy by using municipal waste materials (e.g., sludge, animal manure, crop straw, and by-products from food industries). By-products from biogas production, called digestate, are nutrient rich, which could potentially be reused as green fertilizers in agriculture, thereby providing a sustainable substitute for synthetic fertilizers for farm ecosystem.The biogas production of anaerobic digestion is win–win option for livestock and crop producers to address issues of waste management and energy supply, and to avoid contamination of surface and ground waters and emissions of odors and greenhouse gases.The Anaerobic digestion system is designed to include biogas-processing technology for combined heat and power (CHP) generation for onsite use in saving the energy consumption based on the amount of organic waste to be processed [3].

ZERO WASTE & WASTE TO ENERGY

Zero Waste refers to waste management and planning approaches which emphasize waste prevention as opposed to end-of-pipe waste management. As far as energy generation is concerned Zero Waste supports systems that operate at biological temperature and pressure, such as anaerobic digestion to produce biogas followed by composting of digestate in order to maximise benefits of turning organic matter back to soils. Waste-to-Energy (WTE) is a disposal technology that destroys resources forever; it makes things "go away," and doesn't reduce waste or protect natural resources. "Zero Waste and Bio-Energy." Is the cleanest and safest way forward on dealing with this "residue" is to follow the three-step German approach: sort out any remaining recyclables, "biostabilize" the residue in an anaerobic digester to capture the biogas and use it for energy, and landfill the remaining inert material in a dry tomb landfill [4].

Waste-to-energy (WtE) or Energy-from-waste (EfW) is the process of generating energy in the form of electricity and/or heat from the primary treatment of waste. Waste-to-energy (WTE) systems perpetuate our throw-away society and unsustainable consumption. When we burn materials to produce energy, the resources used to make those products and packaging are destroyed, which means we must continue to extract more resources from the Earth to make new products. And we'll use MORE energy in the process—more than was generated in the WTE facility. That is not moving us toward a circular economy and that is not Zero Waste. Mass burn incineration, pyrolysis, gasification and plasma arc systems are all WTE systems that destroy resources and are not part of Zero Waste. Get the facts on why these technologies are bad for our environment, economy and our communities [4].

Zero Waste only accepts one current technology for making energy from waste: anaerobic digestion. Anaerobic digesters use a low-temperature thermal process to speed up the decomposition of biodegradable materials. The resulting biogas can be used to produce energy and the remaining solids, called digestate, can be conventionally composted. Figure (1) presents net energy generation potential [4].

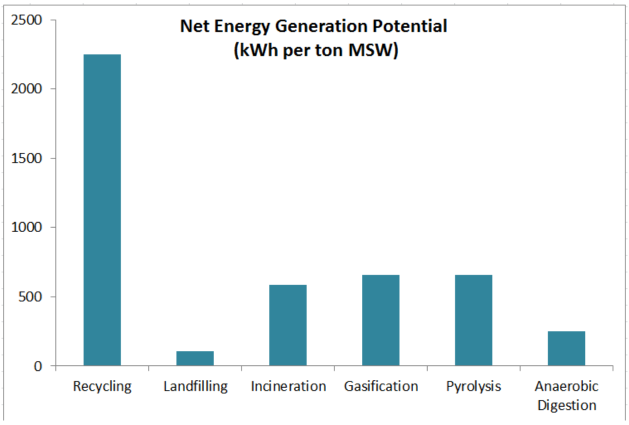

Figure 1. Net Energy Generation Potential [4]

2 ANAEROBIC DIGESTION PROCESS

Anaerobic Digestion (AD) is the process whereby organic matter is broken down by bacteria and enzymes in an oxygen-free environment. The organic matter is released as biogas; this is a mixture of the combustible gas methane (50-75%), carbon dioxide (25-45%), small amounts of water (2-7%) and trace gases such as hydrogen sulfide, ammonia and hydrogen. The type of feedstock used by anaerobic digesters varies; it can include cattle slurry, food waste, energy crops (grass silage, maize silage, grain), municipal solid waste from households and organic solid waste from industry. Materials with high lignin content, e.g. any kind of wood, are not suitable for biogas production. Feedstock is pumped into a closed vessel (digester) which has been inoculated with suitable bacteria. Anaerobic (0% oxygen) conditions are then maintained in the vessel and the temperature is held at a constant value (typically 40°C). Figure (2) shows the digestion process scheme which is used to produce the energy from municipal waste [5].

The biogas produced can be upgraded to natural gas (fossil) quality and injected into the gas grid or used as a vehicle fuel but is normally used on site to generate heat and electricity in a Combined Heat and Power–unit (CHP).The biogas yield depends on the composition of the feedstock and on the ambient conditions in the digester (e.g. temperature, retention time).

The residue or digestate of the AD process can be separated into a liquid and fibrous fraction. The liquid can be returned to the land as a high value fertiliser and the solid fibre used as a soil conditioner. Fermentation improves the quality of manure as nutrients are more available for plants and pathogens and weed seeds are killed. Furthermore, as odours are broken down and neutralised during the fermentation process, the development of odours during liquid manure storage and spreading is greatly reduced. Organic products from industry which are used to produce biogas provide interesting agricultural opportunities. By using organic residues such as distiller's pulp, grease or food wastes, the natural material cycles (carbon and nitrogen) is closed and provides a recirculation of the nutrients into agriculture. Biogas technologies contribute to environmental protection as they release no carbon dioxide (CO2). Energy from biogas is largely CO2 neutral because the CO2 released from burning biogas was already removed from the atmosphere through photosynthesis. The fermentation of manure also reduces emissions from methane, a gas that would have far more devastating effects on the climate than CO2 if it escaped uncontrolled from raw liquid manure [5].

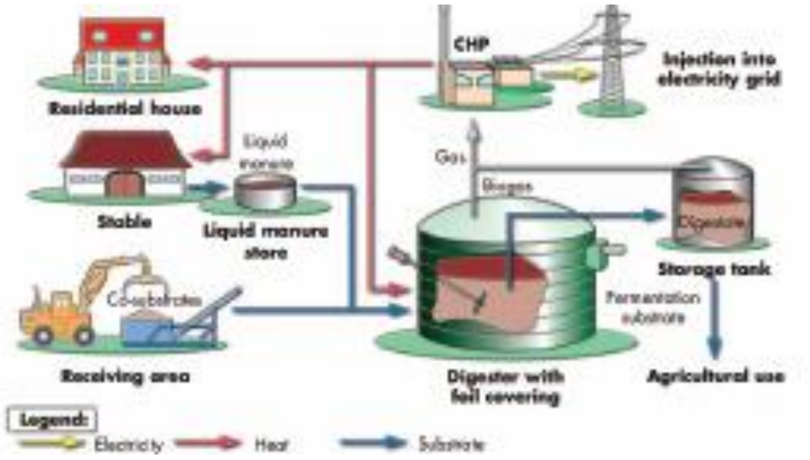

Figure 2. Digestion ProcessScheme [3]

3 ENERGY GENERATION POTENTIAL

The process of biogas generation is divided into four steps:
Preparation of the input material
Digestion (fermentation), consisting of hydrolysis, acetogenesis, acidogenesis and methanogenesis,
Conversion of the biogas to renewable electricity and useful heat with cogeneration / combined heat and power Post-treatment of the digestate

The biogas containing this biologically-derived methane is contained and captured in a gas storage tank which is located separately to the main digester.The biogas is then converted into renewable power in the form of electricity and heat via cogeneration / CHP with gas engines

The composition of biogas largely depends on the type of substrate. Human excreta based biogas contains 65-66% CH_4, 32-34% CO_2 by volume and the rest is H_2S and other gases in traces whiles the biogas composition for a municipal solid waste is composed of 68-72% CH_4, 18-20% CO_2, and 8% H_2S.

The methanization or (anaerobic digestion) is a natural process of transformation of organic substances by bacteria in the absence of oxygen as shown in Figure (3). Three stages can be distinguished during the digestion as shown in Figure (4). The methanization needs specifics physics and chemicals conditions to optimize the biological reaction. It can be realized in mesophilic system (30-40°C) or thermophilic (45-60°C) and with a pH between 6.5~7.2. The typical digester operation is shown in Figure (4). The average composition of biogas from different organic residues as presented in Table 1 [7].

Table 1. Average composition of biogas from different organic residues [7]

Gas	Percentage (%)
Methane (CH_4)	40–75
Carbon Dioxide (CO_2)	25–40
Nitrogen (N)	0.5–2.5
Oxygen (O)	0.1–1
Hydrogen Sulphide (H_2S)	0.1–0.5
Carbon Monoxide (CO)	0.1–0.5
Hydrogen (H)	1–3

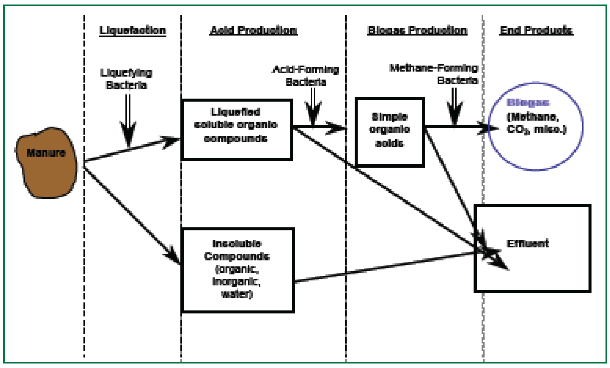

Figure 3. Anaerobic Digestion Stages [5]

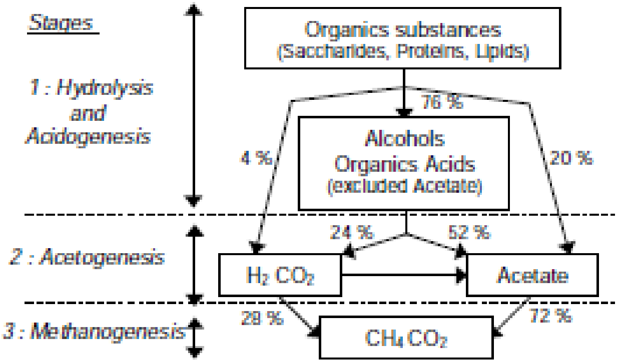

Figure 4. Methanization Process [6]

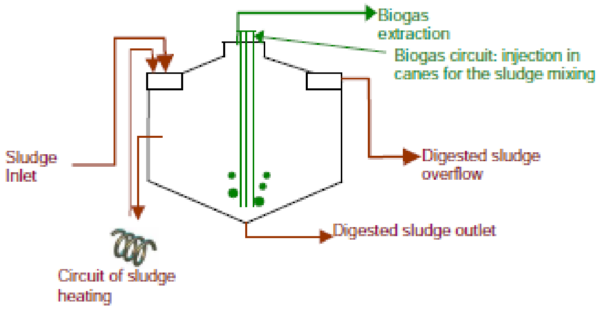

Figure 5. Digester Operation [6]

The estimating the electricity potential from biogas, the average characteristics of the methane present, the biogas engine efficiency, etc are used as presented in Table 2. The calorific value of biogas is about 6 kWh/m^3, which corresponds to about half a liter of diesel oil and can be utilized directly as a heat source or to produce electricity. The biogas must be dehumidified and purified before combustion; otherwise it can damage the gas engine [7].

Table 2. Electricity potential estimation parameters [7]

Parameters	Values
Methane Heating Value	37.78 MJ/m3
Methane Content	65%
Biogas Engine Efficiency	29%
Conversion factor	1 KWh= 3.6 MJ

4 CONCLUSION& RECOMMENDATIONS

There is one waste-to-energy technology (WTE), anaerobic digestion to produce energy from waste sustainably, safely and cost-effectively. Anaerobic digestion (AD) is categorized as waste-to-energy because it produces energy from waste. However, the similarities with other WTE technologies end there. AD is a low-temperature thermal process where biodegradable wastes, such as food scraps, are inserted into a chamber and biodegrade over a number of days, creating a gas (methane) that is captured and used to make energy. AD almost exclusively runs on a separated biodegradable portion of the waste stream, not mixed solid waste.

Zero Waste only accepts one current technology for making energy from waste: anaerobic digestion. Anaerobic digesters use a low-temperature thermal process to speed up the decomposition of biodegradable materials. The resulting biogas can be used to produce energy and the remaining solids, called digestate, can be conventionally composted

It is recommended to use the anaerobic digester to make energy from the source-separated organic (biowaste) portion of the municipal waste stream.Several factors support the development of anaerobic digestion. For example, the problem of becoming sludge evoked in introduction, can be regarded as a lever insofar as methanisation facilitates their outlets. However, the principal levers are the context of the Kyoto protocol, the regulation and the incentive with the green electrical production. Anaerobic digestion is the most economically and environmentally feasible technology for generating energy from waste.

The Anaerobic Digesters Process System have a various benefits as follows:
<u>Waste Benefits</u>
Pathogen and/or weed seed reduction in effluent;
Odor and fly control; and
Production of enhanced nutrient fertilizers, soil amendments, compost, and animal bedding.
<u>Energy Benefits</u>
Production and sale of electricity; and
Production and on-site use of heat.
<u>Environmental Benefits</u>
Reduced carbon dioxide, hydrogen sulfide (H2S), and methane emissions; and
Reduction of total oxygen demand (TOD), reducing the water-quality impact in the event of a spill.

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