BIOGAS PRODUCTION FROM MSW

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ABSTRACT

The considerable increase in the quantity of waste materials generated by human activity and their harmful effects on the environment, have led to growing awareness about urgent need to adopt safe disposal methods.

The best method is minimization of waste generation and maximization of its reuse and recycling.

Most of the Municipal Solid Waste (MSW) is a mix of industrial, household, yard & street waste containing organic as well as inorganic matter.

Energy can be basically recovered from Organic Fraction (OF) of MSW through thermo-chemical or bio-chemical conversion. The bio-chemical conversion technologies are preferred for wastes having high percentage of organic bio-degradable matter and high moisture content.

Anaerobic Digestion (AD), one kind of bio-chemical conversion technologies, has the opportunity to be an integral part of the solution to the most important environmental problems of urban areas: Municipal Solid Waste Management and Renewable Energy.

Through AD, OF of MSW are decomposed by particular bacteria in an oxygen-free environment to produce biogas.

The biogas, which contains between 55% and 75% methane (CH_4), can be used for production of electric power and thermal energy. The solid waste from the reactor (digester) is suitable for composting or can be used as an organic solid & liquid fertilizer.

Worldwide, the application of AD technology has been successful in attempt to reduce the volume of MSW volume, which is otherwise dumped in environmentally unfriendly landfills. In this way, AD is substantially contributing to reduction of dangerous greenhouse gases emissions.

The final objective of this paper is to introduce a project designated to establish, at a pilot level, the technical and economic viability of biogas and fertilizer production from Organic Fraction of Municipal Solid Waste (OFMSW) in Havana City. After successful completion, this shall be the first demonstration project for the utilization of OFMSW in an economically feasible and environmentally friendly way in Cuba.

INTRODUCTION

Despite global success, Cuba has not yet employed AD technology on a large scale, and AD technology is not used to treat MSW at all.

The Project was designated to establish at a pilot level the technical and economic viability of the production of biogas and fertilizer from Organic Fraction of Municipal Solid Waste.

The biogas shall be used as fuel in gas engine-generator to produce electrical power and heat that shall be mainly utilized for digester heating.

The Project Facility shall be located in one of the pre-selected areas in Havana City and the AD system will be fed with OFMSW collected in Havana City.

After separation of all non-organic and other inert waste (glass, metal, plastic, stones, etc,) the remaining OFMSW will be pre-treated and make ready for digester feeding.

Local staff team, after being trained to obtain required skills to run the start-up and trial operation of the Facility as well as performing all necessary tests with initial support from the equipment supplier, will operate and manage the Facility in the future.

While the primary use of the produced electrical power may be at the local level (for system internal and power supply to adjacent workshops, offices and other facilities), the excess electrical power can be exported to 13 kV Local Power Distribution Network.

The solid & partly liquid waste from the digester will be used for composting and later utilized as fertilizer in the agriculture activities.

A major positive effect of the Project will be considerable reduction of environmental degradation and uncontrolled CH_4 emissions caused by disposal of enormous quantities of OFMSW at various landfills in the Havana City.

ANAEROBIC DIGESTION – BIOGAS PRODUCTION

Anaerobic Digestion (AD) is the oldest type of bio-decomposition of organic compounds to occur on Earth. It takes place naturally in oxygen-free organic environments for example in improperly aerated compost piles and at very high level in landfills.

In Europe, Australia and some Asian countries, AD has become a very important option for treating OFMSW and wastewaters.

The highest progress in utilization of OFMSW for biogas and fertilizer production was achieved in Europe, where more than 165 facilities with an installed capacity of around 6 million tons of MSW per year generate electric power in excess of 650 MW.

By doing so, European countries considerably reduce the volume of MSW being sent to waste incineration plants and/or landfills, and therefore reduce the ground water pollution and decrease the emissions of CH_4 and other poisonous gases (which contribute to dangerous GHG emissions) to the atmosphere.

Denmark and Germany, both countries with the stringent environmental legislation concerning MSW disposal, lead the way.

AD occurs in stages to successively break down the organic matter into simpler organic compounds. The product of AD, the biogas is distinguished from syngas (gas produced in mechanical gasifiers) that it is produced through decomposition of organic waste to gaseous fuel by bacteria in the absence of molecular oxygen.

Most digestion systems produce biogas with 55% - 75% CH_4 and about 25% - 45% CO_2 content; the remaining gases are usually smaller amounts of H_2S, N and traces of H_2 and O_2. The relative percentage of these gases depends mainly on the feed material and biodegradation process management.

A variety of factors considerably affect the rate of digestion (biogas production rate). The most important is the process temperature and quality and quantity of organic waste fed to the digester.

Anaerobic bacteria communities can endure temperatures ranging from below freezing to above 65°C, but they thrive best at temperatures of about 25°C→Low-Mesophilic and 65°C→High-Thermophilic (Table 1).

Higher digester temperatures in the thermophilic range (50 - 65°C) shorten processing time, allowing the digester to handle a larger volume of organic waste (i.e. the decomposition -biogas production- occurs more rapidly than in the mesophilic range).

However, the process is highly sensitive to disturbances such as changes in feed materials or temperature. While all anaerobic digesters reduce the viability of pathogenic organisms, the higher temperatures of thermophilic digestion result in more complete destruction.

Although digesters operated in the mesophilic temperature range must be larger (to accommodate a longer period, the retention time, of decomposition within the digester tank), but the process is less sensitive to upset or change in operating regime.

To optimize the digestion process, the digester must be kept at a consistent temperature, as rapid changes will upset bacterial activity.

The typical biodegradation process in function of time is shown in Figure 1.

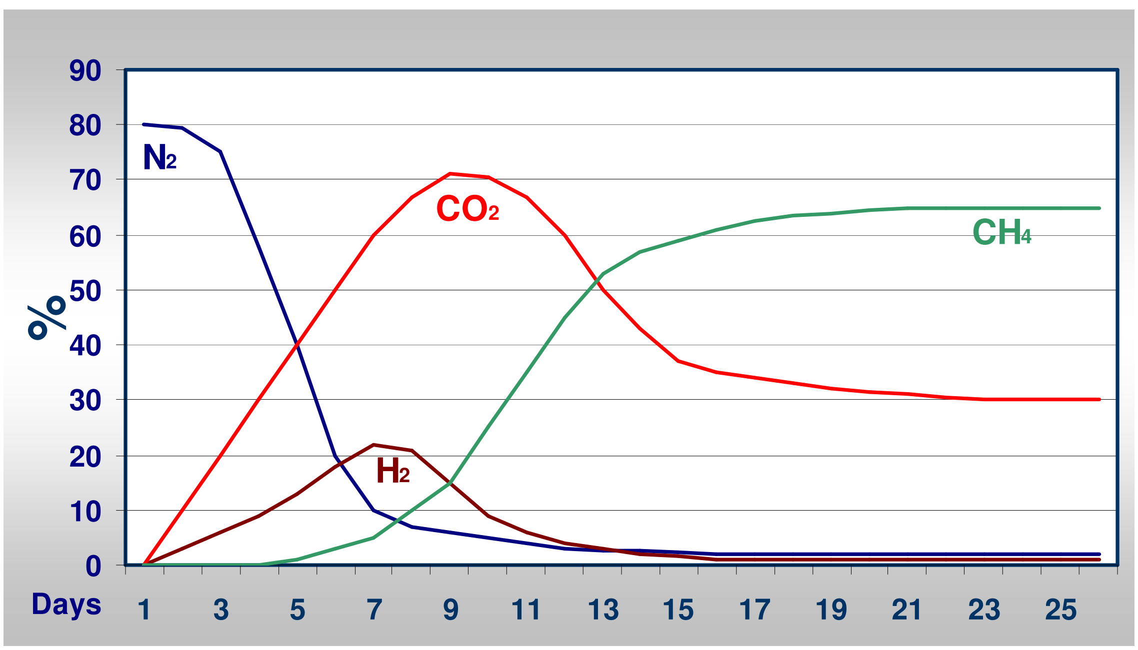


FIGURE 1
TYPICAL BIODEGRADATION PROCESS VS RETENTION TIME

The biogas energy content (the calorific value) depends on the amount of CH_4 it contains. Typical biogas calorific value, with a CH_4 content of 65%, is about 23 MJ/Nm^3 that is equivalent to 0.55 kg of light diesel oil.

The process of biological AD occurs in a sequence of three major steps, hydrolysis, acidogenesis and methanogenesis as illustrated the following Figure 2.

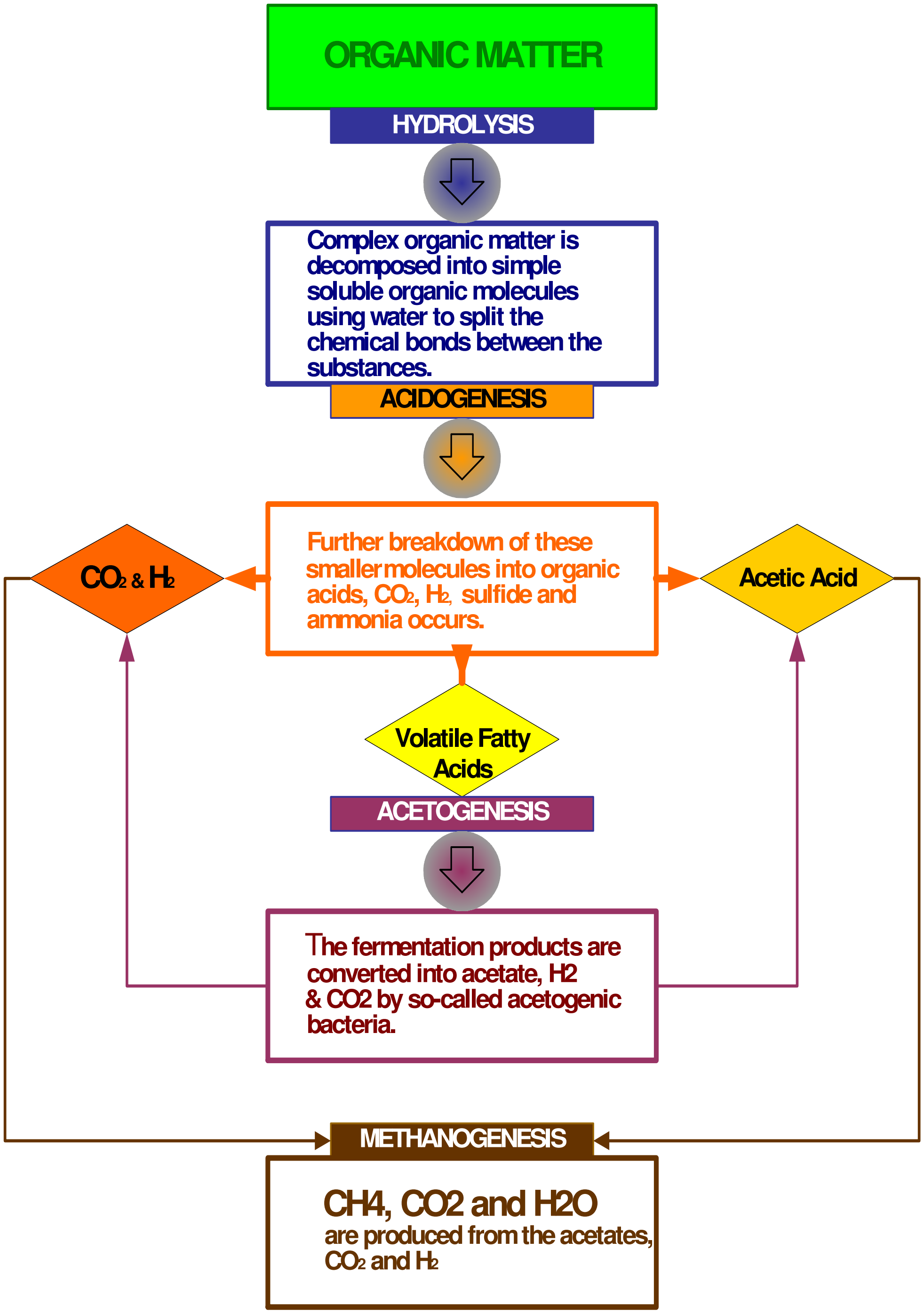


FIGURE 2
ANAEROBIC DIGESTION STEPS

A comparison of various anaerobic digestion systems and process parameters is shown in Table 1.

In many cold areas, digestion vessels require some level of insulation and/or heating. The most economical solution is using the cooling water heat energy from biogas-powered engine-generator around the digester to keep the digestate medium warm. In a properly optimized system, digestate heating substantially enhance biogas production during low ambient temperature periods.

The trade-offs in maintaining optimum digester temperatures to maximize biogas production while minimizing expenses are somewhat complex. The worldwide experience indicates that excellent biogas production can occur in digesters maintained at temperatures as low as 20 - 25°C (psychrophilic).

Digestion Process	Description	Advantages	Disadvantages
Dry	Dry solids content of > 25-40%	Compact, lower energy input, better biogas quality (<80% CH_4), maintenance friendly	Restricted mixing possibilities
Wet	Dry solids content of < 15%	Better mixing possibilities	Higher energy input, lager digester
Psychrophilic	Digestion temperature around 20 - 25°C	Long process time, very slow rate	Minimal energy input
Mesophilic	Digestion temperature between 25 and 40°C	Low energy input	Longer process time, slower rate
Thermophilic	Digestion temperature between 50 and 65°C	Shorter process time, higher degradation, faster rate	Higher energy input Temperature control
Batch	Substrate in closed digester during whole degradation period	Suitable for small plants with seasonal substrate supply	Unstable biogas production
Continuous	Digester is filled continuously with fresh material	Constant biomass production through continuous feeding	No major disadvantages

TABLE 1
ANAEROBIC DIGESTION SYSTEM COMPARISON

Also some other factors affect the rate and amount of biogas output. These include pH, water/solids ratio, C/N ratio, mixing and mixing intensity of the digesting material, the digesting particle size, and digestion retention time.

Pre-sizing and mixing of the feed material allows the bacteria to work more rapidly. Even that in the most cases the pH is self-regulating, bicarbonate of soda can be added to maintain a consistent pH, for example when too much "green" or material with high N-content is added.

It may be necessary to add water to the feed material if it is too dry, or if the N-content is very high. Complete digestion, and retention times, depends on all of the above factors.

The direct combustion of biogas in the boiler can supply useful energy in the form of steam, hot water or hot air. However, after filtering and drying, biogas can be used as precious fuel for internal combustion engines for electric power generation or for mechanical drive applications.

Biogas can also substitute for natural gas or propane in space heaters, refrigeration equipment, cooking stoves or other equipment. Estimated average biogas production from one (1) ton of MSW is 80 – 150Nm^3. The final figure is very much depending on OF fraction (%) in MSW as well as on applied digestion technology.

One (1) Nm^3 with 60% CH4 content is good for generation of around 6.0 kWh energy, which is roughly divided into 2.20 kWh of electrical power (37%), 2.90 kWh (48%) of useful thermal energy. The rest, around 0.9 kWh (or 15%) is waste heat (radiation, low level exhaust heat, etc.).

GENERAL PROJECT INFORMATION

In year 2004 Havana City produced around 2'600 tons MSW per day.

The composition of MSW collected in Havana City is a typical for the urban solid waste in many tropical countries. It contains about the 60% of organic fractions, Figure 3.

The Playa Municipality in Havana City was selected for this Project, in which OFMSW collected in this Municipality shall be used for:-

- biogas production;
- electric and thermal power generation; and
- compost production.

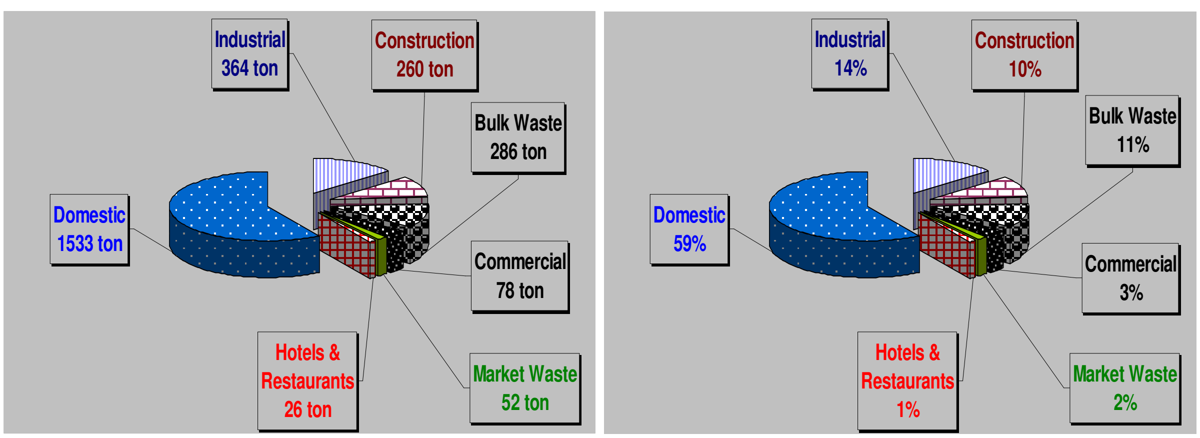


FIGURE 3
COMPOSITION OF HAVANA'S MSW

The main criteria for the selection of the Playa municipality to implement the project were:-

- Different income population stratum in relatively small areas within the same urban area, which includes also semi-rural population.

- Relatively diverse and concentrated business and service oriented economic activities in an area of less than 40 km^2 with a relevant marine costal ecosystem that should be protected from incorrect in-land waste management and disposal practices.
- Possibilities to collect "green materials" from parks and avenues, as well as agro-residues to be used for compost and humus production and suitable amounts of "kitchen" residues for biogas and biofertilezers production through AD.
- Possibilities to demonstrate the alternative sustainable management and disposal methods for MSW in a municipality of relatively high tourist incidence in the country. The experiences gained in Playa could be applied for replication in other tourist areas of the country already developed or planned for future development.

For final implementation of AD facility in Havana City, several factors have been considered.

First, the source of the MSW and the means how to collect and separate it were determined. Simplified diagram showing "at-source-separation & MSW" is shown in Figure 4.

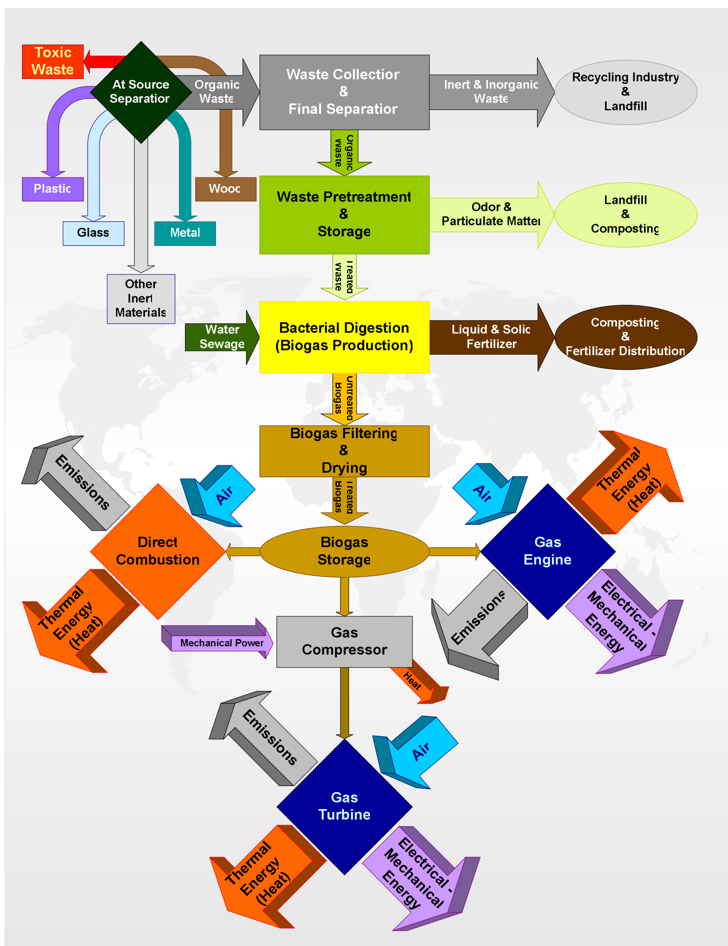


FIGURE 4
MSW SEPARATION & UTILIZATION

Next, an appropriate technology that best suits the characteristics of the collected MSW and space availability for Facility construction was chosen.

Finally, the products off-taker, for biogas as well as for solid and liquid fertilizer, has been identified.

FEEDSTOCK RESOURCE

As mentioned above, the feedstock resource is OFMSW from MSW collection in Playa Municipality in Havana City. The following two possibilities have been evaluated:

- At source-separated organic fraction from available MSW to be delivered to Facility site; and
- Unsorted MSW to be delivered to the Facility site, following by mechanical separation of inert components which would be exported for recycling and landfill.

At the present "At-Source-Separation" technique is not available in Havana-City. That why it was decided to perform the separation into biodegradable and non-biodegradable waste at the Facility site. The biodegradable material will be shredded, slurried, screened and then pumped into the digester.

<u>Acceptable Waste</u>:

- Food waste from restaurants, markets, etc.;
- Food processing wastes;
- At source separated organic wastes;
- Agricultural organic wastes;
- Yard green waste;
- Organic sludge and slurries;
- Non-recyclable paper waste ;
- All other kinds of biodegradable waste.

<u>Not-acceptable Waste</u>:

- Non-recyclable paper fibre waste ;
- Hazardous, biological, radioactive or toxic wastes;
- Explosive or flammable materials;
- Bulky materials;
- Steel, glass, plastic, stones, sand, construction and/or demolition wastes;
- Wood.

TECHNOLOGY SELECTION

Proper technology selection involves the following major parameters:

- OFMSW quantity and quality;
- Available space;
- Ambient conditions;
- Internal energy requirement;
- Available infrastructure;
- Water requirement;
- Simplicity of system operation, control & maintenance;

For a pilot plant project of this kind, the primary concern was to ensure system stability, simple operation and minimal maintenance requirements.

A system without moving parts inside the digester and with limited number of circulating pumps was preferred; so that the Facility shall not need to be disrupted in order to maintain or repair parts with high tear-and-wear excess, especially inside digester.

Another very important aspect which has been seriously considered and evaluated was the digestate temperature control (i.e. temperature control of fermentation processes inside digester).

The evaluation has shown that the mesophilic single-stage digester offers robust system because it establishes an equilibrium that can cope with greater environmental fluctuations in comparison with the high temperature, thermophilic, system.

In order to satisfy the above requirements, Valorga's proven technology has been evaluated as best suitable system for this pilot Project.

Other available and compatible systems, namely Dranco, Linde, BTA and Kompogas have been also compared with Valorga during technical evaluation stage.

The French company Valorga International SAS was formed in 2002 by Steinmuller Valorga Sarl, which was initially founded in 1981 as a MSW treatment company.

The first Valorga process pilot plant was built in 1982. In 1988, the company started the plant for household waste treatment by continuous anaerobic digestion with high solids content in Amiens, France. Valorga currently runs eleven plants to treat MSW (status 2004). Today, Valorga has good experience in the field of waste treatment with the following objective: "maximal valorisation of organic matter, environmental protection and energy production". Up to date, more than 2 million tons of MSW was treated with Valorga process.

The Valorga process was initially designed to treat organic MSW and only later it was adapted to the treatment of mixed MSW; i.e. biowaste (source separated household waste) and grey waste (organic residual fraction after biowaste collection).

The Valorga process plant, Figure 5, consists of five units: MSW Reception and Preparation Unit, Anaerobic Digestion Unit, Biogas Storage and Treatment Unit, Biogas Utilization Unit and Compost Curing Unit. Depending on environmental requirements, an air treatment and a water treatment unit may be added.

MSW will be pre-treated by means of separation (to divide the waste into the organic fraction, including fermentable material, paper and cardboard, and non-organics) at Facility site and than the OFMSW will be delivered to the reception unit.

At the reception unit the shredded OFMSW is unloaded and the waste material is then conveyed and fed to the inlet mixing and diluting tank, where the waste is mixed with re-circulated leachate into a thick sludge of about 20% solids content.

The digester operates in the mesophilic temperature range. There are no rotating mechanical parts inside digester and the digester maintenance mainly consists of periodic cleaning of the nozzles at the bottom of the digester.

The digested material exiting the digester flows through a filter press that separates the compost material from the leachate solution. The leachate is reused for diluting incoming waste and any excess is transferred to the water treatment unit or the municipal sewage network.

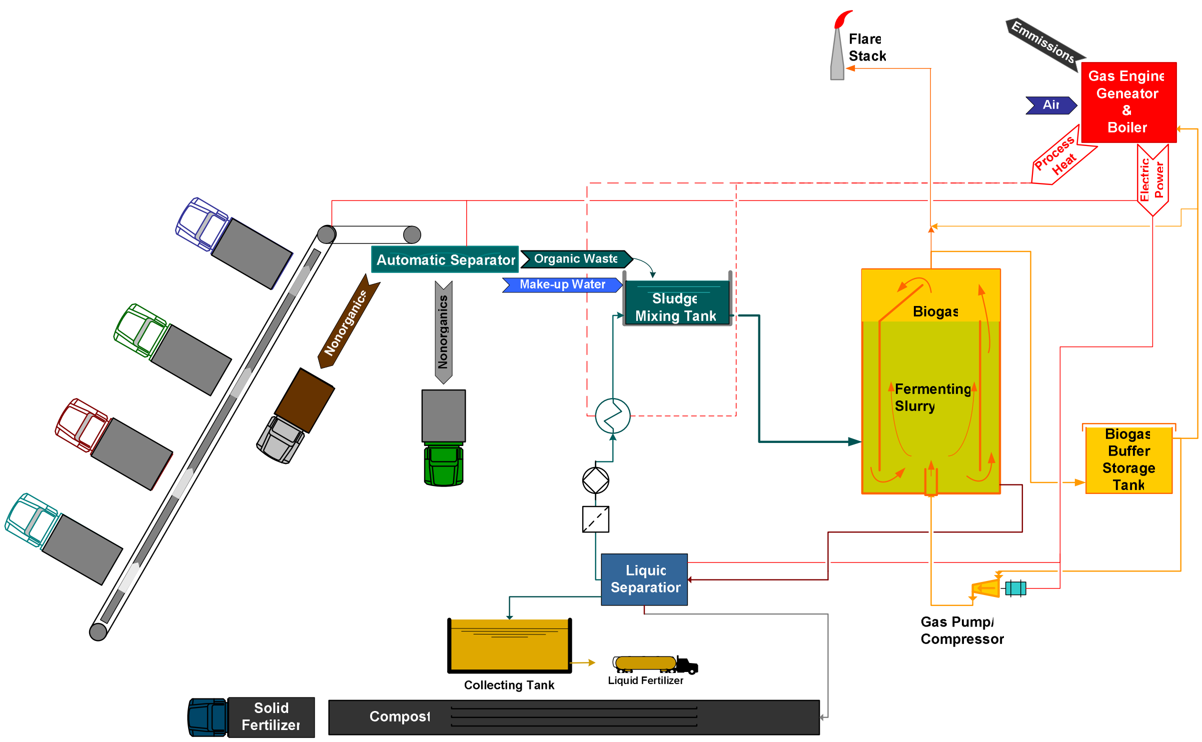


FIGURE 5
SIMPLIFIED SCHEMATIC OF PROPOSED VALORGA AD PLANT

The filter cake is transferred to composting area where it is subjected to curing for about two weeks. Stones and other inert materials are removed. The compost product is considered to be of high quality and is sold as soil conditioner.

The biogas produced is used to generate electricity is fed to the gas engine-generator. Valorga process is best suited for high solid concentration "semi-dry digestion," as sedimentation of heavy particles inside the digester will occur at TS content less than 20%.

FACILITY LAYOUT

Space limitation in Havana City is a crucial consideration. To minimize the Facility's footprint, the size of the digester and the overall the Facility's compactness carefully optimized. Draft Facility layout is shown in Figure 6.

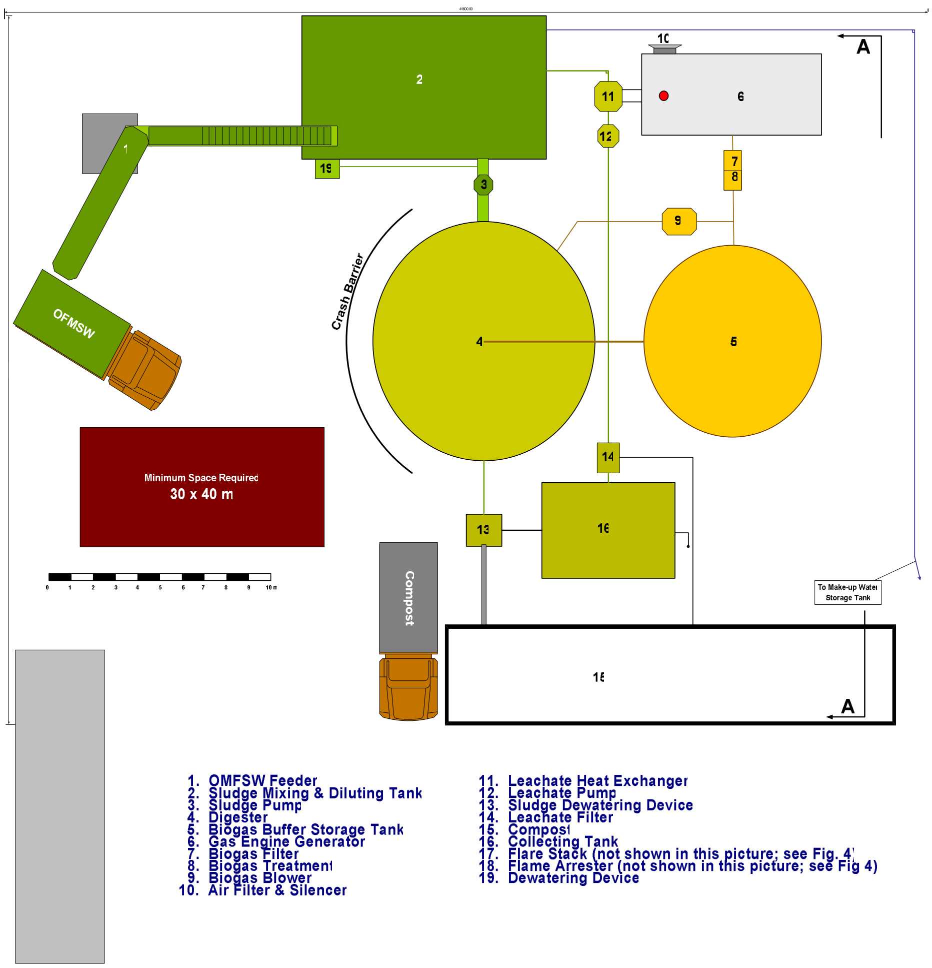
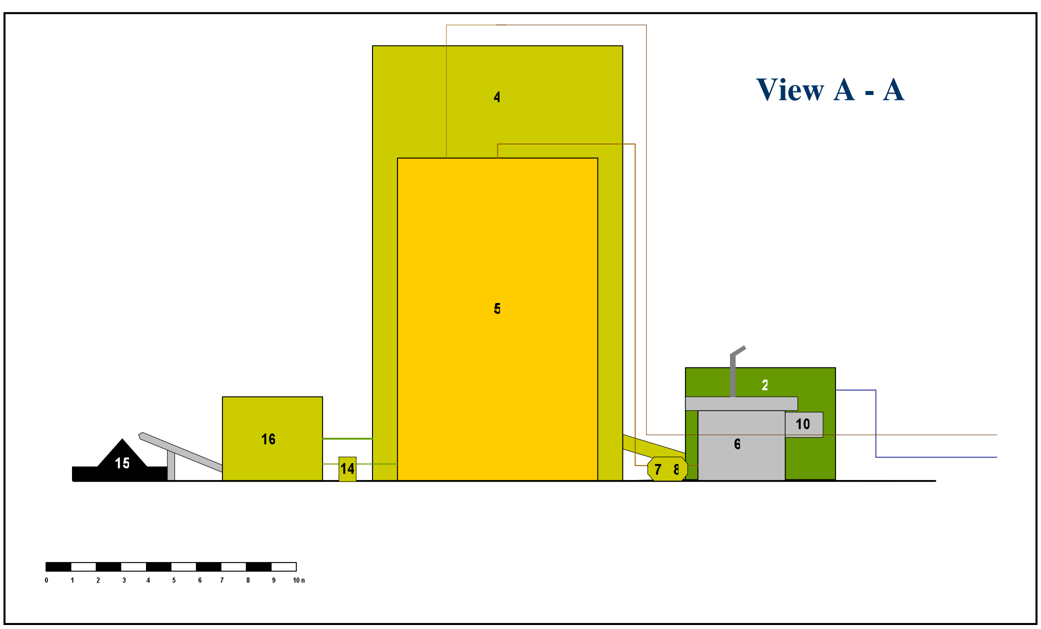


FIGURE 6
PROPOSED FACILITY LAYOUT



ENVIRONMENTAL CONSIDERATIONS

The strongest argument for adopting AD for OFMSW utilization is that it gives the responsible authorities of Havana City an opportunity to dispose produced MSW in environmentally friendly way, resulting in future landfills reduction and partial landfills elimination around the City, in other words: reduction of uncontrolled CH_4 emissions from such landfills.

Another very important environmental benefit includes improved quality of ground water.

FACILITY BASIC DESIGN

The overall AD process is being divided into four stages: <u>Pretreatment, Waste Digestion, Biogas Recovery and Residue Treatment</u>.

Waste pre-treatment is required for feedstock homogenization. The preprocessing involves separation of non-digestible materials and shredding. The separation ensures removal of undesirable or recyclable materials such as glass, metals, plastic, stones etc.

Preliminary Flow Diagram (PFD) is shown in Figure 7. The numbering in the following system description refers to the PFD numbering.

Shredded and sorted OFMSW (1) is forwarded to diluting (mixing & hydrolysing) inlet tank (2) where it mixes with make-up water and with sludge re-circulated from the digester (4). The make-up water is delivered from make-up water buffer storage tank (0).

To ensure proper mixing and dilution of solid particles, the OFMSW remains in this tank for around two to four days (or longer). $Ca(OH)_2$ or H_3PO_4 can be used as pre-treatment diluting agent.

For mixing and dilution in inlet tank, a varying range of water sources can be used such as clean water, sewage sludge, or re-circulated liquid from the digester effluent.

After mixing, dilution and settling-down the clean juice thick sludge, with a TS content of around 15-20%, is led to the digester (4). Depending on final inlet tank level, the juice from inlet tank will be pumped, using special heavy solids pump (3), or forwarded by gravity to the digester (4).

Sediments from inlet storage tank (2) are led to dewatering device (19) where they are separated from solids.

Part of heavy solids from dewatering device are forwarded to the composting area or landfill (z), smaller particles will be returned to the inlet tank (2). The juice from dewatering device will be forwarded to the digester (4).

Inside the digester, the feed is diluted to achieve desired solids content and remains in the digester for a designated retention time.

Biogas produced in digester is stored in the biogas buffer storage tank (5). The sludge from digester flows to the sludge dewatering device (13) where it is dewatered through gravity extraction and pressing.

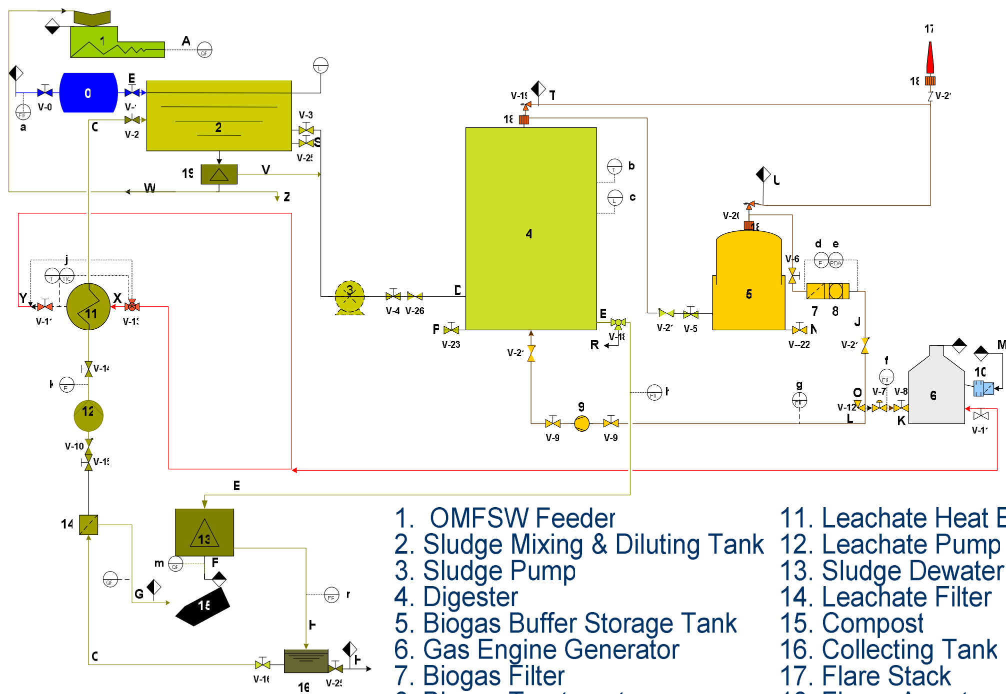


FIGURE 7
SIMPLIFIED PROCESS FLOW DIAGRAM

From there the liquid components are led to open collecting and settling tank (16). Solids, with TS content of about 45%, from the sludge dewatering device are forwarded to the composting area (15) for final aerobic curing and stabilization, which takes around 15-20 days. The clean leachate, liquid sludge, from outlet collecting tank (16) is pumped, using leachate pump (12), via leachate filter (14) and leachate pre-heater (11) to the inlet mixing tank (2).

A heat exchanger (11) is required to maintain temperature in the digesting vessel. In case of residue treatment, the effluent from the digester is dewatered, and the liquid recycled for use in the dilution of incoming feed. The biosolids are aerobically cured to obtain a compost product. Also the sediments from outlet collecting tank (16) will be used for composting.

The biogas from storage buffer tank, after drying (7) and cleaning (8) is fuelling the gas engine (6) that is powering electrical generator to produce electricity (± 37% from biogas fuel energy) and usable waste heat energy (± 48% from biogas fuel energy). The generator shall supply power to the Project infrastructure (facility itself, composting area and related offices and other infrastructure).

Part of the biogas is forwarded to pneumatic pump (9) that injects the biogas under slight overpressure to the digester (4) to ensure proper digestate mixing and fermentation.

Part of waste heat energy from biogas engine is utilized for digester heating (11). In this way, the engine cooling water is re-circulated through water/water heat exchanger that is providing the required heat energy.

During any malfunction of the system or in case of system overpressure the excess biogas will be released via safety relieve valves (V19&20) and flame arrester (18) to the flare stack (17).

MAJOR EQUIPMENT AND COMPONENTS

- OFMSW Siever & Feeder

  Around 20 ton (23 m^3) of prepared (crushed / shredded) OFMSW must be daily unloaded from garbage trucks sieved and forwarded to sludge inlet mixing and diluting collecting tank.

- Inlet and Outlet tank

  Both are open roof, tanks made of reinforced cement concrete or steel with foundations and columns according to soil structure.

- Anaerobic Digester

  The digester, a single stage reactor, is a vertical reinforced concrete or corrosion protected steel cylinder of about 15 m height and 10 meters internal diameter. This geometry ensures around 19 day's residence time in the digester's fermentation chamber.

  It is designed so as to maintain plug flow through the digester. The digester is equipped with a vertical partition in the center that extends over 2/3 of the diameter and over the full height.

  Mixing of the fermenting material is provided by a pneumatic system i.e. biogas at higher pressure is injected through orifices at the bottom of the digester and the energy of the rising bubbles serves to mix the sludge.

  The purpose of mixing in a digester is to blend the fresh material with digestate containing microbes. Furthermore, mixing prevents scum formation and avoids temperature gradients within the digester.

- Biogas Storage Tank

  This is a cylindrical, floating roof tank made of corrosion protected steel or reinforced, gas tight, concrete with foundations and columns according to soil structure.

  In order to prevent mixing air with biogas (explosion danger) the storage tank including also floating roof is be over-pressurized and absolutely airtight.

  Gas piping and pressure relief valves include flame arresters.

- Biogas Purifying

  Biogas filter / separator (incl. condensate and sediment trap) is capable to handle the total biogas flow from the digester. It is designed for moisture and coarse particulate matter removal as well as for fine mechanical filtration.

Depending on hydrogen sulfide content in biogas, a purifier may be necessary for removal of the H_2S from the gas stream. Biogas purifying system is installed immediately downstream of the digester, after the condensate and sediment trap or condensate accumulator.

- Biogas Engine Generator

  Spark ignited biogas engine capable driving electric generator at continuous ISO base load power output of $150kW_{el}$ will utilize produced biogas for electrical power generation (50 kW_{el} for internal system supply and 100 kW_{el} for export). Additionally the waste heat energy from the engine, cooling water and exhaust gas system heat, will be utilized for digester heating.

- Leachate Preheater

  The stainless steel plate heat exchanger shall heat the digestate (leachate) from digester process temperature to approximately 35ºC. This pre-heating shall cover the heat losses in the inlet mixing tank during the period required for diluting OFMSW.

- Leachate Recirculation Pump

  One double diaphragm pump with polypropylene casing and thermoplastic diaphragms will be used to pump leachate from the digester to the sludge inlet tank.

- Leachate Dewatering Device

  After leaving the digester, the leachate (digestate) will be dewatered in a dewatering device, which will reduce solid to a liquid content of about 50%. Dewatering by pressing is preferable and recommendable option.

- Leachate Filter

  To protect the digestate recirculation pump from extensive tear-wear a stainless steel mesh (filter) will be provided.

- Safety Systems

  To ensure safe operation of the Facility and the following safety equipment will be required:

  - Biogas detection and alarm system;
  - CO_2 system within engine-generator enclosure;
  - Portable extinguishers located through the Facility hazardous areas;
  - Self ignition biogas flare stack with associated piping, fittings and valves;
  - Biogas safety relief valves and flame arresters.

- Electrical Systems

  Electrical system will mainly consists of 415-220 V, AC, 60Hz power distribution system and system related auxiliaries.

- Control & Instrumentation Systems

  All C&I systems necessary for reliable, safe and efficient operation are provided which also includes automatic digester temperature control linked to switch on/off of digester preheating system.

SAFETY ASPECTS

It is important to highlight major safety aspects which have to be considered during design, construction, commissioning and operation of the Facility.

Certain precautions should be observed in the operation of biogas systems. Biogas can be explosive when mixed with air in the proportion of one part biogas to around 10 parts air in an enclosed space.

This situation can occur when a digester and or biogas storage tank is opened for cleaning or repair. In such cases sparks and open flames must be avoided.

Negative pressure in a biogas system shall not be allowed during operation.

Negative pressure occurs when the force created by the weight of the gases outside the biogas system is greater than the force inside the system. During normal operation the pressure inside the system must be always higher than the ambient pressure.

Negative pressure will pull air into the biogas system and the mixture of biogas and air may explode. Additionally, the oxygen in the system affect biogas bacteria and the biogas production rate will drop.

FACILITY PERFORMANCE

Figure 8 shows process medium flow diagram. The Facility is fed with 34.2 tons of MSW per each day. 40% from total MSW delivered to the plant is separated at Facility site and dispatched for recycling, landfill or other use.

Remaining 60%, 20.5tons/day (the biodegradable OFMSW fraction), is used for AD process.

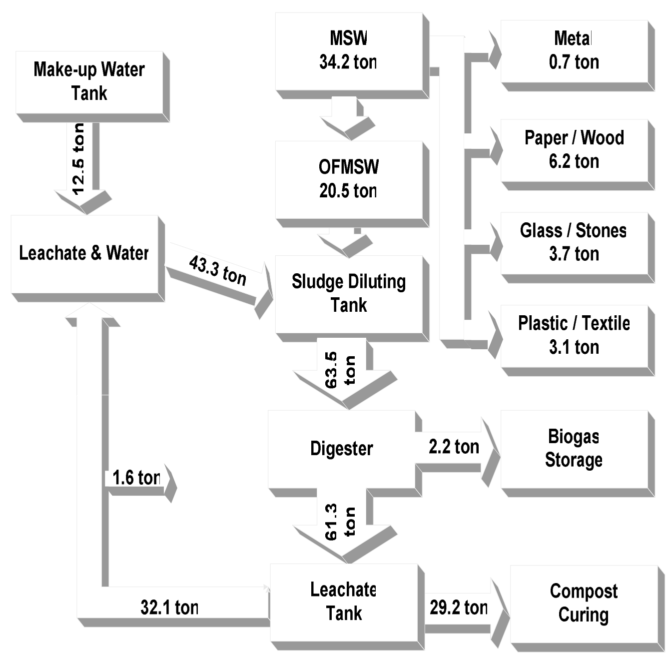


FIGURE 8
PROCESS MEDIUM FLOW DIAGRAM

The Facility was designed for biogas production sufficient for supply 150kW gas engine-generator. Out of 150 kW_{el}, 50 kW_{el} are necessary to feed system auxiliaries (mainly pumps) and 100 kW_{el} for export to adjustment workshops.

SUMMARY & CONCLUSIONS

MSW generated in Havana City and accumulated at City's landfills has the potential to cause significant pollution through atmospheric CH_4 and polluted ground-water.

Initiated by recent fire incidents at miscellaneous landfills in Havana City areas (spontaneous self-ignition of CH_4 during dry season) followed by heavy air pollution in neighborhoods the Cuban Government declared projects of this type as high priority projects.

In Europe, the advances of AD technology have been supported by legislation. Most of the European countries are aiming to limit MSW disposal to landfills to no more than 5% of the collected material and governments in several countries have increased taxes on land-filling. This will ensure that the MSW is properly treated for recyclable, combustibles and organics rather than being buried in the ground.

The 15% renewable energy by 2010 target some other European countries allow AD facilities to sell biogas for electricity generation at a premium.

Similarly, in the United Kingdom, under the Non- Fossil Fuel Obligation (NFFO) act, electricity is sold at a premium from AD system. AD can provide a range of benefits in addition to the valuable renewable energy from the biogas, such as: waste treatment, reducing environmental pollution through MSW as well as recycling of nutrients back to the soil resulting in improved soil quality.

Production and utilization of biogas have both direct and indirect economic benefits and social benefits.

- AD of OFMSW improves landfill gas related problems at landfills such as odours and migration of explosive vapours into the soil surrounding the landfill.
- The benefits of biogas fuelled electricity generation are multi-faceted. Potential landfill related emissions to air are reduced and green power is generated, off-setting the need to consume fossil fuels to provide an equivalent amount of energy.
- Combustion of CH_4 contained in biogas contributes to significant reductions of GHGs emissions.
- Creation of green energy from biogas makes good use of a MWS that would otherwise be dumped at landfill.
- Generation of electricity provides consumers with a source of environmentally friendly green power.
- Ad Facility operator's revenue may be generated from MSW management fees, sale of electricity and sales of compost material.

The calculated environmental performance of the Pilot Project Facility indicates that annually 280 thousands Nm^3 of CH_4 can be recovered and used for electricity generation. This corresponds to 150 tons of carbon in the form of CH_4.

Considering that one ton of carbon as CH_4 is equivalent to 21 tons of carbon as CO_2 the Facility's operation avoids landfill emissions of about 3'150 tons of carbon equivalent.

There is only one planet names EARTH in the Universe.

This is a place where we are living and where the following generations supposed to live, there is no escape if we irreversibly damage it.

Transition of MSW energy is one of the most important steps to preserve life on our precious blue planet EARTH.