

La Producción de Biogas con Vinaza una Alternativa Factible para Contribuir al Desarrollo de la Bioenergía

(Caso estudiado: Destilería de Servicios Manufactureros, S.A.)

Presentación

La imperante necesidad de encontrar combustibles alternativos para sustituir parcial o totalmente el uso de combustibles fósiles, y contribuir así al desarrollo de la bioenergía, sirvió de base para que un grupo de emprendedores empresarios tomaran la decisión de aprovechar la vinaza producida en la destilería Servicios Manufactureros, S.A. Esta destilería opera dentro del complejo industrial que se ha desarrollado a inmediaciones del ingenio Magdalena, en jurisdicción del municipio de La Democracia, Departamento de Escuintla.

Para la concepción del proyecto en referencia se utilizó tecnología de origen hindú, aportada por la empresa UEM, Inc. El diseño y cálculo de la ingeniería del proyecto estuvo a cargo del Ingeniero Hemang Shah, vicepresidente de la empresa.

UEM ha diseñado, instalado y puesto en marcha muchas plantas de tratamiento anaeróbico para destilerías en diferentes partes del mundo, utilizando aguas de desecho. Estas plantas operan exitosamente y garantizan niveles de reducción en la concentración de la demanda bioquímica de oxígeno del orden del 90% y, entre 65% y 67%, de la demanda química de oxígeno. Además, están produciendo un volumen importante de biogás para utilizarlo en calderas de destilerías, con lo cual se han generado ahorros muy importantes en consumos de combustibles fósiles, en beneficio de un retorno más rápido de la inversión.

Descripción General del Proyecto

Servicios Manufactureros, S.A., tiene capacidad para producir un total de 120,000 litros diarios de alcohol, fermentando para tal fin melazas de la caña de azúcar. Como resultado de este proceso industrial se generan residuos líquidos conocidos como vinazas.

La vinaza es fundamental para la producción de bioenergía, pues constituye la materia prima empleada en la producción de biogás. En las características generales de este compuesto destaca que es baja en pH, alta en temperatura, alta en demanda biológica de oxígeno (DBO), alta en demanda química de oxígeno (DQO) y posee importantes contenidos de nutrientes.

Para el aprovechamiento del potencial presente en sus características físico – químicas, la vinaza se somete a un proceso de digestión anaeróbica a través del cual se logra captar el metano. Luego de captarlo en cámaras especialmente

Biogas Production with Vinasse, a Feasible Alternative to Contribute to the Development of Bioenergy

(Case of study: Distillery at Servicios Manufactureros S.A.)

Presentation

The prevailing need of finding alternative fuels to partially or completely substitute the use of fossil fuels and thus, contribute to the development of bioenergy, has been the base for a group of entrepreneurs to make the decision of taking advantage of the vinasse produced in the distillery of Servicios Manufactureros S.A. This distillery operates inside the manufacturing complex that has developed inside Magdalena sugarmill, located in La Democracia, Escuintla, Guatemala.

In its conception, the project used Hindu technology, provided by UEM, Inc. The design and calculations of all the engineering in the project was under the responsibility of engineer Hemang Shah, vice president of the company.

UEM has designed, installed and set off many anaerobic-treatment plants for distilleries worldwide using waste waters. These plants operate successfully and guarantee a reduction of 90% of the concentration of biochemical demand of oxygen, and 65-67% of reduction in the chemical demand of oxygen. In addition, such plants produce an important volume of biogas to be used in distillery boilers, which has represented significant savings in fossil fuel consumption, representing an earlier return of investment.

General Description of the Project

Servicios Manufactureros S.A. has a production capacity of 120,000 liters of alcohol per day, through the fermentation of sugarcane molasses. The result of this manufacturing process is a liquid residue known as vinasse.

Vinasse is critical for the production of bioenergy, as it constitutes the raw material for the production of biogas. Outstanding general characteristics of this compound are low pH, high temperature, high biochemical oxygen demand (BOD), high chemical oxygen demand (COD) and contains a significant amount of nutrients.

To use the potential of its physical and chemical characteristics, vinasse is submitted to an anaerobic digestion process, through which methane is captured into chambers especially adapted to biodigesters. After this, it is conducted to the manufacturing plant, where it is used as fuel to feed the boilers that make up the steam production system. This way the renewable energy or bioenergy required to operate the manufacturing plant is generated.

Biogas will be destined to substitute up to 92% of fossil fuel, and it is expected to substitute at least 85% of C bunker

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fuel used in the production of industrial alcohol at Servicios Manufactureros. These important fuel substitutions will bring beneficial environmental impacts, compared to those caused with the exclusive use of fossil fuels. There will be financial savings, as well as in foreign currency exchange, for not being completely dependent on the purchase of petroleum derivatives to guarantee the industrial production.

It is necessary to emphasize that highly significant benefits will be obtained with the capture and use of methane, due to the reduction of the amount of a greenhouse gas that has the capacity to accumulate approximately 23 times more heat than carbon dioxide, which in general terms causes approximately 12% of global climate change.

Technical bases of the process for biogas production and vinasse treatment

The project consists of an anaerobic digestion plant to generate biogas. This plant takes as raw material the vinasse produced at Servicios Manufactureros S.A., which is placed into open tanks to be cooled down. Vinasse then undergoes an anaerobic process that uses the high organic charges of the chemical oxygen demand present in waste, producing high amounts of methane-rich biogas.

Other compounds present in vinasse, such as nitrogen, phosphorous and potassium do not suffer any changes during the anaerobic digestion process to produce biogas, therefore, treated vinasse continues to be valuable and it is pumped through fertirrigation to sugarcane fields in order to use the nutrients still present, which enhances conditions in sandy areas and nutrient-poor soils.

Benefits obtained with the anaerobic digestion principal are the following: Vinasse is first treated anaerobically, generating biogas (rich in methane), which is used to generate renewable energy. The biogas obtained is transported to distillery boilers at Servicios Manufactureros S.A. to substitute an important amount of fossil fuels (C bunker fuel).

During the process of biogas generation, vinasse suffers transformations on physical and chemical characteristics, such as: a) reduction of 67% in chemical oxygen demand; b) an approximate reduction of 90% of biochemical oxygen demand; and c) up to 80% reduction of dissolved solids. With the reduction levels mentioned, the final effluent exits the process with a substantially lower organic charge, compared to its charge when it enters the plant.

Treated vinasse present in the final effluent has a neuter pH, meaning that no harm is foreseen to any material that comes into contact with it, especially pumping equipment and pipes used in the transport to its final destination.

Characteristics of raw material for the design of the treatment plant

Vinasse general characteristics considered for the design of the treatment plant are the following:

Alcohol production:	120,000 l/day
Design discharge:	1,440 m ³ /day
Minimum discharge:	1,250 m ³ /day
Estimated BOD:	42,300 – 57,000 mg/l
Estimated COD:	91,800 - 111,250 mg/l
pH:	4.5 - 5.1
Temperature:	85°C

Charge for the waste-water treatment plant

BOD (kg/day):	67,473 (based on an average BOD of 46,856 mg/l)
COD (kg/day):	141,025 kg/day (based on an average COD of 97,934 mg/l)

Stages in the process

The biogas generation process can be summarized in the following three stages:

1. Cooling/settlement

Hot vinasse produced at the distillery of Servicios Manufactureros S.A. flows by gravity towards cooling tanks, where settlement takes place. These tanks are open and are approximately 1.5m deep. Here vinasse loses temperature through atmospheric cooling. From the cooling tanks vinasse is pumped with stainless steel equipment into four anaerobic digesters.

2. Digestion in four anaerobic digesters

Anaerobic digesters have floating roofs and the distribution head covers the total width of the reactor. The mud recirculates from the bottom of the reactor towards the distribution head to be mixed with entering waste waters. The treated waste waters are removed from the reactor by a valve that separates solids, liquids and gases.

The digester system operates in a temperature range of 30 to 40°C. They are covered with a floating membrane and the biogas is collected through a biogas collection system installed under each membrane. Raw waste is fed by the head system of the treated waters obtained from the solid-liquid-gas separator. Recirculation and mud extraction system is used to provide an improved contact of the biomass substrate and to eliminate mud excess.

The vinasse from the anaerobic digester recirculates to help control temperature and alkalinity, such that homogeneous conditions are provided to biological aerobic activities.

3. Biogas pressurization, transport to boilers through pipes and safety flare-system

Biogas is separated through a blower system that applies a slight negative pressure under the floating roof for the biogas to be discharged by pressure and subsequently placed into the boilers to produce steam. If biogas is not being used in the boilers, it can also be burned by the safety flare system, which reduces the risk of escapes, explosions and fires, and enables an effective security system.

Most parts of the burner that keep direct contact with the biogas are made of ordinary stainless steel (SS 304) to protect

them from corrosion and guarantee its durability. The rest of the material is steel carbon painted with epoxy to protect it and to make it last longer. The biogas burner is designed with a capacity to manage 50,000-65,000 m³/day and it could exceed its capacity up to 10%.

System pipes to conduct biogas to the burner itself has a variable diameter of 6-12", where it is possible to manage the minimum, average and maximum flow of the biogas generated by the plant.

The process does not need a separate tank to store the excess of biogas produced, since it can be stored under the roof cover. Nevertheless, if the content exceeds the storing capacity, the gas must be burned at the flare installed for such matter.

The entrance head system in the digester is incorporated for the good contact of the substrate with controlled sedimentation of the biomass towards the flow at the lower part of the digester. Biomass and vinasse recirculate to maximize biomass retention and alkalinity. Such recirculation is performed to improve operation and stability. In addition, each digester has low-speed submersible mixers in order to smoothly mix biomass with substrate.

Mud recycling system also has positive effects on waste mud management. However, this operation is seldom performed in the process of biogas production, since the anaerobic digester designed by UEM provides long solid retention times, which guarantees low levels of excess mud that would require handling and final disposal. The great volume of the reactor, along with the great mud mass helps in the management of casual waste effluents with heterogeneous characteristics.

Based on a period of 90 days, anaerobic digester treatment provides the following elimination efficiencies, considering an average discharge and average vinasse characteristics:

Parameter	% Removal
Biochemical Oxygen Demand	90%(average) range of 86% to 92%
Chemical Oxygen Demand	67%(average) range of 64% to 69%

Anaerobically treated vinasse then undergoes an airing process to achieve sulphide oxidation/reduction. For this to occur, retention of 24 hours after anaerobic treatment is necessary. Retention takes place in an open tank, equipped with diffusers that provide airing by means of compressed air. Two blowers or ventilators feed the air into the tank. The operation

included in the process aims at oxidizing sulphides present in waste waters so that they can be precipitated, and the odors caused by the action of hydrogen sulphide (H₂S) are eliminated.

Equipment lifespan proposed by UEM can overcome 15 years if the operation and maintenance are based on the procedures described in the manual.

Performance levels of the project

According to the design of Eng. Hemang Shah, UEM, Inc. Vice president, performance levels of the vinasse treatment system, on which future evaluations must be based are:

PARAMETERS	ENTRANCE	OUTPUT
Biochemical Oxygen Demand (mg/l)	42,300 – 57,000	4,230 – 5,700
Chemical Oxygen Demand (mg/l)	91,800 – 111,250	30,294 – 36,712
Biogás generation	<p>0.53 Nm³ of biogas per kilogram of destroyed COD with 55% of methane content.</p> <p>At 1,440 m³/day and 111,250 mg/l COD: Expected amount of biogas is 56,887 m³/day (based on a COD charge of 160,200 kg/day and a 67% of reduction in COD) with a methane content of 55%</p> <p>At 1,440 m³/day and 91,800 mg/l of COD: Expected amount of biogas is 46,941 m³/day</p> <p>At 1,440 m³/day and 97,934 mg/l of COD: Expected amount of biogas is 50,078 m³/day</p>	

Other characteristics of the project

Estimated labor for the construction stage was 50 persons, distributed as follows: two professionals, eight persons for qualified labor, and 40 persons for unqualified labor. Estimated labor for operation and maintenance stage is six persons with one plant manager and five operators.

General considerations for risk management

The risk management approach was a part of the proposal for the Environmental Impact Evaluation Study, especially because it was about a project without antecedents in Guatemala and, at the same time, it could be used by the project promoters as a basis that would allow them to react in case of fire, spills, escapes, for storage, and for the protection of the staff, natural environment and the industrial complex itself.

- In the project under study methane will not be under pressure and, in case of escapes, the concentration would not be excessive, so under these circumstances risk is not significant.
- Methane is considered as an extremely inflammable compressed gas. At high concentrations it can cause asphyxia

with consciousness or mobility loss in cases of extreme intoxication. At low concentrations methane can cause doping effects and the symptoms are dizziness, headaches, nausea and temporary loss of motor coordination skills.

- In case of fire, methane can produce dangerous smokes and the fire can start far from the point of escape. Being exposed to fire, methane containers can break or explode. In cases of incomplete combustion carbon monoxide can be formed.
- In special cases when methane needs to be stored, it must be kept in a fresh and dry place, separated from oxidizing gases or materials, since it reacts violently with oxidizing materials. Methane must be kept away from ignition sources, including static discharge.
- It is important to purge air from the conduction system before introducing biogas, and it must be considered in the operation of the plant. Personnel must wear at least: gloves, goggles, mask and clothing that avoid contact with the skin.
- Methane can form explosive mixtures with air and must be kept in mind that the known range of inflammability goes from 5 to 15% (% of air volume). The temperature of auto-inflammation in experiments is 595°C.
- Only the burner in the flame arrester system must be used to eliminate excess of biogas.
- In case of fire the affected area must be evacuated and every known extinguisher can be used to smother fire. An escape must not be extinguished if it is not absolutely necessary, since it can produce an explosive spontaneous re-ignition and the effects can reach significant levels of adverse impact.
- After a fire has taken place, the affected area must be ventilated, the sources of ignition must be eliminated and if there are persons affected in confined places, an autonomous respirator should be used.

Final comment

The project under study was considered environmentally viable by the Ministry of Environment and Natural Resources, according to Resolution No. 1163-2007/JAFT/KC, as the main adverse impacts were identified and the proper mitigation measures were proposed. It is important to highlight that the project represents an interesting and important contribution in the reduction of greenhouse gases, for the methane capture and its consequent reduction into a gaseous fuel that allows the generation of bioenergy.

The project offers great opportunities in the frame of mitigation measures for the effects of climate change. It, in its first stages, even though the optimum levels of operation and stabilization have not been reached now, provide 65-70% of the expected amount of biogas. Initial results predict a promising future and open doors for this model to be applied in future similar projects.

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Source of Information

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