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Economic Analysis of the Nisargruna Based Bio-Methanation Plant

Aftab Anjum, Mohit Gupta** and Aadish Jain****

ABSTRACT

In the present paper economic as well as technological aspects of the biomethanation plant has been studied. Nisargruna technology converts almost any type of organic solid waste to bio methane as compared to the conventional cowdung/ animal faeces based biogas plants. The reduction in the size of the plant has attracted many institutions to erect it in a rather confined space with less setup time and reduced waste processing period along with enhanced output, this has greatly reduced the gestation period. A Nisargruna based plant has been installed at Delhi Technological University which handles 500 kg of organic solid waste per day aimed to supply the biogas to the university's canteen. About 60-65% biogas along with high quality manure which is completely organic in nature can be obtained from the plant. It can be inferred from the economical aspects that the plant has a gestation period between 2-3 years.

Keywords: *Economic Analysis; Performance; Bio-methanation of Organic Solid Waste; Green House Gas; Liquified Petroleum Gas.*

1.0 Introduction

Bio-methanation can also be considered as new conventional source of energy. According Mohit and Aadish Bio-methanation is a sustainable solution for the problem of solid-waste management in metro cities such as Delhi on the basis of their study [9]. A Sensible renewable technology must be simple to understand, reliable in functioning and economical in production. Along with these properties if it helps in addressing some major problems of the urban areas of developing world then the technology becomes lucrative and can be more easily accepted. [1] The search for promising and renewable sources of carbohydrates for the production of bio-fuels and other biorenewables has been stimulated by an increase in global energy demand in the face of growing concern over greenhouse gas emissions, solid waste management and fuel security. In particular, interest has focused on lingocellulosic biomass as a potential source of abundant and sustainable feedstock for bio-refineries. Further, Solid waste management for the same biomass is a serious problem in the urban areas of a fast developing nation like India. With the rapid increase in urban population the problem is becoming more severe with every passing day. However the solution to the problem on the same scale is still at large.

It is believed that substituting various bio-fuels for fossil based fuels will reduce production of greenhouse gases as bio-fuels sequester carbon through the growth of the feedstock. The studies supporting this belief may have omitted the amount of carbon emissions that occur as farmers worldwide change cropland to replace the grain and divert to bio-fuels(estimate emissions from land-use change pattern)various studies found that corn-based ethanol, instead of producing a 20% savings, nearly doubles greenhouse emissions over 30 years and increases greenhouse gases for 167 years. Bio-fuels from switchgrass, if grown on U.S. corn lands, increase emissions by 50%. This result raises concerns about large biofuel mandates and highlights the value of using waste products. [5]

Converting forests, peat lands or grasslands to produce food crop–based bio-fuels creates a “bio-fuel carbon debt” by releasing 17 to 420times more CO2 than the annual greenhouse gas (GHG) reductions that these bio-fuels would provide by displacing fossil fuels. Whereas, bio-fuels derived from waste

**Corresponding Author: Department of Mechanical Engineering, Delhi Technological University, Delhi, India*
(E-mail: aftabanjum915@gmail.com)
***Department of Mechanical Engineering, Delhi Technological University, Delhi, India*
****Department of Mechanical Engineering, Delhi Technological University, Delhi, India*

biomass incur little or no carbon debt and can offer immediate and sustained GHG advantages. [4]

Biomass such as cattle dung, agriculture wastes and other organic wastes provide a vast scope to convert these sources into biogas. Biogas production is a clean low carbon chain technology which converts fermentable organic wastes into cheap, versatile as well as clean fuel and organic soil conditioner. Biogas produced by anaerobic digestion of mentioned organic matters and biomass wastes can be used as an energy source for various applications such as cooking, heating, space cooling/ refrigeration, electricity generation and gaseous fuel for vehicular application. [6]

India is implementing one of the World's largest programme in renewable energy. The country ranks second in biogas utilization. Unlike Solar energy Biogas can be generated and supplied round the clock and is immune to the problem of intermittent availability if planned adequately. Biogas plants provide one solution for concerns such as fuel, organic soil conditioner and waste management.

Bio-methanation process of converting waste biomass into gaseous fuel is superior and a sustainable process in comparison to general practice of burning waste which produces pollutant, ash and hence needs to be preferred for such biomass materials that can be processed in biogas plants.

Vipul and Shivangi of Delhi Technological University [7] have already conducted a study for feasibility of a Biogas plant in Campus and proposed 3 digesters of 1000 liters each to cater to the food waste at the campus. They suggested digesters to be placed near kitchen as food waste can be directly used as feedstock and calculated a potential of 650 lit of biogas daily in 1000 lit reactor, under ideal conditions [7] (like maintaining pH, VFA, Alkalinity, etc.) and also concluded that biogas from food waste can save at least 50 % of the LPG (9-10 cylinders/day) gas consumption of the campus and also provide substantial amount of manure for gardening purposes in the campus.

2.0 Functional Principal

A Biogas plant based on this NISARGRUNA technology digest all kinds of organic solid wastes comprises mainly of long organic polymer chains such as carbohydrates, fats and proteins in presence of Biocatalysts while undergoing processes like Hydrolysis, Methanogenesis and Aerobic enrichment to give out Methane and carbon di oxide.

3.0 Description

The whole process of converting biomass to biogas is through 5 steps namely

1. Hydrolysis
2. Acidogenesis
3. Acetogenesis
4. Methanogenesisand
5. Aerobic Enrichment

1 **Hydrolysis:** As we feed the digester at first the mass has to go through hydrolysis. During this process long organic polymer chains breaks down to smaller parts such as simple Sugars, Amino and fatty acids. Molecules such as volatile fatty acid are first catabolized to smaller compounds.

2 **Acidogenesis:** Fermentation of the remaining components by Fermentative Acidogenic Bacteria

occurs and fatty acids, ammonia and carbon di oxide are produced along with some other by-products. This biological breakdown towards smaller chains is also known as Acidogenesis.

3 **Acetogenesis:** The third stage anaerobic digestion. Here simple molecules created through the Acidogenesis phase are further digested by acetogens to produce largely acetic acid as well as carbon dioxide and hydrogen.

4 **Methanogenesis:** The final stage is Methanogenesis, during this stage Methanogenic bacteria (methanogens) utilizes the products formed in the earlier stages to give Methane, Carbon di oxide and some water-vapour which is mainly the Bio Gas. These methanogens act between a certain range of pH only i.e. pH level should be maintained from 6.5 to 8 for the process to occur.

5 **Aerobic Enrichment:** The treated non-digestible overflow from this digester tank which is not digested by the bacteria is aerobically enriched and is converted to high quality manure.

The earlier Biogas plants conventionally used cow dung/ animal focus as primary or only fuel and required regular supply of feed stock and water for longer durations which made biogas plants unattractive for investment.

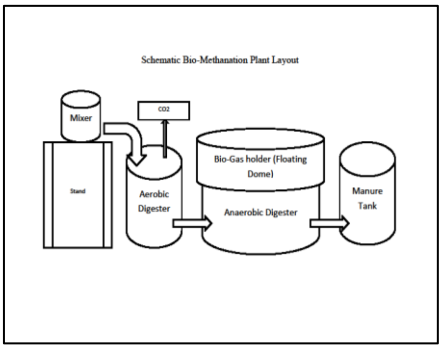
But recent developments and introduction of NISARGUNA, the plants can run on nearly all type of solid bio waste such as Kitchen waste, spoiled or leftover food, all kinds of bio oils, used cooking oil, extracted tea powder, used flowers or leaves, gardening waste etc.

and the whole process can be completed in time period of as low as 1 day for small scale plants.

With introduction of this technology minimum required size of the plant is greatly reduced.

This has given freedom of selection of size of the plant required and has also attracted many institutions to invest in biogas as size is the main economic factor for such kinds of plants.

Fig 1: Schematic Bio-Methanation Plant Layout



4.0 Some Important Components of the System

1 **Receiving / Sorting /Mixing platform:** Steel platform prefabricated & installed at some height. It holds mixer.

2 **Mixer:** Motor driven mixer is specially fabricated in M.S. and S.S. top for loading of waste and is connected to control panel with necessary electrical wiring and fixers

3 **Thermophilic Aerobic Bioreactor**: Digester with manholes , inlet and outlet holes working with compressor and solar water heater, constructed in mild steel with acid proof & rust proof two coats of red oxide and two coats of oil paint, connected to main digester with coated pipe (Total effective Capacity). Major amount of carbon-di-oxide is released in this tank. And the contents are tranfrered to Anaerobic Digestor.

4 **Anaerobic Bioreactor:** Has a dome on top for coaction of released methane gas, constructed in mild steel with acid proof & rust proof two coats of red oxide and two coats of oil paint coating, connected to slurry handling system with coated pipes. Accessories such as pressure control valves, partition walls along with methane recycling grids and various other smaller components with equal importance are also connected to this tank.

5 **Gas Holder:** Thick Mild Steel dome with necessary supports of angles and brackets surface finished with rust proofCoating & two coats of red oxide and two coats of oil paint and Gas outlet. 6. Water pump, Compressor, Air and Water Injection, non-return valves and fittings, Control panel, Gas meter, Gas measuring equipment, Dome Balance system for balancing dome are also part of the standard equipment.

5.0 Output of the Plant

Description	Quantity
Capacity of Digester	500 kg / Day
Biogas Produced	40-60 m^3 / Day
LPG Equivalent	18kg – 27kg /day
CO_2 Produced	50-60 m^3 / Day
Manure Produced	50 -75 kg / Day
Cylinders saved per day	1 to 1.5

Cost of each 19kg cylinder Cost of LPG/kg	Rs. 1500 /cylinder 1500/ 19 = Rs. 79/kg
Cost saved	79 x 18 x 300= Rs. 426600 /annum
Cost of Organic Manure Rs. 5/kg	Rs.250 –Rs. 375 /day
Annual income from manure	Rs. 75000–Rs. 112500
Total annual income	Rs. 506600
Annual maintenance cost	Rs. 120000
Net Annual Income	Rs. 386600
Project Cost	Rs. 1000000
Pay Back period	2-3 years

Above calculation are done with some basic assumptions which are generally valid such as:

- Standard LPG cylinder is taken 19kg for the cost of Rs. 1500/unit.
- Cost of organic manure is taken as Rs. 5/kg
- Average waste feed was around 400 kg to 500kg over the considered period
- 1m3 of biogas is taken equivalent to 0.45 kg of LPG[8]
- Cost of the plant does not include Land cost as that may vary from place to place.

Primary output is Bio gas (i.e. around 60-65% biogas 35-30% carbon di oxide along with some water vapors and H2S gas), can be directly used as cooking gas which burns with clear blue flame and gives out high energy. Although secondary but the digester waste or spent slurry is very good quality manure which is 100% organic in nature. This 100% organic manure has good concentration of stable carbon which will help soil in improving microbial activity, nitrogen fixation and water retention and soil fertility and can be used in gardens or potted plants.

6.0 Benefits from the Plant

1 100% recycling of organic / bio waste: with the freedom of putting any organic matter to the digester and get organic manure and high grade biogas and no other by product.

2 Treatment of waste locally at source reduces the load on Municipal corporations.

3 This type of system can be installed on individual or cooperative basis by hotels, chains

or restaurants, malls, group of small eateries in a region and can get cooking gas without having to worry about the waste disposal.

4 Reduced dependence on petroleum based resources.
5 Highly environment friendly as the waste will eventually degrade on landfill site and release the products to the environment and water may seep and pollute underground water is now being channelized to produce energy and other resources.
6. Reduction in Green House Gas emissions can help government to earn carbon credits.

7.0 Conclusion

It can be concluded from the analysis that nearly 1-1.5 LPG cylinders can be saved per day .With the economical perspective of the above study , the technology is highly advantageous for an individual ,commercial establishment such as restaurants, hotels, municipal departments as well as economy as a whole in Indian context.

NISARGRUNA biogas technology has accelerated the Bio-methanation process which has reduced the time taken for the biodegradation of the bio mass and could be a potentially a good solution for the problem of solid waste management.

Methane on one hand has high calorific value is also very lethal as Green House Gas (i.e. nearly 21 times more than CO2) which is generally released in the environment if waste goes to land filling sites along with carbon dioxide. The payback period is estimated to be only 2-3 years.

8.0 Future Scope

Being an agricultural economy, India generates large amount of biomass annually.

This certainly gives biogas an edge to become the fuel for the cause of economic growth and Energy Security. Technologies must be established for production, Bottling / storage, transporting of biogas in a decentralized manner.

With sustainable technologies in demand various solar thermal technologies provide clean energy but these technologies have an inherent problem of being intermittent and inconsistent in operation [10].

The various solar thermal technologies can be integrated with the biogas technology to overcome the problem.

Further, Biogas has nearly 65% of methane and enrichment processes can be applied to make it equivalent to Compressed Natural Gas (CNG) and the infrastructure for CNG is already well established and thus will not incur any new cost in this regard and Bio-methane could replace CNG as fuel for transportation etc.

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