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Biogas generation and Techno-Commercial analysis to provide Feasible Business Model

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Abstract: *Biogas being the most suitable form of renewable energy. It is most affordable as the capital investment required is less also per unit cost of production is less compared to other sources of energy. Biogas generation methods are discussed in the paper. Biogas is generated from different types of wastes. This paper proposes the sustainable business solution for usage of biogas as a fuel on large scale. Also provides detailed techno-commercial status to produce biogas from available waste and explores feasibility of implementation.*
Keyword: *Biogas energy,Techno-Commertial analysis,Business model*

I. Introduction

The rapidly increasing energy demands and exhausting stocks of fossil fuels have led to its shortage and rise in prices of conventional fuels. Also its burning has adverse effects on environment like the problems of Global Warming, Air pollution and emission of Greenhouse gases. Hence, it is necessary to have an alternative, affordable and clean source of energy which will be able to satisfy the increasing demands. Biogas is the most suitable form of renewable energy. It is most affordable as the capital investment required is less also per unit cost of production is less compared to other sources of energy Biogas is generated from different types of waste. Biomass is the only important source of energy in the developing Nations especially within the domestic sector, although some of local industries like brick firing, bakeries or steam production are also dependent on fuelwood [1].

II. Methods of Biogas Generation

From biomass biogas is produced, using anaerobic digestion (AD) process. Biogas is generated by the anaerobic decomposition of biomass and it comprises of 20–45% carbon dioxide, 50–70% methane, and traces of other gases like hydrogen sulphide [3]. It's clean but slow burning gas and having calorific value between 5000 to 5500 kcal/kg. Biomass is comprised of living matter on Earth. Biomass contains carbohydrates, proteins, fats, cellulose, and hemicellulose, which is used as feedstock for biogas production. Resources of biomass in India are crop residue, agro waste, municipal solid waste, and waste-water sludge from water treatment plants, animal manure and industrial waste [3]. Depending upon temperature they can be further divided as Thermophilic and Mesophilic Digestion.

1.1. MUNICIPAL SOLID WASTE

Municipal Solid Waste contains both inorganic and organic fractions. Organic fractions are digested According to census 2001 there are about 5000 towns and 593 districts in India. Out of total Indian population around 27.8% i.e. more than 1 billion lives in urban areas. 33.4% of the total will be the urban population by the year 2026[1]. The Fig.1 shows graph which indicates the land requirement will increase in future for disposal of solid waste. Hence, it has become necessary to utilize the municipal solid waste generated in every city

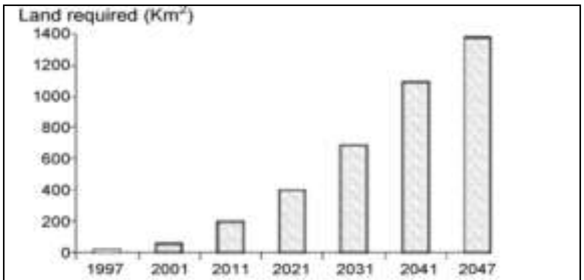

Fig. 1 Cumulative land required for land filing [1]

1.2. Waste water

The waste water generated from urban area is collected (on an average 80% of generated volume) through organized sewage collection system [3]. The obtained sewage is treated and obtained sludge from the treatment is then dried and used as manure. Biogas can be produced when wastewater sludge is anaerobically digested. In cities from south, north, western and eastern part of India 2911, 5578, 3469, 3434(Mld) wastewater is generated, out of which 1812, 3932, 2275, 2151(Mld) is collected respectively.

1.3. CROP RESIDUE AND AGRICULTURAL WASTE

In India for majority of people agriculture is the main source of livelihood. The quantity and quality of biomass produced from cultivation of different crops varies significantly. No specific crops are grown in India for anaerobic digestion for producing biogas. However, there is lot of biomass available in crop residue and agricultural waste which can be used for anaerobic digestion. The biogas potential for crop residue and agricultural waste is estimated as 45.8Mm^3/day [3]. In Maharashtra 52.7(tonnes) total crop residue is generated from various crops like wheat, rice, coarse cereal, pulse, oilseed, sugarcane, and cotton. Maximum of crop residue is generated in Uttar Pradesh i.e. 109.2 tonnes, whereas least is generated in Jammu & Kashmir i.e. 1.8tonnes [4].

1.4. ANIMAL MANURE

India has one of the largest bovine populations which are estimated to be 304 million in the world for the year 2018 including bullocks, cows, calves and buffaloes. Estimated population of total livestock for 2012 is 512.2 million. The amount of production of dung mainly depends upon animal population. Bovine population and Total livestock population has increased from 1951 to 2012 in India, indicating rise in the potential to produce biogas from animal dung [5].Biogas is largely produced from animal dung in rural areas of India. 32 Kg/day Cattle dung is required to produce 1 cu.m of biogas per day. While Pig manure and Poultry manure required is 20Kg/day & 12 Kg/day respectively [6].

1.5. SUGAR INDUSTRIES

In India, Sugarcane is one of the most popular crops having more than 5 million hectares of land under cultivation. More than 75000 kg/hectare is the average yield of sugarcane with the total production exceeding 360 million tonnes in 2017-2018[7]. Sugar industries generate pulp as a solid waste and alternative method wastes embrace effluent and press mud. The obtained wastewater can be used for anaerobic digestion and production of biogas. Table.1. gives typical characteristics of combined wastewater from a sugar industry. In Satara district, Maharashtra, India there is largest biogas plant which is established by Green Elephant. From 600 tons of sugarcane waste obtained from sugar mills in the vicinity 25,000 cubic meters of biogas is generated every day. Obtained gas is converted to compressed biogas (CBG) and used as fuel. An advanced Continuous Stirred Tank Reactor is used in this plant for faster anaerobic process [8].

Table 1 Characteristics of wastewater of sugar industry [3]

Parameter	Temperature(^{0}C)	pH	Total dissolved solids(mg/L)	Suspended solids(mg/L)	BOD(20^{0}C,5 Days) (mg/L)	COD(mg/L)	COD:BOD	Oil and Grease(mg/L)
Range	30-40	4.5-6	1000-1200	250-300	1250-2000	2000-3000	1.5-1.6	60-100

1.6. Kitchen Waste

Waste generated can be used to produce biogas. 200 cubic meters of biogas is produced every day from the waste obtained from canteen of Tata Consultancy Services [8].

Some other sources of biogas production are:

- Dairy Industries
- Pulp and Paper Industries
- Distillery
- Slaughter Houses
- Tannery

III. Technologies And Tools

The technology used for production of biogas is Anaerobic Digestion (AD).The most commonly used types of biogas plants are:

a) Fixed-Dome Plants

A fixed-dome plant consists of an indoor sterilizer with a hard and fast, non-movable gas area. Within the higher a part of the sterilizer gas is keep. The suspension is displaced into the compensating tank, once the assembly of gas commences. The quantity of the sterilizer mustn't exceed twenty m³ because the pressure level will increase with the quantity of gas storage. The pressure level is low, if there's very little gas within the holder. Fig.2 shows a fixed-dome biogas plant.

b) Floating-Drum Plants

Floating-drum plants consist of a digester and a moving gasholder. The gasholder floats either in its own water jacket or direct on the fermentation slurry. The gas is collected in the gas drum, which thereby rises. If gas is drawn off, it falls again. By using a guide frame tilting of gas drum is prevented.

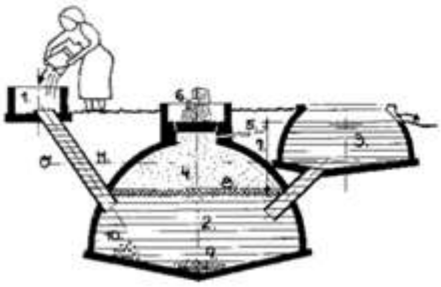

Fig. 2 Fixed dome type[9]

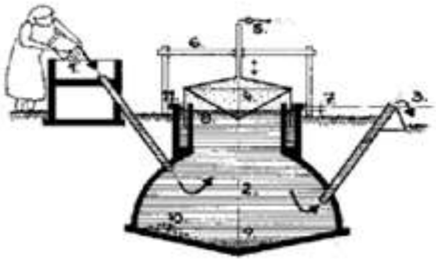

Fig. 2 Floating Drum type[9]

Opportunities for new technology development:

Digester technology can be implemented and integration of digestion with waste preprocessing and composting operations. Design of Creative digester and integration of unit operations to provide higher energy efficiencies and more capabilities to handle variable influent. Co-digestion of different wastes (e.g. food waste with sewage or manure)

Problems with solid waste:

Millions of tons of organic waste dumped in landfills every year result in harmful greenhouse gas (GHG) emissions • Mandates require businesses producing high volumes of organic waste to seek more property waste disposal solutions • Businesses have committed to property and area unit currently scrambling to follow through Wal-Mart: Zero waste by 2014; all suppliers should report waste and greenhouse gases. Campbell: new sustainability policy. Anaerobic digestion (AD) of organic solid waste has not been with success enforced within the U.S.A. up to now in industrial scale [11].

IV. Technical Analysis

Case study of a small scale biogas plant, set up for cooking purpose.

Figure 4 Biogas Plant

Figure 5 The outpur(slurry) of plant

Table 2 The Plant Specifications

Sr. No.	Parameter	Details
1.	Capacity	3 m^3
2.	Input of Plant	Animal Dung.
3.	Number of Animals	6 cattle (3 cows and 3 calves.)
4.	Cow dung and water (1:1.5) per day	120 kg
5.	Composition of gas	CH_4= 60-70%, CO_2=30-40% and traces of hydrogen sulphide.
6.	Density	About 1.15 kg/ m^3.
7.	Calorific value of Biogas	27.68 MJ/m^3.
8.	Number of people served by gas (Cooking and Heating purpose)	6
9.	Calorific value of LPG	46.1 MJ/m^3.
10.	Space Required	225m^2

V. Economic Analysis

Economic analysis of a small scale biogas plant is carried out in order to implement feasible business solution.

This plant was set up **15 years ago**.

- Cost of project = INR 20,000
- Sources to meet the cost of project:
  - -Own Capital = 10% of cost of project= INR 2,000
  - -Government Subsidy= 15% of cost of project= INR 3,000
  - -Bank Contribution (Loan) = INR 15,000
- Rate of interest on loan =_10% per annum

The family had requirement of 2 LPG cylinders one for cooking and another for heating before setting up the biogas plant.

Average cost of 1 LPG cylinder considering the subsidy on the cylinder in last 15 years= INR 300.

- Monthly requirement of LPG cylinders=2
- Yearly requirement of LPG cylinders=2 x 12=24
- Cost of 24 LPG cylinders=24 x 300= INR 7,200
- Money saved on LPG cylinders/year by setting up biogas plant= INR 7,200

Table 3 Bank Payback Schedule for the Biogas plant (Household Purpose)

BANK REPAYMENT SCHEDULE								
Year	Opening Balance (INR)	Amt. Received during year(INR)	Installment during a year(INR)	Closing Balance (INR)	Interest (INR)	Money Saved on LPG cylinders (INR)	Net amount saved (INR)	Profit(Savings) required to nullify the initial cost (INR)
I year	nil	15,000	3,000	15,000-3,000-3,000(Govt. subsidy)=9,000	1,500	7,200	7,200-1,500=5,700	20,000-5,700 =14,300
II year	9,000	nil	3,000	9,000-3,000 =6,000	900	7,200	7,200-900=6,300	14,300-6,300 =8,000
III year	6,000	nil	3,000	6,000-3,000 =3,000	600	7,200	7,200-600=6,600	8,000-6,600 =1,400
IV year	3,000	nil	3,000	3,000-3,000 =0	300	7,200	7,200-300=6,900	1,400-6,900 = -5,900

From the above table The Payback Period as 4 years (Round figure.)

The slurry produced from biogas plant is used as Manure for trees in the backyard

Additional value of fertilizer saved= INR 2500/ year

Based on the Economic Analysis of existing plant, business solution for a Hotel is as below:

LPG consumption of Hotel=15 commercial cylinders of 19 kg every month

- Cost of project = INR 3, 00,000
- Sources to meet the cost of project:
  - -Own Capital = 10% of cost of project= INR 30,000
  - -Government Subsidy= 15% of cost of project= INR 45,000
  - -Bank Contribution (Loan) = INR 2, 25,000
- Rate of interest on loan = 10% per annum

_Cost of 1commercial LPG cylinder considering the subsidy on the cylinder = INR 1,000.

- Monthly requirement of LPG cylinders=15
- Yearly requirement of LPG cylinders=12x15=180
- Cost of 24 LPG cylinders=180*1000=INR 1, 80,000

Hence, money saved on LPG cylinders/year by setting up biogas plant =INR 1, 80,000

From the below table ***The Payback Period is 4 years*** *(round figure)*
The slurry produced from Biogas plant is used as Manure for trees in backyard.
Additional value of fertilizer saved=INR 2500/ year

Table 4 Bank Payback Schedule for the Biogas plant (Household Purpose)

BANK REPAYMENT SCHEDULE								
Year	**Opening Balance (INR)**	**Amt. Received during year(INR)**	**Installment during a year(INR)**	**Closing Balance (INR)**	**Interest (INR)**	**Money Saved on LPG cylinders (INR)**	**Net amount saved (INR)**	**Profit(Savings) required to nullify the initial cost (INR)**
I year	nil	15,000	3,000	15,000-3,000-3,000(Govt. subsidy)=9,000	1,500	7,200	7,200-1,500=5,700	20,000-5,700 =14,300
II year	9,000	nil	3,000	9,000-3,000 =6,000	900	7,200	7,200-900=6,300	14,300-6,300 =8,000
III year	6,000	nil	3,000	6,000-3,000 =3,000	600	7,200	7,200-600=6,600	8,000-6,600 =1,400
IV year	3,000	nil	3,000	3,000-3,000 =0	300	7,200	7,200-300=6,900	1,400-6,900 = -5,900

VI. Cost Benefit Analysis

Specific answer to the economic feasibility of biogas production is not there. An important role is played by

National economic considerations. In India, transportation costs of coal and oil to the rural areas is high and an extra burden on an already poor farmer. 182.4 M tons coal, 31.64 M tons oil, 96.2 billion Kwh electricity, 335.61 M tons of firewood is the consumption of commercial and non-commercial energy for the whole of India, as determined for the period 1960 - 1971 by the Fuel Policy Committee Report, is provided [10].

VII. Conclusion

A household purpose biogas plant was analysed and was found to be technically and economically viable solution. Based on this analysis, economically feasible business solution for biogas setup for a hotel is given. The Payback Period is less than 4 years.

Conflict of interest The authors declare that there is no conflict of interests regarding the publication of this paper.

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