Planning and Design for Commercialization of Biogas Bottling Plant for Production of Green and Low-Cost Fuel with Utilization of Biomass Resources

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Abstract— Keeping in view the energy shortage in the country there is a need to tap biomass resources such as cattle dung, kitchen waste, agricultural waste etc. for generation of biogas through the involvement of entrepreneurs and industries to set up decentralized biogas based energy infrastructure in the country, at the potential sites where biomass available is plenty. Under technology demonstration of new RDD&D Policy of Ministry of New and Renewable Energy (MNRE), the Ministry took up a new initiative for bottling of biogas to demonstrate an Integrated Technology-package in entrepreneurial mode on medium size mixed feed biogas-fertilizer plants (BGFP) for generation, purification/enrichment, bottling and piped distribution of biogas. Installation of such plants aims at meeting stationary and motive power, cooling, refrigeration and electricity needs in addition to cooking and heating requirements. There could be a huge potential of installation of medium size biogas-fertilizer plants in the country. Under this review paper work detailed studies will be conducted for analyzing the commercialization of biogas bottling plant for green and low-cost fuel in India.

Index Terms— *Bio gas*, *BGFP*, *Bio fertilizer*, CNG, CBG, MNRE, UNDP

1 INTRODUCTION

In the present era of ever-increasing energy consumption and dwindling fossil fuel reserves, the importance of biomass based, decentralized fuel such as Biogas and Biomass based power generation has been greatly increased. It is a well-established renewable and environment friendly fuel for rural energy needs. Biogas is ideally suited for rural applications where required animal or human excreta and agricultural waste are available in plenty. Harnessing such a resource promotes rural industries, agriculture, dairy and animal farming in a sustainable way [1]. This will also increase employment in the rural regions and discourage migration to cities.

Biogas is an environment friendly, clean, cheap and versatile fuel. Biogas is produced by anaerobic digestion of degradable wastes such as cattle dung, vegetable wastes, sheep and poultry droppings, municipal solid waste, sewage water, land fill etc. Presently the biogas is mainly used for cooking and lighting purposes in the rural areas. The use of biogas in stationary engines used for different agricultural operations is going on. Its utilization is also feasible in automobiles, used for transportation purposes by enriching and compressing it in cylinders. Biogas can be converted in bio CNG after enrichment and bottling. It becomes just like CNG.

Rapid industrialization and population increase has resulted in the generation of huge quantities of waste, both solid and liquid, in industrial sectors such as sugar, pulp and paper, food processing, sugar/starch, distilleries, dairies, tanneries, slaughterhouses, poultry farms, etc. Hence, there is a huge potential for the installation of medium (85-1,000 m3/d) to large-size (>1,000 m3/d) biogas plants in the country depending upon the availability of the feedstock.

Biogas typically consists of methane (50-70%), carbon dioxide (30-45%), traces of water vapor, and hydrogen sulfide (H2S). The composition varies according to the feed material used[2]. Biogas has a heating value of 20-24 MJ. The presence of methane renders it combustible while carbon dioxide, besides being non-combustible, restrains its compressibility thereby making it difficult to be stored in containers. Raw biogas has to be upgraded to natural gas quality in order to be used in vehicles that are designed to use natural gas. This means that carbon dioxide (CO2), hydrogen sulphide (H2S), ammonia, particles, and water and sometimes other trace compounds have to be removed so that it can be used in vehicles. This is because by itself, biogas has a methane content of more than 90 per cent by volume. This upgraded gas is generally referred to as Biomethane which is bottled at discharge pressure of 200 bar. This is termed as Compressed Biogas (CBG). Further, using a CNG dispensing cable and a nozzle to NZS standards, this CBG can be used for filling the gas into the vehicles.

2. BOTTLING OF BIOGAS

Upgraded and bottled biogas is a renewable energy source which can help both in waste management and in building a clean and sustainable environment. This technology is an economically viable option for biogas produced at medium to large scales [3]. The Ministry of New and Renewable Energy (MNRE) has developed a national Management Programme and biogas fertilizer plants for biogas upgradation and bottling programme with assistance from UNDP/GEF. The Government of India is exploring anaerobic digestion potential from all sources municipal solid waste, crop residue, sewage sludge, animal manure, industrial waste which includes distilleries, dairy plants, pulp and paper, poultry, slaughter houses, sugar industries excluding waste water treatment plant for two significant reasons; one being rocketing fuel pricing and the other stringent environmental regulations. The total potential of biogas from all sources has been estimated to be 48,382 million m3/year. This amount when

upgraded and when assumed that 50 per cent of total upgraded biogas contributes towards transport sector and 50 per cent for cooking sector — then according to the Indian Petroleum and Natural Gas Statistics 2011-2012, this much upgraded and bottled biogas can fulfill 43.4 per cent of total transport sector demand and similarly around 41.7 per cent of cooking sector needs.

A biogas bottling system typically consists[4] of the following equipment (Figure 1):

1. High pressure gas compression
2. Storage for upgraded biogas
3. Dispensing nozzle system

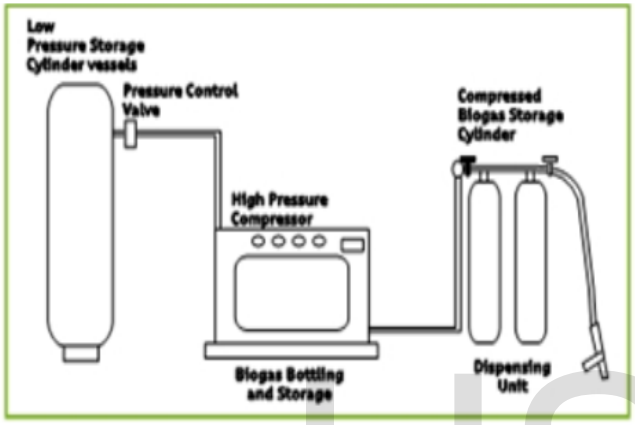

Fig -1: Biogas bottling System

Indian Institute of Technology, Delhi(IIT-D), has developed a small-scale biogas upgrading system using water scrubbing technology (20 m3/h system). The water-scrubbing-based biogas up gradation and compression/bottling system is patented IIT-D for enhancing the utility of biogas application that is, in vehicles and cooking applications. The system consists of a water scrubbing column and a methane-enriched biogas compression system.

3. CASE STUDY: THE FIRST BIOGAS BOTTLING PLANT TOWARDS COMMERCIALIZATION IN INDIA

The proposals are proposed to be evaluated by experts and considered by Technology Demonstration Appraisal Committee of the Ministry. Recommended projects are to be implemented, operated and owned by the concerned industries/entrepreneurs/ project developers.

A 500cum biogas generation per day capacity BGFP project for generation, purification/enrichment, bottling of biogas has sanctioned by the MNRE with Rs. 50 lakh CFA during the year 2009-10 to Ashoka Biogreen Pvt. Ltd. at village Talwade, District. Nasik (Maharashtra). Accordingly, the first biogas bottling plant (Figure 2) under Technology Demonstration of new RDD&D policy of MNRE has been commissioned on 16.03.2011 after obtaining license for filling and storage of compressed biogas in CNG cylinders from Petroleum & Explosives Safety Organization (PESO).

Fig -2: BGFP Project at Village - Talwade, Taluka- Trimbakeshwar, District- Nashik (Maharashtra)

The biogas generated from the plant at vill.- Talwade, Dist. - Nasik (Maharashtra) by Ashoka Biogreen Pvt. Ltd. have been purified and a purity of 98.4% methane has been achieved through test conducted by Shriram Institute for Industrial Research, Delhi (NABL). The results are shown in Table 1.

The purity of the enriched biogas is continuously monitored by online analyzing system alongwith calibration of analyzers. The purified biogas is equivalent / similar to CNG[6].

TABLE -1:

PURITY OF THE ENRICHED BIOGAS

		(As on dry basis except moisture)		
S. No.	Parameter	Unit	Test Value	Protocol/ Method Followed
1.	Methane (CH_4)	% v/v	98.4	GC-FID
2.	Carbon dioxide	%v/v	1.2	IS: 13270
3.	Oxygen (O_2)	ppmv	50	Oxygen Analyzer
4.	Hydrogen Sulphide (as H_2S)	ppmv	4.3	IS: 11255 (Pt-4)
5.	Nitrogen (N_2) & other gases	%v/v	0.4	By difference (Remainder)
6.	Moisture	ppmv	44	Gravimetric, Ref. IS: 307

The biogas generation capacity of the plant is 500 cum per day and based on NISARGRUNA (BARC) Technology. The purity of biogas is about 98% and compressed to 150-bar pressure for filling in cylinders [6].

The upgraded biogas is used for power generation, cooking and industrial application. The slurry of biogas plant is being based as an organic fertilizer in their nearby agro fields. The field trials have indicated 150% growth in agro-production and substantial improvements in the quality.

The salient features of BGFP project are shown in Table 2. Figures mentioned are on per day basis.

TABLE -2:
SALIENT FEATURES OF BGFP PROJECT

Particulars	Description	Remarks
Quantity processed	12.5 MT	Cow dung, agricultural waste etc.
Biogas generated	500 NM^3	
Purified/Upgraded Biogas	270 NM^3	
Purified Biogas used for captive power generation	81 NM^3	30 %
Power generated	160 units	
Purified/Upgraded Biogas Filled in Cylinders at 150 bars	16 Cylinders of 9 kg each filled.	Equivalent to Rs. 5040 of CNG or Rs. 7200 of commercial LPG
	20000	Used as liquid fertilizer substituting

4. POTENTIALS OF TECHNOLOGY

Biogas has mostly been used as fuel for cooking and running stationary engines. However, its potential has not fully utilized, yet. There is a great enhancement in its utilization potential particularly where bigger plants are in operation e.g. Institutional biogas plants in Gaushalas, dairy farms or community biogas plants in villages. Gaushalas are running generally on charity basis and most of Gaushalas are not in sound financial position. Enrichment and bottling of biogas will help to improve it.

India has a vast potential of 6.38 X 1010 cubic meter of biogas per annum from 980 million tones of cattle dung produced. A National Project on Biogas Development (NPBD) was launched by Government of India in 1981. A total of about 36.5 lakh family biogas plants have been installed under this programme all over the country till Dec. 2004. This is about 30 % of the total 120 lakh family type biogas plants potential. More than 3380 Community Biogas Plants (CBP), Institutional Biogas Plants (IBP) and Night-soil based Biogas Plants (NBP) have been installed all over the country with most reporting satisfactory performance levels. The family biogas plants in the country are estimated to be saving 39.6 lakh tones of fuelwood per year. Besides, about 9.2 lakh tones of enriched organic manure are being produced every year from these plants.

There are number of Gaushalas, dairies, village communities having large number of cattle which have potential of installing biogas enrichment and bottling system. In urban areas, large quantity of biogas can be produced in sewage treatment plants using anaerobic digestion. Okhala Sewage Treatment Plant, New Delhi is an example where more than 10,000 cubic meter of biogas is produced every day. Due to rising cost of petroleum products and environmental concerns it has become imperative to make use of local resources as an alternate to petroleum fuels. There for it is world wide trend to explore and make use of biogas as an alternate fuel in vehicles.

5. SCOPE OF THE TECHNIQUE

Enriched biogas is made moisture free by passing it through filters after that it is compressed up to 200 bar pressure using a three stage gas compressor. Compressed gas is stored in high pressure steel cylinders as used for CNG. There is large potential of this technology in buses, tractors, cars, auto rickshaws, irrigation pump sets and in rural industries[7]. This will help to meet our energy demand for rural masses thus reduces burden of petroleum demand, moves towards energy security and will improve economic status by creating employment generation in rural area[8].

6. COST ANALYSIS

Estimate for 500 m3 Biogas Bottling Plant

Biogas Plant:

Waste Required : 10 Tons Cattle Dung

Water requirement in Biogas Plant : ~ 10 000 liter

Biogas Production Cost : 500 NM3/Day

Biogas Purification & Bottling System:

Raw Biogas Quantity : 500 NM3/Day

Purified Gas Quantity : ~ 190 Kg

Purified Gas Composition : CH4: 95 %, H2S: < 25 ppm, Moisture: < 20 ppm

Cost: Rs. 50 lakhs

Slurry Management System:

Slurry Production : ~ 10 Tons (50 % solid)

Cost : Rs. 12 Lakhs

Other Cost: Land preparation, Civil work, High pressure gas storage Cylinders Taxes , Logistic etc. Rs. 18 Lakhs.

Total Initial Cost of Project : Rs.0.8 Crore

Revenue:

Purified Gas : (Rs. 40/kg) * (190kg) = Rs. 7600/day: (Rs. 30/kg) * (375 kg) = Rs. 11250/day

Slurry : (Rs. 3/Kg) * (3000 Kg) = Rs. 9000/day: (Rs. 2/Kg) * (6000 Kg) = Rs. 12000/day

Total Revenue : Rs. 16600/day: Rs. 23250/day

Annual Revenue: (Rs. 23250/day) * (350 day) = Rs. 59.76 Lakhs

Cost of Dung : (Rs. 300/ton) * (30 tons) = Rs. 3000/day

Annual cost of dung : (Rs. 3000/day) * (365) = Rs. 10.95 Lakhs : (Rs. 5000/day) * (365) = Rs. 18.25 Lakhs

Cost of Water & Electricity: Rs. 10 Lakhs (Annual) : Rs. 15 Lakhs (Annual)

Manpower Cost: Rs. 4 Lakhs (Annual) : Rs. 6 Lakhs (Annual)

Annual Maintenance cost: Rs. 5 Lakhs : Rs. 8 Lakhs

Total Recurring cost: Rs. 29.95 Lakhs : Rs. 47.25 Lakhs

Annual Profit: Rs.29.76Lakhs : Rs.34.125 LakhsIn BGFP project there is a provision of 50% subsidy

Beneficiary Expenditure: Rs. 50 Lakhs : Rs. 75 Lakhs

Annual Profit: Rs. 29.76 Lakhs : Rs. 34.125 Lakhs

Payback Period: 3 years

7. CONCLUSIONS

Biogas is a potential renewable energy and carbon neutral source for rural as well as for urban India. There is a need for tax incentives, support, and regulations in this direction from the government to enable our country to be self-reliant in the energy sector. Taking biogas generation as a base activity and compressing it for decentralized power production, cooking needs at highway motels, industrial complex, dairy, food processing units can be taken up, which will not only help us towards reducing unemployment and alleviating economy, it will also help us mitigate climate change by the use of bio-energy in an efficient way. In this paper efforts are made to exploit biomass resources in the region and suggest some of the cost effective and environment friendly ways to meet the demand. The cost analysis[9] predict in spite of having huge capital and installation cost renewable energy sources prove to be more reliable and environmental friendly source to provide electricity in remote or off grid areas.

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