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Techno Market Feasibility Study and Risk Analysis of Bio-Compressed Natural Gas (Bio-CNG) Project in India

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Abstract— Every nation across the globe needs energy to sustain and progress. Some energy sources are perishable and some are renewable. Energy from hydrocarbon contributes to about 2/3rd of the energy basket today but is perishable in nature. Moreover, extensive use of petroleum products has created serious impact on the environment. In India, a major chunk of its oil and natural gas requirements comes from imports and that puts a heavy burden on its import bill. The regulator for hydrocarbon downstream sector in India has an ambitious vision to increase the transmission and distribution of natural gas to the markets across pan-India but there are barriers like lack of supporting infrastructure and large initial capital needs.

A new and exciting development in the form of Bio-Compressed Natural Gas (Bio-CNG) is taking shape in India and can be an alternative to conventional CNG. Bio-CNG is obtained from bio sources instead of natural gas which is obtained from oil and gas fields.

Bio-CNG can be produced from various feedstocks such as waste from sugar industry, sewage treatment plant, animal waste etc. Each feedstock has characteristics that vary the methane purity in Bio-CNG and therefore the need to carry out technical assessment in terms of the production process configuration and cost involved. This clean source of energy has applicability in various sectors like energy intensive process industry, automobile and power generation. It has a reduced per unit energy cost and less harmful to the environment. Bio-CNG production requires technology driven investment and therefore the need to carry out corresponding prospective market potential for sales of Bio-CNG produced. This paper focuses on studying the business model of bio-CNG viz. appraising the market potential, technical study & raw material selection and risk associated for commercial production and distribution.

Keywords – Compressed Natural Gas, Bio-CNG, technical study, financial feasibility

I. INTRODUCTION

Energy is the life line of every society and country. Every government tries and ensures their energy security. Types of energy resources are: Non-renewable energy resources: Non-renewable energy resources cannot be renewed, recycled or re-grown. Fossil fuels such as oil, coal and natural gas are some examples of non-renewable energy resources.

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Non-renewable energy resources take millions of years for its refurbishment in a natural way and cannot be replaced as fast as they are consumed.

Renewable Energy sources: Renewable energy sources are natural resources that can be re-grown, recycled or renewed by natural processes at a rate equal or faster than rate of consumption. Wind, hydroelectricity, solar and tidal waves are permanent renewable resources. Some other natural renewable energy resources include geothermal power and biomass. The renewability of these resources is proven from their life cycle evaluation, which gives their ability to re-grow or renew. Unlike fossil fuels, a renewable energy resource can have a sustainable yield.

1.1 Biogas as a sustainable energy source in India:

India as an agrarian economy is blessed with renewable energy sources such as hydro, wind energy, tidal energy, biomass and solar energy. Biogas is typically produced from locally available bio degradable raw material such as manure, sewage, municipal waste and surface recycled wastes through anaerobic fermentation. Bio gas mainly contains methane (60-65%) and carbon dioxide and smaller quantities of hydrogen sulphide, siloxanes & moisture (35-40%). Combustion of methane releases energy thus allowing biogas to be used as fuel. Unwanted gases cause pollution and limit the calorific value of the biofuel. Fortunately, we can take out all the undesired gases such as H_2S and CO_2 using a two stage process consisting of scrubber and dryer.

India is implementing one of the largest biogas schemes in the area of renewable energy. Biogas is produced and delivered round the clock whereas solar and wind energy are intermittent in nature. Biogas plants provide three solutions - a gaseous fuel, the production of organic fertilizer and wet biomass disposal / management. Converting biomass into gaseous fuel i.e. bio-methanation process is superior and sustainable. India has pioneered in developing simple and easy to operate biogas plants. The Khadi Village Industries Commission (KVIC) model, developed in India, has withstood the test of time and is also being promoted in a large number of African and Asian Pacific countries. Latest in the efforts for technology improvement is the development of fixed dome & portable, prefabricated high density polyethylene based ‘complete and portable family size biogas plants’ suitable for rural, semi-urban and urban areas. These portable biogas plants help to achieve the twin

objectives of energy generation and better sanitation. Initially biogas plants were developed for digesting cattle dung, however over a period of time technology has been developed for bio-methanation of various types of mixed feed and biomass materials. Biogas plants are available from 0.5 m^3 to higher unit sizes and multiples of those can be installed for achieving higher biogas plant sizes depending on availability of the raw material for community, industrial and transport applications.

1.2 Bio-CNG applications:

Bio-CNG is purified form of biogas where all the unwanted gases are removed to produce up to 95% pure methane gas. Bio-CNG is exactly similar to commercially available natural gas in its composition and energy potential with calorific value of approximated 52000 kJ/Kg. As it is generated from biomass, it is considered as renewable energy source and thus attracts all the commercial benefits applicable to all other renewable sources of energy. Bio-CNG can directly replace almost every utility of LPG and CNG. It has potential to be the future of renewable fuel because of abundance of bio mass in India. Bio-CNG production also eases the burden of Natural gas imports and LPG subsidy in India. It is estimated that bio-CNG can replace 66 % of India's natural gas import. Some applications of Bio-CNG are as below.

a. Industrial Applications – Bio-CNG can be used for heat intensive processes. As it has high calorific value, it can be used more effectively.
b. Automotive Sector – India is 5th largest globally for CNG vehicles used. By replacing CNG with bio-CNG, we can cut down NG imports and hence the forex.
c. Domestic/Commercial Applications – Bio-CNG can replace LPG for household and many commercial applications.
d. Power Generation – Many townships and commercial building use Diesel or Petrol engine as prime mover for power backup. With minor changes in engine, bio-CNG can be used.

Table No. 1: Comparison of cost of energy

Fuel	Calorific Value	Fuel Cost*	Cost of Energy
CNG	52000 kJ/kg	Rs. 42.0/kg	1238 kJ/Rs.
Bio-CNG	52000 kJ/kg	Rs. 38/kg	1368 kJ/Rs.
Auto LPG	46000 kJ/kg	Rs. 53.6/kg	858 kJ/Rs.
LPG (Domestic)	46000 kJ/kg	Rs. 27.5/kg	1673 kJ/Rs.
Petrol	36000 kJ/litre	Rs. 79.4/litre	453kJ/Rs.
Diesel	37200 kJ/litre	Rs. 59.4/litre	627 kJ/Rs.

*Prices at New Delhi.

Source: Greenbrick Eco-Solutions.

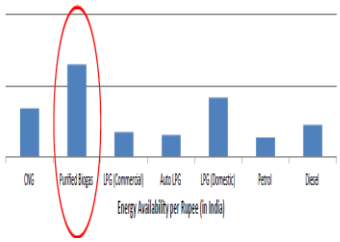

Table No. 2: Potential to produce Bio-CNG in India

Sr. No.	Type of Source	Potential (in tons/year)
1	Sugar Industries	63,09,109
2	Distillery Industries	11,652
3	Animal Waste	70,20,385
4	Municipal Waste	16,567
5	Total	1,33,57,713

II. MARKET APPRAISAL FOR BIO-CNG PROJECT:

A. Market Potential:

India is growing in terms of industrialization and power generation but still there is a huge deficit of energy. Conventional energy sources are not enough to meet the energy demand and therefore, bio-CNG can be used commercially and can replace fossil fuel requirement partially. As stated in Vision 2030 of Natural Gas and Infrastructure in India,

- Natural gas availability in India is projected to fall short of the total natural gas demand by around 97 MMSCMD in 2012-13.
- Lowest demand supply gap during 2017-18 will be 42 MMSCMD.
- The demand-supply gap is likely to again post 2017-18 and reach about 272 MMSCMD by 2029-30 as a result of increase in supply lag behind a steady increase in demand.

B. Prospective Customers:

Bio-CNG has a variety of application based on its properties like high calorific value, less carbon footprint and cheaper &clean source of energy compared to the fossil fuel alternatives. Following are some application areas where bio-CNG finds better suitability:

i. Forging Industry:

Forging industry require pre-heating as well as annealing. Both the processes require heating up to the crystallization temperature of the metal generally above 1000^0C. In case of cold forging temperature ranges from 500^0C to 900^0C. In both cold and hot forging, metal is heated in closed furnaces

and for that many fuels like CNG, acetylene ,LPG are used which can be replaced by bio-CNG

ii. Casting Industry:

In casting, many metals like steel, aluminum, bronze and other commercial metals are melted and poured into molds. For the above reason heating is a major activity and consumes fuel considerably. Generally, for melting the steel, cupola furnaces are used and coal or CNG is the major heat producing agent. Consumption of CNG and coal in these furnaces emits carbon dioxide in large quantity. This can be replaced with bio-CNG which is more cost effective and environment friendly.

Note: 1. To find out market potential for Bio-CNG, we have considered only casting and forging industrial applications and Pune district in Maharashtra state as the target market for the study. Casting and forging being heat intensive industry and major contributor to the manufacturing sector are growing rapidly and therefore we have limited our study to these two industries.

2. Constrained by availability of data, the sample studied may not represent population.

Table No. 3: Different sources of energy and their annual consumption by the forging industry in Pune for the year 2011–12

Energy Source	Annual Energy Consumption (ToE)	Contribution (in percentage)	Million Rs./Annum
Electricity	6,794	28%	540
Furnace Oil	11,995	50%	841
Light Diesel Oil	3,044	13%	158
High Speed Diesel	592	2%	33
Natural Gas	1,294	5%	62
LPG	533	2%	24
Total	24,252	100%	1,658

Source: Cluster Profile Report Pune Forging Cluster - By SIDBI (Page No - 19)

Table No. 4: Equivalent required quantity of Bio-CNG compared to other fossil fuel requirement

Energy Source	Required Quantity	Equivalent required quantity of Bio-CNG (in Kg)
Furnace Oil	5,00,00,000 Litre	3,57,85,537
Light Diesel Oil	1,30,00,000 Litre	93,04,240
High Speed Diesel	20,00,000 Litre	14,31,421
Natural Gas	26,62,500 Kg	30,52,500
LPG	12,21,000 Kg	10,80,115#

1 kg of LPG = 0.884 Kg of CNG

III. TECHNICAL STUDY OF BIO-CNG PROJECT:

A. Process for producing Bio-CNG:

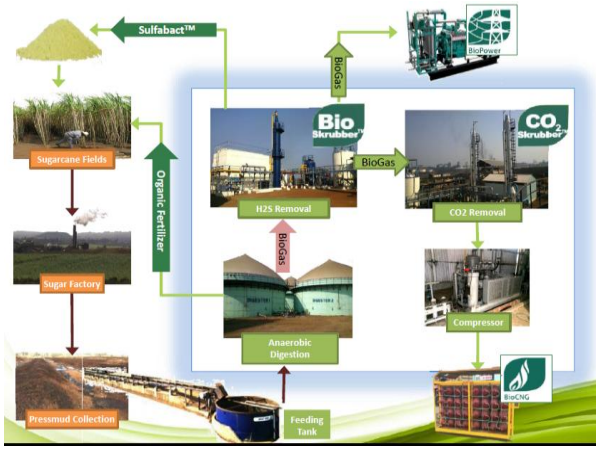

Figure 1: Process of Bio-CNG production

B. Steps involved in Production of Bio-CNG

a. Pressmud (raw material from sugar factories) collection and direct open storage
b. Feeding tank mixed pressmud and water to form uniform mixture
c. Digesters generate biogas anaerobically in four stages namely hydrolysis, acidogenesis, acetogenesis and methanogenesis
d. Cleaning system for removal of H_2S and CO_2 from biogas via a two stage process
e. Drying unit for moisture removal in Bio-CNG to ppm level
f. Compressor to compress bio-CNG from 7 bar to 200 bar and then bottled
g. Bio-CNG is stored in cascades and transported

IV. SOURCING OF RAW MATERIAL FOR BIO-CNG PROJECT:

Table No.5: Below is a scorecard that shows the comparison of different feedstocks for Bio-CNG generation considering the factors viz. reliability of source, calorific value of feedstock and cost parameter in feedstock selection.

Feedstock	Cost score	Reliability score	Calorific value score	Total Score
Press mud & Molasses	2	4	4	10
Cow Dung	3	3	3	9
Municipal Waste	4	1	1	6
Vinasse	1	2	3	7

For cost**,** Highest Cost – 1 and Lowest Cost - 4

For other parameters**,** Highest Rating – 4 and Lowest Rating – 1

Therefore, we considered Press mud and Molasses as the feedstock for bio-CNG production in our sample calculations.

V. Approvals and clearances required for Bio-CNG Project in India:

Looking at the properties and composition of bio-CNG, Government of India has taken some precautionary measures to make the future operations smooth and safe for the operators and also for the consumers in all aspects. To the safe environment for generation and distribution of Bio-CNG, the following clearances and approvals are required.

1. Petroleum and Explosives Safety Organizations
2. State Pollution Control Board
3. Local Gram Panchayat/ Municipality - No objection certificate
4. Cooperation certificate from the villagers residing close to the manufacturing unit of Bio-CNG.

VI. Risk Analysis of a Bio-CNG project:

We used the Failure Mode Effect Analysis also known as FME Analysis for risk assessment. RPN is Risk Priority Number. Lowest - 1 and Highest - 10. Higher the RPN, higher is the risk.

FMEA Analysis

Department	Risk	Probability	Severity	Detection	RPN
Market Risk	ARAI Approval	3	5	6	90
	Clearance for residential and Comercial	4	4	3	48
	Subsidy for LPG (Resdential)	5	5	4	100
	Bio Gas Feasiblity for Power Generation	3	5	4	60
Sourcing Risk	Contract Breach	3	7	3	63
	Land Acquisition	5	5	4	100
	Seasonal Availability	5	7	3	105
	Raw material Price Variation	4	5	4	80
Technical Risk	Capacity Expansion	4	5	3	60
	Operation & Maintenance Experties	3	6	4	72
	Technology Obsolence	6	4	5	120
Safety Risk	Explosion	6	7	5	210
	Transportation gas leaks	3	4	3	36

VII. Conclusion:

India as an agrarian economy can possibly look at bio-CNG generation throughout the century because of the ample availability of raw material. Bio-CNG being renewable energy results into a clean energy source from a low cost raw material thereby gives higher profit margins for a prospective business model.

Feedstock options for bio-CNG and their easy accessibility shows great opportunity for the bio-CNG business to growth as substantial energy source which has potential to support and fulfill a part of the deficit in the demand and supply of the natural gas thereby helping the countries from energy security goal. The report shows that the market potential for bio-CNG is huge and can replace the traditional fossil fuels up to 50,653.813 tons in Pune city itself.

In spite of few risk involved in this venture, all the risk can be mitigated with collective efforts from the producers, consumers and government agencies which will then give a boost for the promotions of Bio-CNG business model. In support of this, Government of India is providing subsides and technical support through central financial assistance scheme. Thus, looking at all the aspects of commercialization of bio-CNG generation and distribution, it is a sustainable venture in the future and can support the Indian economy in terms of saving of forex through reduction in of imports of hydrocarbon.

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