

**White Paper**  
**on**

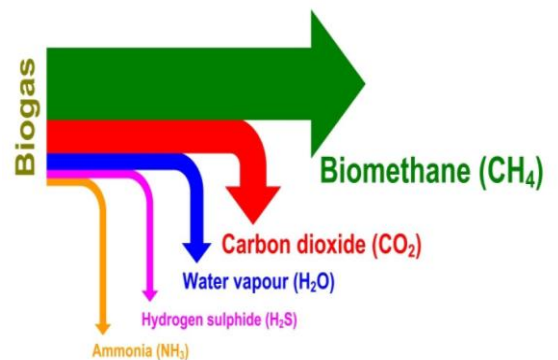
**Compressed Bio Gas (CBG)**  
*The Fuel of the Future*

## Table of Contents

|             |                                                                          |          |
|-------------|--------------------------------------------------------------------------|----------|
| <b>I.</b>   | <b>Introduction.....</b>                                                 | <b>3</b> |
| <b>II.</b>  | <b>Global Initiatives .....</b>                                          | <b>4</b> |
| <b>III.</b> | <b>Policy Support .....</b>                                              | <b>4</b> |
| <b>IV.</b>  | <b>Compressed Bio Gas (CBG) in India .....</b>                           | <b>5</b> |
| <b>V.</b>   | <b>CBG Production Technology .....</b>                                   | <b>6</b> |
| <b>VI.</b>  | <b>Envisaged Business Model for Oil Marketing Companies (OMCs) .....</b> | <b>8</b> |

## I. Introduction

1. India is among the fastest growing economy in the world and its energy consumption is slated to increase rapidly. According to the Ministry of Petroleum and Natural Gas (MoP&NG) estimates, India has a total reserve of 763 Million Metric Ton (MMT) of crude oil and 1,488 Billion Cubic Meter (BCM) of natural gas. The country currently imports nearly 77% of its crude oil requirements and about 50% of natural gas requirement, leading the Government of India to set a target of reducing this import by at least 10% by 2022. Further, it has set a target of increasing the contribution of gas in India's energy mix from existing 6.5% (global average is 23.5%) to 15% by 2022.
2. Hon'ble Prime Minister has given the following four pillars of our vision of India's energy future – energy access, energy efficiency, energy sustainability and energy security. The Government of India has also set a target of – 'Doubling Farmers Income by 2022'.
3. Waste / Bio-mass sources like agricultural residue, cattle dung, sugarcane press mud, municipal solid waste and sewage treatment plant waste, etc. produce bio-gas through the process of anaerobic decomposition. The bio-gas is purified to remove hydrogen sulfide ( $H_2S$ ), carbon dioxide ( $CO_2$ ), water vapor and compressed as Compressed Bio Gas (CBG), which has methane ( $CH_4$ ) content of more than 90%.



**Fig. 1 : Components of biogas**

4. CBG has calorific value and other properties similar to CNG and hence can be utilized as green renewable automotive fuel. Thus it can replace CNG in automotive, industrial and commercial areas, given the abundance biomass availability within the country.
5. Conversion of agricultural residue, cattle dung and municipal solid waste (MSW) into CBG in a commercial scale is expected to have the following benefits
  - Import reduction of natural gas and crude.
  - Utilization of agricultural residue, cattle dung and MSW for the production of CBG and thus to achieve reduction in emissions and pollution.
  - A boost towards fulfillment of National commitments in achieving climate change goals.

- Providing a buffer against energy security concerns and crude/gas price fluctuations.
- Contribution towards Swachh Bharat Mission through responsible waste management
- Lowering pollution and carbon emission.
- Providing additional source of revenue to the farmers, rural employment and amelioration of the rural economy

## **II. Global Initiatives**

1. Countries such as Germany, Italy, UK, France and Switzerland are promoting bio-gas usage promoted by supporting legal frameworks, education schemes and the availability of technology. Biogas produced in European countries is mostly fed into local natural gas grids and used for power generation. Grid injection is most common in European states followed by vehicles fuelled with biogas (either pure or in blend with natural gas) and biogas is also used for heating purposes either directly or blended to natural gas.
2. The number of bio-gas plants in Germany has doubled to nearly 9,000 plants from 4,136 plants in 2010. The total bio-gas production capacity of the plants is 8.98 Billion Cubic Meter (BCM) equivalent to 6.6 Million Metric Ton (MMT). They are primarily operated by farmer co-operatives, and utilize crops like maize or turnips as feedstock in their plants.

## **III. Policy Support**

1. Government of India has released the National Policy on Bio-Fuels 2018 vide gazette notification no. 33004/99 dated 8.6.2018. The policy emphasizes on promotion of advanced Bio-fuels including CBG.
2. The Galvanizing Organic Bio-Agro Resources Dhan (GOBAR-DHAN) scheme was launched by Government of India to convert cattle dung and solid waste in farms to Bio-CNG (CBG) and compost. GOBAR-DHAN scheme proposes to cover 700 projects across the country in 2018-19.
3. Ministry of New and Renewable Energy has notified Central Financial Assistance (CFA) for Bio-CNG.

#### IV. Compressed Bio Gas (CBG) in India

1. The estimated CBG potential from various sources in India is nearly 62 MMT with bio-manure generation capacity of 370 MMT. CBG is envisaged to be produced from various bio-mass / waste sources including agricultural residue, municipal solid waste, sugarcane press mud, distillery spent wash, cattle dung and sewage treatment plant waste.
2. The other waste streams viz. rotten potatoes from cold storage, rotten vegetables, dairy plants, chicken/ poultry litter, food waste, horticulture waste, forestry residues and industrial Effluent Treatment Plants (ETPs) treating organic waste can be used in the generation of biogas.
3. The biogas produced contains approximately 55% to 60% methane, 40% to 45% carbon dioxide and trace amounts of hydrogen sulphide. Biogas is purified to remove carbon dioxide and hydrogen sulphide gases to prepare CBG. The CBG can be transported through cylinder cascades or pipelines to retail outlets.
4. Vide Gazette Notification no. 395 dated 16th June 2015, Ministry of Road Transport and Highways, Government of India had permitted usage of bio-compressed natural gas (bio-CNG) for motor vehicles as an alternate composition of the compressed natural gas (CNG).
5. Compressed Bio Gas (CBG) to be supplied shall meet IS 16087:2016 specifications of BIS (detailed below) and any other further revisions in the said specifications.

**Table 1 : Composition of CBG**

| IS 16087 : 2016 Standard |                                                                                                            |                      |
|--------------------------|------------------------------------------------------------------------------------------------------------|----------------------|
| S No.                    | Characteristic                                                                                             | Requirement          |
| 1                        | Methane percentage (CH <sub>4</sub> ), minimum                                                             | 90.0 %               |
| 2                        | Only Carbon Dioxide percentage (CO <sub>2</sub> ),, maximum                                                | 4%                   |
| 3                        | Carbon Dioxide (CO <sub>2</sub> )+ Nitrogen (N <sub>2</sub> )+ Oxygen (O <sub>2</sub> ) percentage maximum | 10%                  |
| 4                        | Oxygen (O <sub>2</sub> ) percentage maximum                                                                | 0.5%                 |
| 5                        | Total sulphur (including H <sub>2</sub> S) mg/m <sup>3</sup> , maximum                                     | 20 mg/m <sup>3</sup> |
| 6                        | Moisture mg/m <sup>3</sup> , maximum                                                                       | 5 mg/m <sup>3</sup>  |

6. Also as per the IS 16087:2016 specifications, the following shall also be met
  - i. CBG shall be free from liquids over the entire range of temperature and pressure encountered in storage and dispensing system
  - ii. The CBG shall be free from particulate matter such as dirt, dust, etc.
  - iii. CBG delivered shall be odorized similar to a level found in local distribution (ref. IS 15319)

- The CBG is to be compressed at 250 Bar and supplied through Cascades to the Oil Company Retail Outlets as mentioned in the EOI document.

## v. CBG Production Technology

- Biogas is a product from the process of degradation of organic matter by anaerobic bacteria. The biogas generation process consists of four subsequent chemical and biochemical reactions i.e. Hydrolysis reaction, Acidogenesis reaction, Acetogenesis reaction and Methanogenesis reaction.
- Hydrolysis reaction decomposes organic molecule such as carbohydrates, proteins and fats into glucose, amino acids and fatty acids, respectively. Acidogenesis converts those generated small organic molecules to volatile organic acids with help from bacteria. During the Acetogenesis process, bacteria in the acetic group digests volatile organic acids and releases acetic acid. Lastly, anaerobic bacteria in the methanogenic producing bacteria group will complete the Methanogenesis process by converting acetic acid to methane gas and other gases like carbon dioxide and hydrogen sulfide.
- Hydrogen sulfide is a corrosive gas. Presence of carbon-dioxide in the bio-gas reduces its calorific value. Hence the bio-gas needs to be purified. Various technologies are used for removal of hydrogen sulfide, as detailed below:

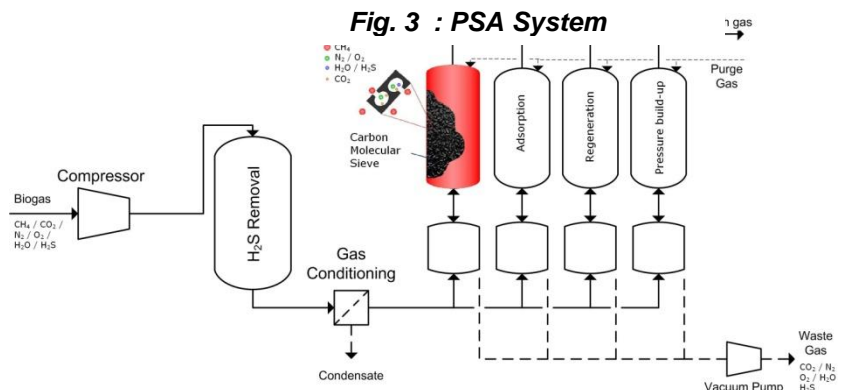
**Table 2 : Comparative analysis of technologies to remove Hydrogen Sulphide**

| Method                         | Efficiency | Cap Cost | O&M      | Complexity |
|--------------------------------|------------|----------|----------|------------|
| <b>Biological Fixation</b>     | Moderate   | Moderate | Low      | Moderate   |
| <b>Iron chloride dosing</b>    | Moderate   | Low      | Moderate | Low        |
| <b>Water scrubbing</b>         | High       | High     | Moderate | High       |
| <b>Activated Carbon</b>        | High       | High     | Moderate | Moderate   |
| <b>Iron Hydroxide or Oxide</b> | High       | Moderate | Moderate | Moderate   |
| <b>Sodium Hydroxide</b>        | High       | Moderate | High     | Moderate   |

- For removal of carbon dioxide, the following technologies are used

- **Pressure Swing Adsorption (PSA)**

This technology is most prevalent for large bio-gas systems in India. With this technique, carbon dioxide is separated from the biogas by adsorption on a surface under elevated pressure. The adsorbing material, usually activated carbon or zeolites, is regenerated by a sequential decrease in pressure before the column is reloaded again, hence the name of the technique. Hydrogen sulphide and water needs to be removed before the PSA-column. There is significant loss of methane (20-30%) in this process.



- **Water scrubbing**

Carbon dioxide has a higher solubility in water than methane. Carbon dioxide will therefore be dissolved to a higher extent than methane, particularly at lower temperatures. In the scrubber column carbon dioxide is dissolved in the water, while the methane concentration in the gas phase increases. The gas leaving the scrubber has therefore an increased concentration of methane.

**Fig. 4 : Water Scrubber System**



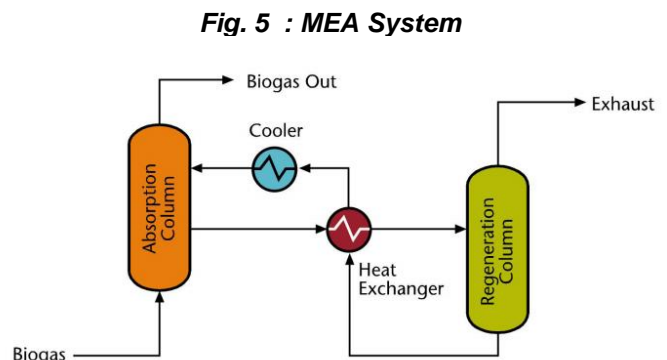
There are technologies available through which 97% purity of methane can be achieved with minimal (<5%) methane loss.

- **Membrane Separation**

Dry membranes for biogas upgrading are made of materials that are permeable to carbon dioxide, water and ammonia. Hydrogen sulphide, and oxygen permeate through the membrane to some extent while nitrogen and methane only pass to a very low extent. Usually membranes are in the form of hollow fibers bundled together.

- **Chemical scrubbing - Monoethylamine (MEA) system**

This is one of the best systems for bio-gas purification achieving 99.9% purity with negligible loss of methane. The systems are being extensively used in Germany for purification of bio-gas. Carbon dioxide is not only absorbed in the liquid, but also reacts chemically with the amine in the liquid. Since the chemical reaction is strongly selective, the methane loss might be as low as <0.1%.



Apart from the above, there are also developing technologies like Cryogenic upgrading. A comparison of the available technologies is as under:

**Table 3 : Comparative analysis of technologies to remove Carbon Dioxide**

| Parameter                                          | PSA    | Water Scrubber | Mono-ethylamine (MEA) system |
|----------------------------------------------------|--------|----------------|------------------------------|
| <b>Pre- H<sub>2</sub>S removal required</b>        | Yes    | No             | Yes                          |
| <b>Working pressure (bar)</b>                      | 4-7    | 4-7            | No pressure                  |
| <b>Methane loss</b>                                | 20-30% | 5-10%          | <0.1%                        |
| <b>Methane content in upgraded gas</b>             | >96%   | >97%           | >99%                         |
| <b>Electricity consumption (kWh/m<sup>3</sup>)</b> | 0.25   | <0.25          | <0.15                        |

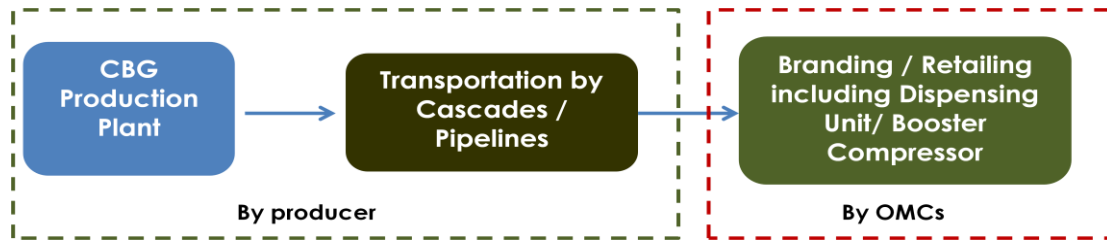
## VI. Envisaged Business Model for Oil Marketing Companies (OMCs)

1. The CBG Plants shall be set up by mainly through independent Entrepreneurs and in few specific cases OMCs may consider setting up of CBG plant. The marketing of all the CBG produced through such plants will be through OMC network, under their respective brand names.

Producer(s) / Seller(s) (Party/Entrepreneur) shall deliver CBG (within 25 Km, an indicative maximum distance), at Public sector Oil Marketing Companies' existing or new Retail Outlet / Stand alone Selling Point, through Cascades. The equipment for dispensing CBG at Public sector Oil Marketing Companies' existing or new Retail Outlet / Stand alone Selling Point shall be installed and maintained by Public sector Oil Marketing Companies', however, the CBG nozzles shall be manned and operated by RO Dealer. Electricity expenses towards dispensing of CBG through sale point shall be reimbursed to the Party who is actually bearing the costs. The outlet flange of



the Cascade / Inlet Flange of Compressor at the Retail Outlet shall be the Point of Sale for CBG. The cascade to remain connected to the compressor at retail outlet till the dispensation is operationally feasible.



### Pricing Framework of CBG

**(To be retailed through OMCs / Fixed for three years from 1.10.2018 / The price will be reviewed at the end of 3 years.)**

| Item                                                                                                                      | Unit   | Price        |
|---------------------------------------------------------------------------------------------------------------------------|--------|--------------|
| Basic Price of CBG meeting IS 16087 : 2016 standard, compressed at 250 bar and delivered at OMC Retail Outlet in cascades | Rs./kg | 46.00        |
| GST at 5%                                                                                                                 | Rs./kg | 2.30         |
| <b>Total supply price (incl. GST) to be paid to party</b>                                                                 | Rs./kg | <b>48.30</b> |

Additionally, an element of Rs. 2 per kg of CBG towards cost of setting up of infrastructure e.g. booster compressor, dispensing unit, etc. at retail outlet and Rs. 0.50 per kg of CBG towards electricity charges for operation of booster compressor, dispensing unit, etc at retail outlet, shall be provided to OMC or APPLICANT, as per whosoever sets up infrastructure at retail outlet.

\*\*\*\*\*