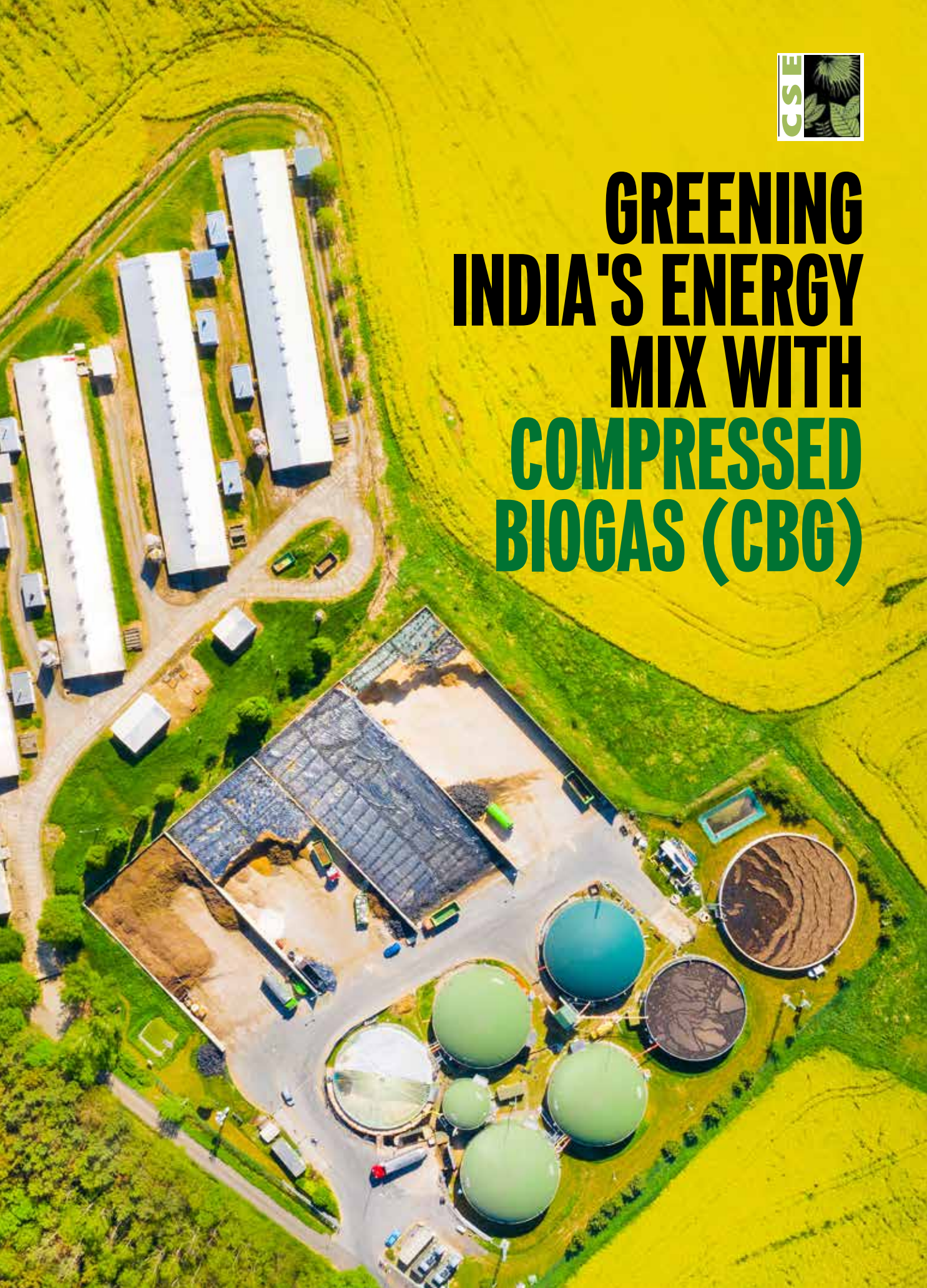

GREENING INDIA'S ENERGY MIX WITH COMPRESSED BIOGAS (CBG)

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Abbreviations

AD	Anaerobic Digestion
AIF	Agriculture Infrastructure Fund
BDTC	Biogas Development and Training Centre
BIS	Bureau of Indian Standards
CAPEX	Capital Expenditure
CBG	Compressed Biogas
CNG	Compressed Natural Gas
CFA	Central Financial Assistance
CGD	City Gas Distribution
CH_4	Methane
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
CPCB	Centre Pollution Control Board
CSTR	Continuously Stirred Tank Reactor
COE	Consent to Establish
COP	Conference of the Parties
FCO	Fertilizer Control Order
FOM	Fermented Organic Manure
FPO	Farmer Producer Organization
GAIL	Gas Authority of India Limited
GHG	Greenhouse Gas
GDP	Gross Domestic Product
GOBAR	Galvanizing Organic Bio-Agro Resources
GOI	Government of India
GST	Goods and Service Tax
HPCL	Hindustan Petroleum Corporation Limited
IGL	Indraprastha Gas Limited
IEA	International Energy Agency
IOC	Indian Oil Corporation
LBG	Liquified Biogas
LOI	Letter of Intent
MMT	Million Metric Tonnes

MMTPA	Million Metric Tonnes Per Annum
MT	Million Tonnes
MNRE	Ministry of New and Renewable Energy
MOA	Ministry of Agriculture
MEA	Mono-ethylamine
MOPNG	Ministry of Petroleum and Natural Gas
MSW	Municipal Solid Waste
MJ	Mega-joule
NDC	Nationally Determined Contribution
NOC	No Objection Certificate
NPK	Nitrogen, Phosphorous, Potassium
OMC	Oil Marketing Company
OPEX	Operational Expenditure
PESO	Petroleum and Explosives Safety Organization
PPP	Public-Private Partnership
PSL	Priority Sector Lending
PSA	Pressure Swing Adsorption
SATAT	Sustainable Alternative Towards Affordable Transportation
SBM	Swachh Bharat Mission
SCADA	Supervisory Control and Data Acquisition
SDGs	Sustainable Development Goals
TPD	Tonnes Per Day
UNFCCC	United Nations Framework Convention on Climate Change

1. INTRODUCTON

- India is expected to experience a great increase in energy demand over the next few decades, with its share of global energy consumption doubling by 2050.
- Increased use of modern bioenergy is essential for energy transition and usage of compressed biogas within bioenergy is needed for spreading the benefits of the transition locally.
- The Indian government has announced an outlay of Rs 10,000 crores in the 2023–24 budget for the Galvanizing Organic Bio-Agro Resources Dhan (GOBARdhan) scheme.

India's energy demands and contribution to global greenhouse gas emissions

Over the next twenty years, India is expected to experience the greatest rise in energy demand compared to any other country due to its huge growth needs. By the year 2050, India's share of global energy consumption will double from 7 per cent to 14 per cent. Additionally, India's demand for oil and gas is anticipated to triple by 2050, with gas consumption growing threefold by 2030.[1] The International Energy Agency (IEA) forecasts that India will contribute to 25 per cent of the world's growth in energy demand between 2020 and 2040.[2] Globally, the energy sector currently produces approximately 75 per cent of all greenhouse gas (GHG) emissions and it is crucial in preventing the most severe consequences of climate change, which is arguably one of the most significant crises humanity has encountered as a whole.[3]

India's global environmental commitments

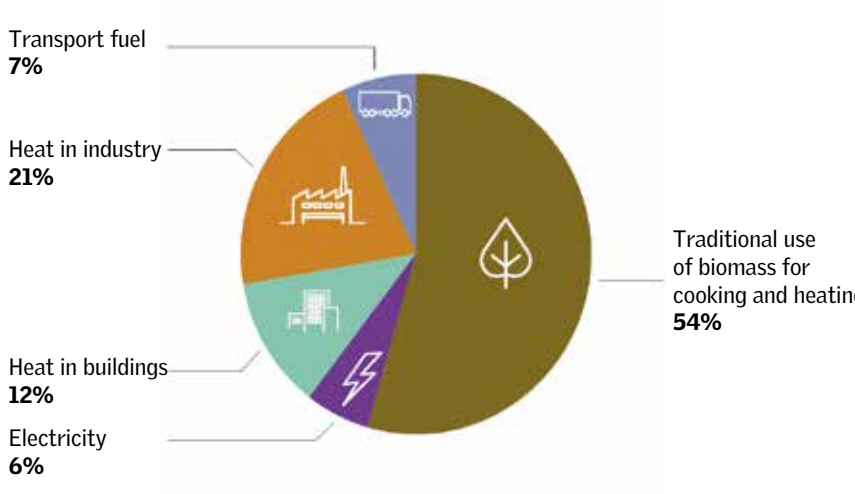
According to India's Nationally Determined Contribution (NDC) submitted to the United Nations Framework Convention on Climate Change (UNFCCC), India has pledged to decrease the emissions intensity of its gross domestic product (GDP) by 45 per cent by 2030 compared to the levels in 2005.[4] Additionally, India aims to generate around 50 per cent of its cumulative electric power from renewable energy sources by 2030 and is also committed to achieving net-zero GHG emissions by the year 2070. During the 26th Conference of the Parties (COP 26) held in Glasgow in November 2021, the Glasgow Climate Pact was adopted, which aims to transform the 2020s into a period of climate action and assistance. At the conference, the Prime Minister of India emphasized seven essential components of India's energy strategy, two of which include increasing efforts to transition to a gas-based economy and relying more on domestic sources to promote biofuels.

Role of modern bioenergy in energy transition

Bioenergy is an energy source that derives from organic matter present in plants or other organic waste. Using biomass in traditional cooking is problematic due to its inefficient use and the emission of harmful air pollutants, which can cause respiratory illnesses, especially in women and children. In 2020, around 54 per cent of bioenergy used was in the form of biomass for traditional cooking or heating (see *Graph 1: Share of global bioenergy consumption by end-use in 2022*).[5] There is widespread agreement that the traditional use of biomass should be phased out as soon as possible.

Modern bioenergy, which involves utilizing commercial solid, liquid and gaseous biomass-based fuels with advanced technology, can play a crucial role in combating climate change. It not only decreases GHG emissions but also contributes to regional energy supply, generates income for rural communities and enhances energy system flexibility, thereby increasing the resilience of societies worldwide. Modern bioenergy allows for the usage of domestic

Graph 1: Share of global bioenergy consumption by end use in 2022



Source: IRENA

resources more efficiently, resulting in affordable and clean energy. It is versatile in its applications, which range from solid bioenergy and biogases combusted for power and heat in homes and industrial plants to liquid biofuels used in cars, ships and airplanes.

The use of modern bioenergy increased at an average rate of approximately 7 per cent per year between 2010 and 2021, and this trend is expected to continue.[6] According to IEA's energy analysts, bioenergy is projected to account for 18 per cent of the total energy supply in 2050. By 2050, bioenergy will also be responsible for 15 per cent of energy consumption in industry, 16 per cent in transport and 10 per cent in buildings. It will also result in negative emissions through bioenergy carbon capture and storage, with a potential reduction of 1.3 billion tonnes of CO_2 per year.[7] However, further efforts are necessary to accelerate the deployment of modern bioenergy to meet the Net Zero Scenario.

Significance of compressed biogas in modern bioenergy

Achieving net zero emissions requires more than just offering renewable electricity; renewable gases and liquids are equally important. Compressed biogas (CBG), which can be integrated into the existing gas infrastructure, provides the easiest route to decarbonizing natural gas applications. The use of biomethane reduces the total cost of ownership of the energy system as the infrastructure for distribution and usage is already in place. Additionally, anaerobic digestion produces not only biogas, but also digestate that can be utilized as a renewable biofertilizer locally, either directly or after upgrading. The CO_2 that needs to be separated from the biogas to obtain biomethane can also be valued as a co-product.

Biogas systems offer a versatile way to produce energy from a variety of organic feedstock, including waste materials such as municipal or industrial organic waste, agricultural residues, and plant materials. One of the advantages of biogas systems is that they can be set up and operated locally, providing a dependable source of energy and contributing to energy security. In addition to replacing fossil fuels, biogas systems are also multi-functional. They help in improving waste management, promoting a circular economy and reducing greenhouse gas emissions.[8]

Sustainable development goals and CBG

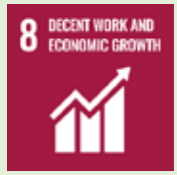
Sustainable development goals (SDGs) are a set of 17 global goals established by the United Nations General Assembly in 2015 to be achieved by 2030. They aim to address a range of social, economic and environmental challenges facing the world, including poverty, hunger, health, education, gender equality, climate change, and sustainable cities and communities. The production of biogas has a direct impact on and supports a majority of the SDGs.[9] Specifically, it serves as an affordable and clean source of energy that can facilitate the attainment of other goals, including clean water and sanitation, and resolving the water-energy nexus. Moreover, biogas plays a significant role in climate action by reducing carbon and GHG emissions. The connection of CBG production to 15 SDGs has been listed in Table 1.

CBG-related announcements in the Indian Union Budget 2023–24

On 1 February 2023, the Indian government announced a budget of Rs 35,000 crores to accelerate the transition towards clean energy and promote energy security. A significant portion of this budget, amounting to Rs 10,000 crores, will be utilized for the Galvanizing Organic Bio-Agro Resources Dhan (GOBARdhan) scheme. This scheme aims to install 500 new waste-to-wealth bio-CNG plants that will generate compressed biogas from organic waste.

Out of the 500 bio-CNG plants, 200 will be CBG plants, and 75 of these plants will be located in urban areas. The remaining 300 plants will be community or cluster-based plants. Additionally, the government plans to introduce a mandate for all organizations marketing natural gas to use at least 5 per cent CBG in the future. The Minister of Finance, Nirmala Sitharaman, also proposed exempting excise duty on GST-paid CBG that is contained in blended compressed natural gas to avoid cascading taxes.

Table 1: The role and interconnectedness of biogas in achieving sustainable development goals

Relevant SDG	CBG contribution	Relevant SDG	CBG contribution
	Helping small-scale farmers by providing them with affordable fertilizer and addressing the challenges associated with the complicated process of getting fertilizer to them.		Establishing a sustainable infrastructure and creating value from waste through the production of biogas.
	Boosting the efficiency of farming by improving the quality of soil through the restoration of depleted nutrients, organic materials and carbon.		Preventing diseases by collecting organic waste and treating wastewater, while simultaneously decreasing unpleasant odours and improving air quality, as well as increasing access to green energy.
	Decreasing the level of contact with both methane gas discharges and chemical fertilizers.		Improving the utilization efficiency of natural resources by decreasing air and water pollution, and enhancing the process of waste recycling.
	Enhancing the availability of energy in rural regions would enhance the standard of education.		Lowering GHG emissions by offering an energy source that emits less, as well as minimizing methane emissions from various industries.
	Supplies an inexpensive energy source to the nearby villages in rural regions, thereby enhancing the standard of living for women and children.		Preventing pollution from land sources as a means of decreasing marine pollution.
	The availability of energy could lead to an increase in wastewater treatment capacity, which could improve water quality. Additionally, managing household and animal waste may also enhance hygiene conditions.		Decreasing deforestation through the substitution of solid fossil fuels with biogas, while also improving land-use productivity and minimizing land-use change.
	Enhancing energy sustainability through improved reliability and affordability of energy supply, as well as increased energy storage capacity.		Improved energy access is related to peace. It can contribute to economic development and job creation, reducing poverty and social inequality, which are often root causes of conflict
	Improving waste management practices and reducing the carbon footprint of materials can boost the GDP.		

2. CBG BASICS, INDIA'S ROADMAP AND INSTALLED CAPACITY

- CBG or bio-CNG is primarily methane (>90 %) with a calorific value of 47–52 MJ/kg and can be used as a substitute for fossil fuels like natural gas, petrol and diesel.
- India's CBG industry got a major push by the introduction of the Sustainable Alternative towards Affordable Transportation (SATAT) scheme by the Ministry of Petroleum and Natural Gas in 2018.
- As of March 2023, 58 CBG plants have been operationalized in India, and a letter of intent for setting up similar plants has been issued to 3,694 prospective investors.

Difference between biogas and compressed biogas

The main difference between biogas and compressed biogas (CBG) is in their composition and properties (see *Table 2: Composition of biogas and CBG*). Biogas is a mixture of gases, primarily methane and carbon dioxide, produced by the breakdown of organic matter in the absence of oxygen. It also contains small amounts of other gases such as hydrogen, nitrogen and hydrogen sulphide.

On the other hand, bio-CNG or CBG is a purified form of biogas that has been compressed to high pressure and has undergone further processing to remove impurities such as carbon dioxide, moisture and hydrogen sulphide. This results in a gas that is primarily methane, with a methane content of at least 90 per cent, and can be used as a substitute for fossil fuels like natural gas and diesel.

Table 2: Composition of biogas and CBG

Composition	Raw biogas	Bio-CNG/CBG
Methane	55–65%	>90%
Carbon dioxide	30–40%	<4%
Hydrogen sulphide	0.1–4%	<16 ppm
Nitrogen	3%	<0.5%
Oxygen	0.1–2%	<0.5%
Moisture	1–2%	0%
Calorific value	19.5 MJ/kg	47–52 MJ/kg

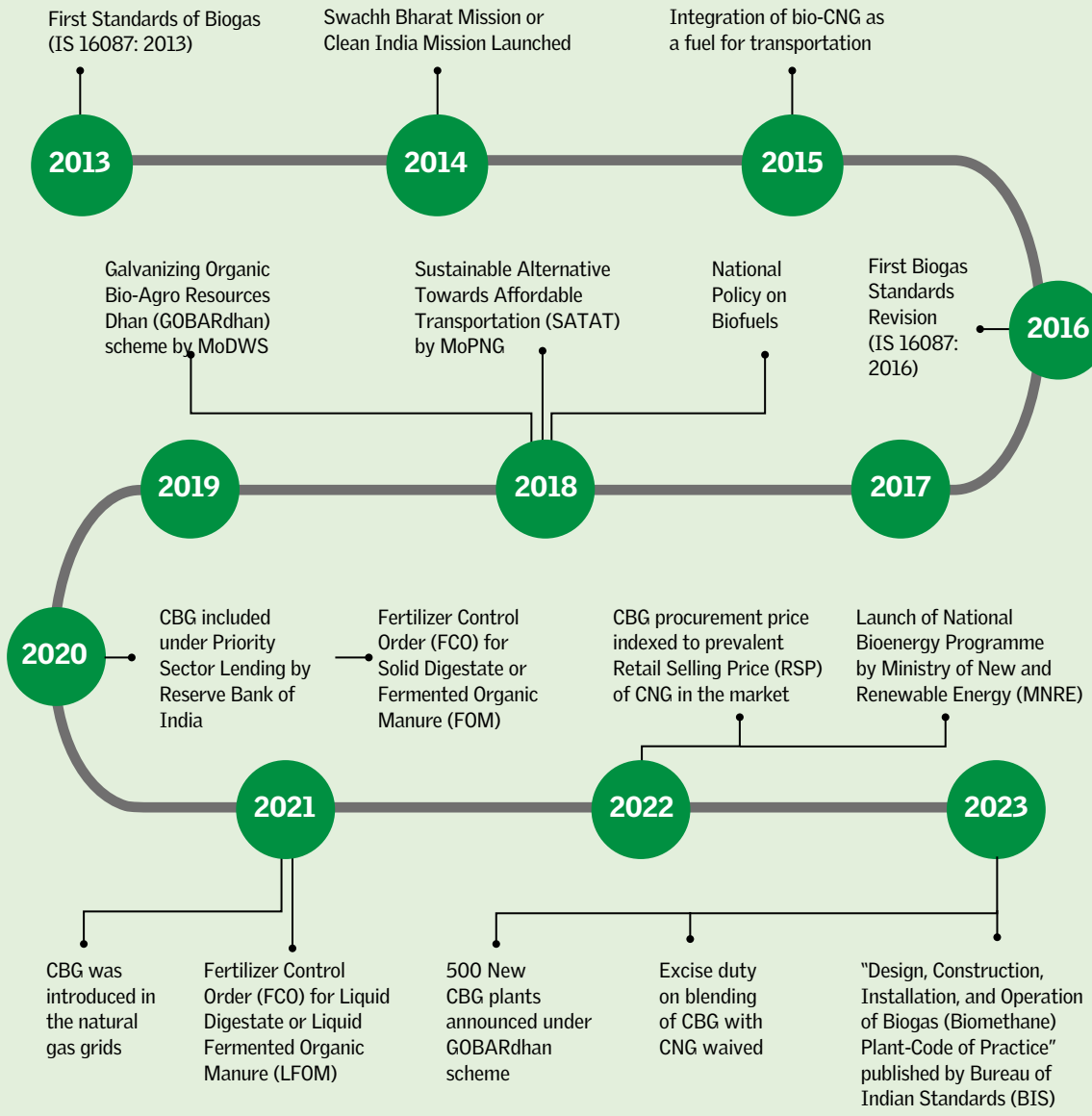
How biogas compares with other fuels

The energy content of biogas is compared to other fuels in terms of its heating value, which is a measure of the amount of energy released when the fuel is burned (see *Table 3: Quantity of different fuels required to produce heating value equivalent to 1 m^3 of biogas*). The heating value of biogas depends on its composition, particularly its methane content, which typically ranges from 50–70 per cent. The higher the methane content, the higher the heating value of the biogas.

Table 3: Quantity of different fuels required to produce heating value equivalent to 1 m^3 of biogas

Name of the fuel	Equivalent quantity to 1 m^3 of biogas
Kerosene	0.62 l
Firewood	3.50 kg
Cattle dung cake	12.3 kg
Charcoal	1.46 kg
Furnace oil	0.40 l
Electricity	1.25 kW
LPG	0.43 kg
Diesel	0.52 l
Coal	1.6 kg

India's CBG roadmap



Installed capacity and commissioned plants

According to the information available on the Sustainable Alternative Towards Affordable Transportation (SATAT) portal and MNRE, 58 CBG plants have been commissioned in India, and 3,694 potential investors have been issued a letter of intent (LOI) for setting up similar plants as of March 2023. Moreover, as of that date, approximately 9,019 tonnes of CBG has been sold (see *Table 4: Details of the 58 commissioned CBG plants as of March 2023*).

Table 4: Details of the 58 commissioned CBG plants as of March 2023

Sr. No.	State	Project developer	Location of plant	District	Type of feed stock	Bio-CNG production (kg/day)
1	Andhra Pradesh	M/s Vyzag Bio-Energy Fuel Pvt Ltd	Visakhapatnam, Andhra Pradesh	Visakhapatnam	Mixed waste	850
2	Andhra Pradesh	M/s Gayathree Innovative Energies Pvt. Ltd	Rangam peta, East Godavari, Andhra Pradesh	East Godavari	Mixed waste	600
3	Andhra Pradesh	Mahindra Waste to Energy Solutions Limited (Piduguralla)	Survey No: 892/49/A , Seetharampuram Mines road, Piduguralla Municipality (V), Guntur	Guntur	MSW (Biodegradable)	850
4	Andhra Pradesh	Mahindra Waste to Energy Solutions Limited (Adoni)	Survey No. 155 , Adoni Municipality (V), Adoni (M), Kurnool (District), Andhra Pradesh - 518301	Kurnool	MSW (Biodegradable)	800
5	Andhra Pradesh	Mahindra Waste to Energy Solutions Limited (Tirupati)	Survey No :731, Tukivakam Village, Renigunta (Mandal), Tirupati ,Chittor (District), Andhra Pradesh- 517502	Chittoor	MSW (Biodegradable)	1,680
6	Chhattisgarh	M/s R.G. Organics	M/s R.G. Organics,25-27, Industrial Area Birkoni,Mahasamund	Mahasamund	Livestock (cattle dung)	400
7	Gujarat	M/s Bharat Biogas Energy Ltd.	R.S. No. 806, Palki Road side, Sundalpura, Tal. & Dist. Anand, Gujrat	Anand	Mixed waste	6538
8	Gujarat	M/s Greenearth Biogas Pvt Ltd.	Survey No.442, Kukuda Village, MuliTaluka, Dist.Surendranagar, Ahmedabad-Rajkot Highway No17, Gujarat	Surendranagar	Mixed waste	6,000
9	Gujarat	M/s Rockstone Infrastructure Pvt. Ltd.	Sewage Treatment Plant, AMC, Ahmedabad	Ahmedabad	Urban (STP)	6,400
10	Gujarat	M/s Agricultural Produce Market Committee (APMC) , Surat	Sardar Market, Dumbhal, Surat, Gujarat	Surat	Mixed waste	2,200
11	Gujarat	M/s Goverdhannathji Energies LLP	village - Pij, Tal. Nadiad, Dist.Kheda, Gujarat	Kheda	Mixed waste	7,200
12	Gujarat	M/s Apex Green Energy Corporation	village Chavaj, Dist Bharuch, Gujarat	Bharuch	Mixed waste	5,600
13	Gujarat	M/s Turquoise Bio Natural Energy Pvt Ltd	Village Ochhan, Amod, Bharuch, Gujarat	Bharuch	Mixed waste	5,600
14	Gujarat	M/s Glow Green Biotech	Dungra, Surat,Gujarat	Surat	Mixed waste	2,200
15	Gujarat	APMC, Ahmedabad	Ahmedabad	Ahmedabad	Mixed waste	1,200
16	Gujarat	M/s Shri Hari BioCNG & Fertilizer LLP	District-Bharuch, Gujarat	Bharuch	Mixed waste	5,628
17	Gujarat	Sayaji Bio Energies LLP	Bahutha	Vadodara		3,000
18	Gujarat	M/s. Aryan Associate and Company	Vadodara	Vadodara		2,000
19	Gujarat	Bleach Energy	Sundalpura, Umreth	Anand		2,000
20	Haryana	M/s Sarovar Agro Farms & Biogas Pvt. Ltd.	Village - Jatwar, Tehsil:- Naraingarh, Dist. Ambala (Haryana)	Ambala	Industrial (poultry litter)	600

Sr. No.	State	Project developer	Location of plant	District	Type of feed stock	Bio-CNG production (kg/day)
21	Haryana	M/s Panchkula Farms Pvt. Ltd.	Village Jaspur, Distt. Panchkula, Chandigarh	Panchkula	Industrial (poultry litter)	1,450
22	Haryana	M/s JPS Agrotech, Haryana	Village -Assan, Tehsil & Dist. Rohtak(Haryana)	Rohtak	Livestock (cattle dung)	2,200
23	Haryana	M/s Spectrum Renewable Energy Pvt Ltd	Village-maruadi Jattan, Kalanaur, Rohtak,Haryana	Rohtak		6,000
24	Haryana	M/s Amrit Fertilizers	Bada Gaon Road, Village Kunjpura,Distt. Karnal,Haryana	Karnal	Livestock (cattle dung)	4,200
25	Karnataka	M/s Mahindra & Mahindra Ltd	Survey No.71/3, Santhehalli Village, Malur Taluk, Kolar District, Near Bengaluru, Karnataka	New Bengaluru	Urban (biodegradable)	1,800
26	Karnataka	M/s Bombay Burmah Trading Corporation Ltd.	Elkhil Estates, Siddapur, Kodagu, Karnataka	Kodagu	Mixed waste	2,500
27	Karnataka	M/s Noble Exchange Environment Solutions Bangalore Pvt. Ltd.,	Village Kannahalli, S.No. 85, Yashwanthapura Hubli, Magadi Road, Bangalore	Bangalore urban	Mixed waste	5,221
28	Karnataka	M/s Kyathi Green Energy Pvt. Ltd	Haveri Distt.	Haveri	Mixed waste	1,100
29	Madhya Pradesh	M/s Shri Dayoday Urja Evam Jaivik Khaad	Vill-Dob Barkhedi Sukhi Sevania, The- Huzur, Bhopal	Bhopal	Livestock (cattle dung)	1,200
30	Madhya Pradesh	M/S. Aryan Associate and Company	Ujjain	Ujjain		2,000
31	Madhya Pradesh	Indore Clean Energy Private Limited	Plot No 154/174, Trenching Ground, Devguradiya , By Pass Nemaver Rad,, Indore , Madhya Pradesh-452016	INDORE	Urban (biodegradable portion of MSW)	15,300
32	Maharashtra	M/s Clarus Bioenergy Pvt. Ltd.	Plot No. D-5, Shirala Industrial Growth Center, MIDC, Shirala, Dist. Sangli,Maharashtra.	Sangli	Livestock (cattle dung)	3,613
33	Maharashtra	M/s Green Elephant India Pvt. Ltd.	Kisanveernagar, Bhuinj, Tal. Wai, Dist. Satara, Maharashtra	Satara	Industrial (distillery effluent)	7,920
34	Maharashtra	M/s Spectrum Renewable Energy Pvt. Ltd.	Warana nagar, Kolhapur, Maharashtra	Kolhapur	Industrial (distillery effluent)	8,000
35	Maharashtra	M/s Noble Exchange Environment Solutions Pune LLP	Ambi, Pune: Maharashtra	Pune	MSW (biodegradable)	8,190
36	Maharashtra	Jakraya Sugar Ltd.	Solapur	Solapur		7,000
37	Maharashtra	M/S. Sama chemo pvt. Ltd	Sangli	Sangli		8,000
38	Maharashtra	Natural Sugar and Allied Industries Ltd	Sainagar Ranjani, Taluka Kallam, District Osmanabad, Ranjani, Maharashtra 413528	OSMANABAD	Industrial (distillery)	5,500
39	Punjab	M/s Arc Biofuel Pvt. Ltd.	Village Khotesaran, Handiaya, Marisa Rd. Barnala, Punjab	Barnala	Livestock (cattle dung)	1,847
40	Punjab	Verbio India Pvt. Ltd.	Vill. Bhutal kalan, Lehra Dugal, K-M Stone 7-8, Raidharana road, tehsil-Lehragaga, Sangrur	Sangrur	Agricultural (paddy straw)	33,000

Sr. No.	State	Project developer	Location of plant	District	Type of feed stock	Bio-CNG production (kg/day)
41	Punjab	T R Mega Foods and Beverages LLP	Ludhiana	Ludhiana		5,000
42	Rajashtan	M/s Brajdham Power Pvt. Ltd.	Sewage Treatment Plant, Delawas, Jaipur, Rajasthan	Jaipur	Urban (STP)	3,000
43	Rajashtan	M/s NRB Bio-Energy,	2 PBN, Dabli Rathan, Teh. & Distt. Hanumangarh, Rajasthan -335 512	Hanumangarh	Livestock (cattle dung)	1,000
44	Tamil Nadu	M/s IOT Biogas Pvt Ltd (Formely IOT Mabagas Pvt Ltd)	Namakkal, Tamil Nadu	Namakkal	Mixed waste	15,000
45	Tamil Nadu	M/s SLR Energy	Cuddalore, Tamil Nadu	Cuddalore	Mixed waste	2,800
46	Tamil Nadu	Energim Sustainable Solutions, Cuddalore	SIPCOT Industrial Complex, Phase 3, Cuddalore, Tamil Nadu	Cuddalore	Mixed waste	10,600
47	Tamil Nadu	Srinivas Waste Management Service Private Limited	Block No. 0029, S.F. No. 465/4, 20, 30, Spur Tank Road, Egmore, Part 1 Village, Egmore, Taluk, Chennai-600031	CHENNAI	Urban (biodegradable portion of MSW, fruit and vegetable market waste, hotel/ restaurant/ kitchen waste)	4,800
48	Telangana	Solika Energy Pvt Ltd	S No. 604/605/607, Udityal village, balanagar mandal, mahabubnagar district,Telangana	Mahabubnagar	Industrial (poultry litter)	2,400
49	Telangana	M/s Ramky group (M/s Hyderabad Integrated MSW limited)	Survey 173, Near Army College of Dental Sciences, Village: Jawaharnagar, Mandal: Kapra, District: Medchal, Hyderabad-500087, Telangana	Medchal–Malkajgiri	MSW (landfill)	2,000
50	Telangana	Solika Energy Pvt Ltd	Plot No.82, Kavuri Hills, Phase 2, Madhapur, Hyderabad	Madhapur	Livestock waste, poultry waste,	3,000
51	Uttar Pradesh	M/s Samagra Agro	ViiI. Phuphwar Sui Thok, Sarsaul Kanpur Sadar	Kanpur	Livestock (cattle dung)	2,000
52	Uttar Pradesh	Indian Potash Limited	Village - Baheri, P.O. Rohana Mill, Block - Charthawal, Tehsil & Distt.- Muzaffarnagar, (U.P.)	Rohana Mill, Block - Charthawal	Industrial (sugar industry effluent)	10,200
53	Uttar Pradesh	M/s PS Green GAS	Khataaulli, Muzzafarnagar	Muzzafarnagar	Mixed waste	5,600
54	Uttar Pradesh	Varanasi Municipal Corporation	Varanasi	Varanasi		2,500
55	Uttar Pradesh	Sobti Engineering Works Pvt. Ltd.	Village Bhadauli, Tehsil Modinagar, Ghaziabad	Ghaziabad		2,400
56	Uttarakhand	M/s Century Pulp & Paper	Lalkuan, Nainital, Uttarakhand.	Nainital	Industrial (paper industry effluent)	5,460
57	Uttarakhand	M/s Shree Krishnayan Desi Gauraksha Evam Goulok	Basochandpur, Haridwar, Uttarakhand	Haridwar	Livestock (cattle dung)	420
58	West Bengal	Phoenix India R & D Group	Birbhum	Birbhum		6,000

Source: MNRE

3. INDIA'S BIO-CNG PRODUCTION POTENTIAL

- **In India, CBG production primarily relies on major feedstocks such as agricultural waste, animal and poultry waste, sewage sludge, pressmud and the organic fraction of municipal solid waste.**
- **Among all the states in India, Uttar Pradesh holds the highest potential for CBG generation.**
- **Napier grass and agricultural residue exhibit the highest CBG conversion efficiency at 10%.**

Availability of different feedstocks and their production capacity

Biomass refers to organic matter derived from living organisms—including plants, animals and microorganisms—that grow on land or water. This organic matter can be utilized to generate biogas, which is a renewable energy source. India has a diverse range of feedstocks available for biogas generation. The most common feedstocks include animal waste, agricultural residue, organic fraction of municipal solid waste (MSW) and sewage sludge.

Agriculture is the primary source of livelihood for over 50 per cent of the population in India. While energy crops are not commonly grown specifically for anaerobic digestion, there is a significant amount of crop residue generated as a by-product of crop production, which can be used for this purpose. Moreover, India has one of the largest livestock populations in the world, with 536.76 million animals as of 2022, including 308 million cattle. On average, these animals produce approximately 4–5 per cent of their body weight in dung per day. Since animal waste is composed of organic material, moisture and ash, there is significant potential for biogas production from the massive amount of animal manure produced.

Table 5: Contribution of different feedstocks for CBG generation in India

Categories of organic waste	Annual feedstock potential (MT)	Estimated potential of bio-CNG (MMT)	Contribution (%)
Surplus agro-residues	150	20	32
Spent wash/pressmud	20	2	3
Municipal solid waste (MSW): Organic fraction	62	5	8
Sewage treatment plants	50	10	16
Animal and poultry waste	190	25	41

Source: Petroleum Research, Vol 7 Issue 3, https://doi.org/10.1016/j.ptlrs.2021.12.003

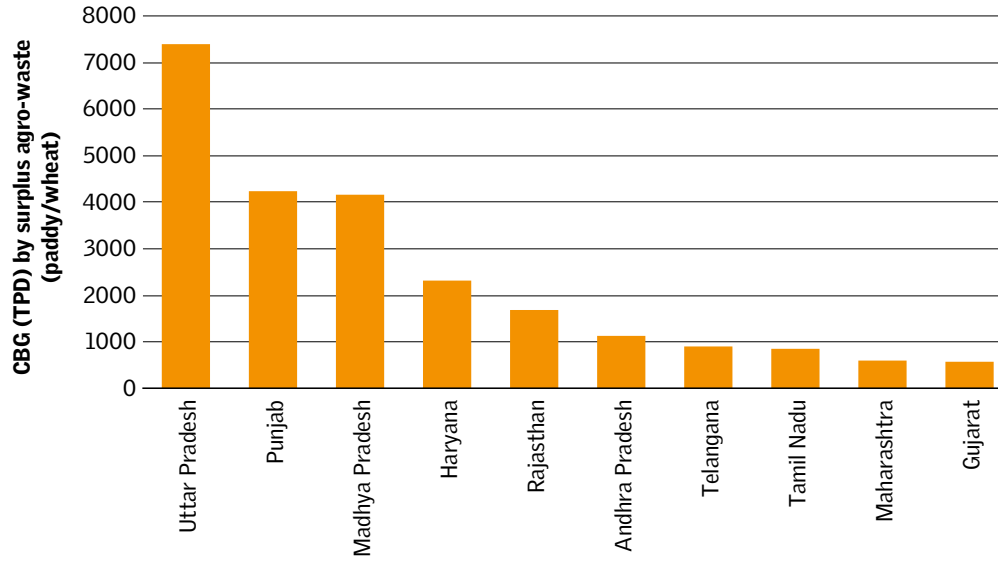
Animal waste and agricultural residue are the primary sources of CBG production in India. Cattle dung and chicken litter have a potential to produce 25 million metric tonnes per annum (MMTPA) of CBG, while agricultural residue has a potential to produce 20 MMTPA of CBG. Other sources such as pressmud, municipal solid waste and sewage from sewage treatment plants have potentials to produce 2, 5 and 10 MMTPA of CBG respectively.[10] In the case of agro-residue surplus, sugarcane and rice straw have the highest contributions at 23 and 24 per cent respectively. Wheat has a contribution of 14 per cent, while the remaining crops such as maize, soybean, gram, mustard, groundnut, castor and tur, have a combined contribution of 22 per cent in agro-residue surplus. The total dry biomass generated from these 11 crops is 638 MMTPA, with a surplus of 26 per cent or 178 MMTPA that can be utilized to produce 51 billion litres of bioethanol or alternatively 20 MMTPA of CBG.

State-wise availability of different feedstock

The potential for CBG production has been assessed for various sources of feedstock in different states of India.[11] These sources include surplus agricultural residue from paddy and wheat crops (*see Graph 2*), municipal solid waste (*see Graph 3*), wastewater sewage (*see Graph 4*), dairy industry waste (*see Graph 5*), and waste from the sugarcane and distillery industry (*see Graph 6*).

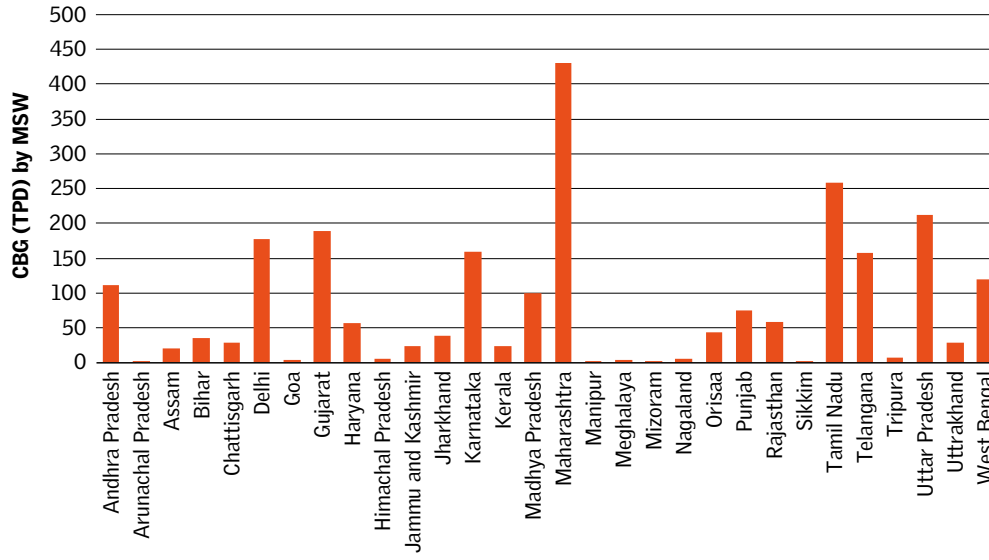
The states with the highest potential for generating CBG from agricultural waste are Uttar Pradesh, Punjab, Madhya Pradesh and Haryana.[12] Maharashtra has the greatest potential for generating CBG from municipal solid waste at 430.6 TPD (about 18 per cent), followed by Tamil Nadu with a potential of 258.8 TPD (about 11 per cent). When it comes to wastewater sewage, Maharashtra, Uttar Pradesh, Tamil Nadu and West Bengal are the top producers. In terms of sugarcane and distillery waste, Maharashtra and Karnataka are the frontrunners. Gujarat and Maharashtra have the greatest potential for generating CBG in the dairy industry. Overall, Uttar Pradesh is the state with the highest CBG generation potential, followed by Punjab, Madhya Pradesh, Haryana, Rajasthan, Andhra Pradesh, Maharashtra, Telangana, Tamil Nadu and Gujarat. Among the northeastern states, Assam has the highest potential at 36.4 TPD, while Sikkim has the lowest at 2.17 TPD. Even though almost every state in India has the capacity to generate it, CBG plants are only found in a few states.

Graph 2: CBG generation potential by surplus agricultural residue (paddy and wheat straw) in different states of India



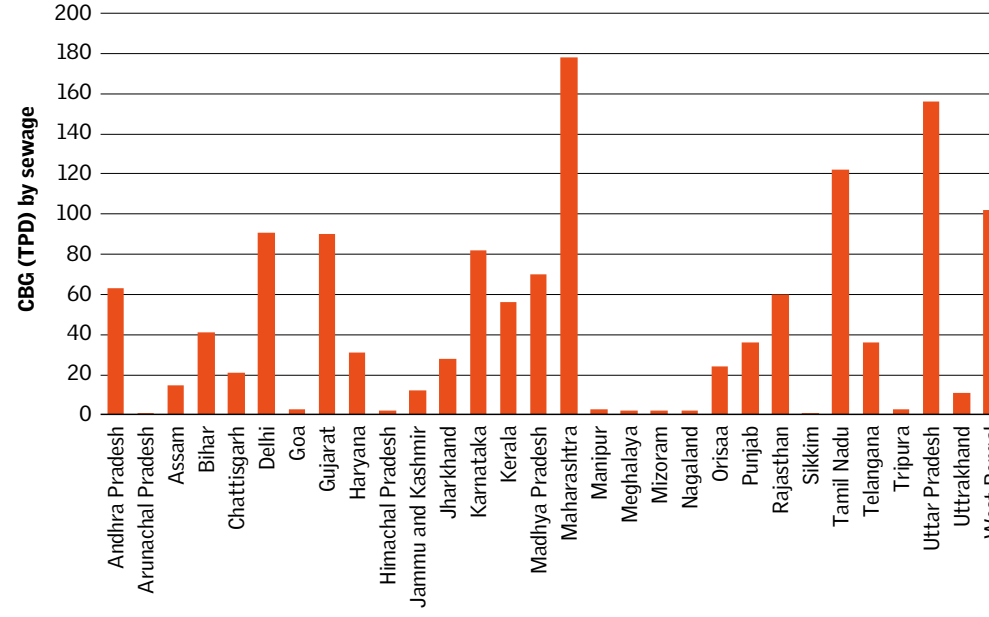
Source: Author analysis based on data by Global Green Growth Institute[13]

Graph 3: CBG generation potential by municipal solid waste in different states of India



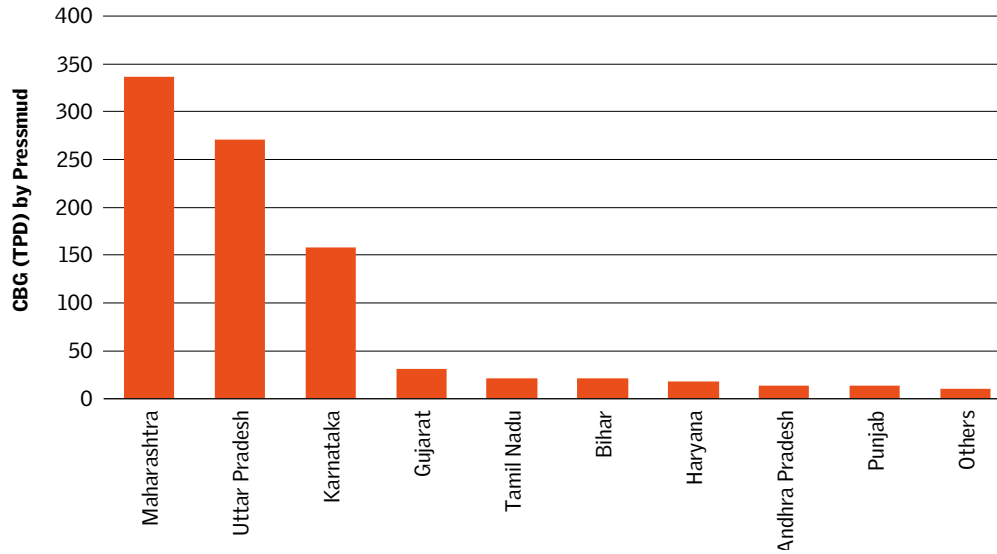
Source: Environmental Technology and Innovation, Volume 26, May 2022[14]

Graph 4: CBG generation potential by wastewater sewage in different states of India



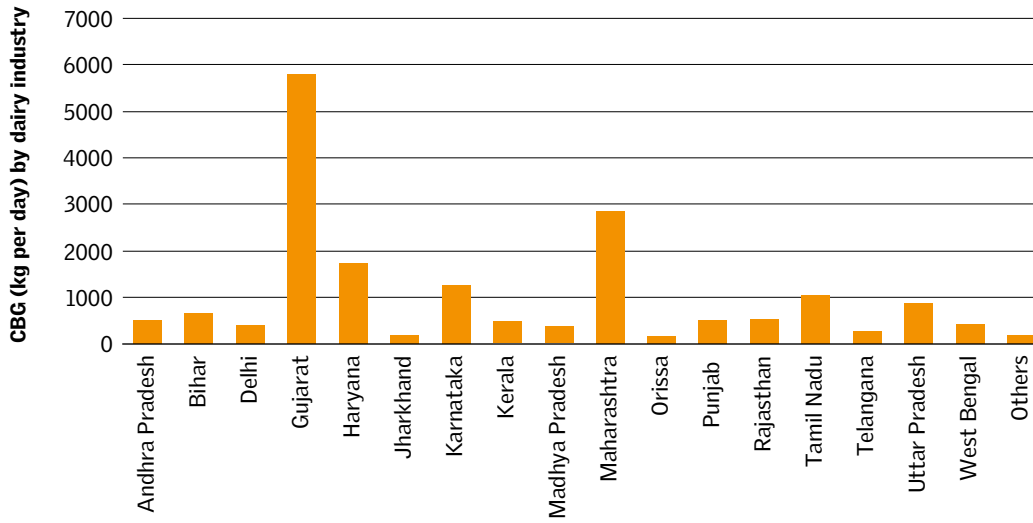
Source: Environmental Technology and Innovation, Volume 26, May 2022[15]

Graph 5: CBG generation potential by pressmud in different states of India



Source: Author analysis based on data by Statista[16]

Graph 6: CBG generation potential by dairy industry in different states of India

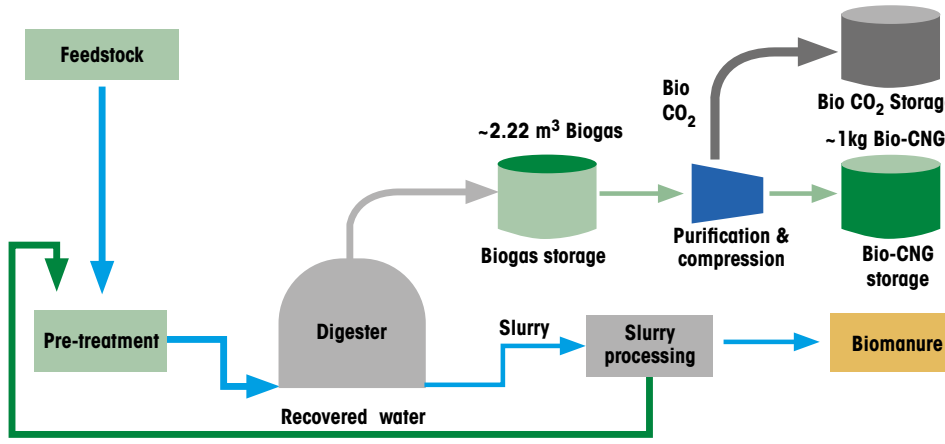


Source: Environmental Technology and Innovation, Volume 26, May 2022[17]

Bio-CNG production efficiency of various feedstocks

The efficiency of biogas production from different feedstocks depends on the substrate characteristics and process conditions. Table 6 highlights the CBG production potential of different feedstocks whereas Table 7 presents the average animal waste and corresponding biogas yield from different animals.[18]

Figure 1: Process of producing and storing compressed biogas



Source: GGGI[19]

Table 6: Biogas and CBG production efficiency of different organic feedstocks

Feedstock	Feedstock requirement	Biogas production	CBG production
Agriculture residue	10 kg	2.2 m^3	1 kg
Pressmud	25 kg		
Sewage sludge	20 kg		
Bagasse	10 kg		
Municipal solid waste	25 kg		
Cow dung	50 kg		
Chicken litter	25 kg		
Forest residue	15 kg		
Napier grass	10 kg		

Table 7: Waste production and biogas yield from different animal varieties

Animal	Waste produced (kg/day)	Biogas yield (m^3/kg)
Cattle	10	0.04
Buffalo	15	0.04
Sheep	2	0.04
Goat	2	0.037
Pigs	4	0.075
Horse	15	0.04
Donkey	10	0.048
Camel	8	0.03
Poultry	0.18	0.05
Mithun	16.5	0.02

Source: Biomass Conversion and Biorefinery (2021)[20]

4. SCIENCE AND TECHNOLOGY OF BIO-CNG PRODUCTION

- **CBG generation involves four key steps, namely feedstock pretreatment, anaerobic digestion, biogas purification and compression.**
- **Chemical scrubbing with amines provides the highest purity methane (> 99%) with minimum losses and power consumption during the upgradation.**
- **Temperatures between 35–38°C, pH between 6.5–7.2, and C:N ratio of 30:1 have been found optimum for biogas production.**

Biogas: Technology for a circular economy

The process of anaerobic digestion uses various organic materials to create biogas, which is composed mostly of methane (40–60 per cent) and carbon dioxide (30–35 per cent), with small amounts of impurities such as H_2S, ammonia and moisture. A number of products with many potential uses can be derived from anaerobic digestion (see *Figure 2: Schematic of different products produced from the anaerobic digestion process*).

Figure 2: Schematic of different products produced from the anaerobic digestion process

Source: Energies 2021, 14(13), https://doi.org/10.3390/en14133856[21]

The generated biogas can either be utilized as a cooking fuel or processed further to remove CO_2, H_2S and moisture content, resulting in a fuel of higher calorific value. If the methane content of the upgraded product is above 90 per cent, it can be used directly as a transportation fuel to replace CNG or injected into gas grids. Alternatively, biogas can be utilized to produce electricity and heat through a combined heat and power (CHP)

gas engine. CHP maximizes fuel efficiency and converts it into electricity with 35 per cent efficiency and into heat with 50 per cent efficiency. This method is ideal for commercial use at hospitals, nursing homes, laundries and hotels where demand for hot water is high. Another significant by-product of this process is biofertilizer, which can be separated into solid and liquid fragments. This is an excellent soil conditioner and can replace the use of toxic chemical fertilizers. Biogas is an excellent example of developing a circular economy where waste resources are transformed into clean energy and organic fertilizers.

Setting up a CBG Plant: Steps and machinery

Feedstock pre-treatment

One significant problem with certain types of feedstocks is that they are difficult for microorganisms to break down, or the process of breaking them down is extremely slow. In such cases, pre-treatment methods can be used to eliminate inhibitory compounds and accelerate digestion. These methods not only increase biogas production, but also decrease the volatile solid content. Pre-treatment methods can be several—physical, chemical, thermal, biological, mechanical, etc.

Mechanical pre-treatment aids in separating different components of the feedstock, grinding solid particles and increasing the surface area. In thermal pre-treatment, the feedstock is subjected to varying temperatures to degrade it. In chemical pre-treatment, strong acids, alkalis or oxidants are employed to break down organic compounds. It is commonly used in the treatment of wastewater sludge and lignocellulosic biomass. A combination of these pre-treatment methods may also be utilized to achieve optimal results. The effectiveness of each method varies depending on the unique characteristics of the feedstock. To transform solid waste into the consistency of a slurry, water is also often added in a specific amount depending on the nature of the waste material.

Equipment required: Receiving platform, shredders, screw press, conveyor belts, sorting system, grinders, agitators, hydrolysis unit (in the case of agro-waste), pre-treatment tank, feeding tank and feed pump.

Anaerobic digestion

After pre-processing, the feedstock is transported to the digester where mesophilic or thermophilic organisms facilitate the digestion process. To reduce the start-up period's lag phase, bio-augmentation is implemented by introducing specific microorganisms or enzymes. Both pure cultures and mixed consortia are viable options, but the latter may be more advantageous due to the potential synergistic interactions between different microorganisms. Materials such as cow dung and poultry droppings are popular for enhancing biogas production due to the abundance of microorganisms in them.

Table 8: Biological steps involved in biogas production

Step	Description
Hydrolysis	Hydrolysis is a chemical procedure that decomposes intricate organic compounds like carbohydrates, fats and proteins into simpler substances such as glucose molecules, fatty acids and amino acids. To alter organic molecules, microbes require them to be soluble. Acid hydrolysis is aided by hydrolase, an enzyme secreted by microorganisms that converts insoluble polysaccharides into soluble molecules.
Acidogenesis	Following hydrolysis, bacteria convert glucose derivatives, fatty acids and amino acids into volatile fatty acids (VFAs) and alcohols.
Acetogenesis	The volatile fatty acids and alcohols are converted into hydrogen, carbon dioxide and ammonia via the acetogenesis pathway.
Methanogenesis	Methanogenesis is the final stage in which archaea—single-celled organisms—convert hydrogen and acetic acid into methane and carbon dioxide. Maintaining the optimal pH range is critical for methanogens. The optimum pH range for methanogens has been found to be between 6.5 and 7.5, and any deviation from this range can cause delays or complete cessation of methane production.

Anaerobic digestion systems can be categorized into three types—batch, semi-continuous and continuous—depending on how the feedstock is introduced to the digester. Batch systems involve filling the digester to capacity without any mixing of additional feedstock until the process is complete. These systems are the most resilient to contamination and do not require extensive feedstock pre-processing. They are used for both low-solid content feedstock, such as manure and sludge, and high-solid content feedstock, such as organic matter from municipal solid waste. In semi-continuous systems, a set quantity of feedstock is added to the reactor periodically, usually daily, and the same amount of digestate is removed from the digester's effluent end. These anaerobic digestion systems can process both low-solid content materials like manure and high-solid content materials like food waste.

Continuous reactors are characterized by continuous inflow and outflow of feedstock and digestate. The flow rate is adjusted to ensure optimal digestion of the feedstock. To prevent mechanical issues, these reactors require low-solid content feedstock that is pumpable and free from contaminants. These systems are complex and need skilled operators and carefully prepared feedstock. They are suitable for sludge from wastewater treatment plants, wastewater from food processing and diluted manure.

Moreover, improving biogas production in a one-stage digester is challenging due to variations in metabolic properties, nutritional requirements, growth rates and optimum operational factors in different stages of digestion. A two-stage digestion process, which separates the hydrolytic and acidogenic steps from the acetogenic and methanogenic steps, can enhance methane yield while reducing retention time. However, the cost of implementing such a complex system is a notable drawback.

Equipment required: Continuously stirred tank reactor (CSTR), covered lagoon, plug flow digester, anaerobic sequencing batch reactors (ASBRs) and up-flow anaerobic sludge blanket (UASB) are some of the models employed for digestion. "Design, Construction, Installation, and Operation of Biogas (Biomethane) Plant — Code of Practice" was released in February 2023 by the Bureau of Indian Standards. It explains different CBG digesters in detail (*see Annexure 1*). SCADA (Supervisory Control and Data Acquisition) connected panel system which involves a combination of hardware and software that allows operators to remotely control and monitor multiple devices and systems from a central location. The system consists of a network of sensors, controllers and other devices that gather data and send it to a central control panel, which is typically connected to a computer or a SCADA system. This system allows operators to monitor and control various processes and components, including temperature, pressure, flow and other critical parameters, and make necessary adjustments in real-time.

Biogas cleaning and upgrading

Pollutants in biogas constitute all those gases considered undesirable. Biogas purification process consists of two steps: biogas cleaning and biogas upgrading. The first step involves eliminating harmful or toxic elements like ammonia, hydrogen sulphide, carbon monoxide and siloxanes. The objective of the second step, biogas upgrading, is to increase the energy content of biogas and transform it into a fuel that meets specific standards. Biogas upgrading includes separating carbon dioxide from methane and drying the gas to eliminate moisture. Biomethane is the term used for biogas that has been upgraded and contains >90% (v/v) methane. Its composition is very similar to that of natural gas, which makes it suitable for use in the transportation industry and for direct injection into gas pipelines. Here are the four common biogas upgradation methods that are used:

1) **Water scrubbing:** Compared to methane, carbon dioxide is more soluble in water, particularly at lower temperatures. Therefore, in a scrubber column, as carbon dioxide dissolves in the water, the methane concentration in the gas phase increases. Consequently, the gas that exits the scrubber column has a higher concentration of methane.
2) **Pressure swing adsorption** (**PSA**) is commonly used in large biogas systems in India. This method involves separating carbon dioxide from the biogas by adsorbing it on a surface under high pressure. Activated carbon or zeolites are typically used as the adsorbing material. The technique gets its name from the fact that the adsorbing material is regenerated through a sequential reduction in pressure before reloading the column again.
3) **Membrane separation**: Membranes used for biogas upgrading are typically made of materials that are selectively permeable to certain gases. These materials allow carbon dioxide, water and ammonia to pass through easily, while impurities like hydrogen sulphide and oxygen can permeate through the membrane to some extent. The selective

permeability of these membranes is what allows for the separation of carbon dioxide from biogas, resulting in upgraded biogas with a higher methane concentration. These membranes can be in the form of hollow fibres bundled together, providing a large surface area for gas separation to take place.

4) **Chemical scrubbing**: In this technique, biogas is passed through a scrubber column, where it comes in contact with a chemical solvent known as monoethylamine (MEA). The MEA reacts with acidic gases, such as carbon dioxide and hydrogen sulphide, which are dissolved in the biogas, to form a chemical complex that can be easily separated from the gas stream. The chemical reaction with MEA reduces the concentration of impurities in the biogas stream, resulting in purified biogas with a higher methane content. Compared to other methods, the amine-scrubbing technique has advantages such as reduced methane losses, lower energy requirements and a higher final methane concentration. Nevertheless, this process has the potential to generate wastewater containing harmful chemicals that requires proper disposal.

Table 9: Comparison of biogas upgradation methods

Parameter	Pressure swing adsorption	Water scrubbing	Membrane separation	Chemical scrubbing
Pre-H_2S removal required	Yes	No	Yes	Yes
Working pressure (bar)	4–7	4–7	7–24	No pressure
Methane loss	20–30%	5–10%	0.5%	<0.1%
Methane content in upgraded gas	>96%	>97%	99%	>99%
Electricity consumption (kWh/m^3)	0.25	<0.25	0.23	<0.15

Source: CPCB[22]

Compression and distribution

Biogas which has been refined or purified is pressurized at a level of 250 bar, resulting in a type of fuel known as compressed biogas (CBG), which shares similar properties with compressed natural gas (CNG). It is sent to a bottling unit where it is filled and sealed into cylinders. These cylinders are then placed into cascades and transported for storage and sale. CBG is stored at gas filling stations using two commonly used systems: buffer and cascade storage systems. In a buffer storage system, the pressure of CBG is maintained at a consistent level of 250 bar for all reservoir cylinders. In contrast, in the cascade storage system, the reservoir cylinders are kept at varying low, medium and high pressures. CBG can be distributed through pipelines at low (~40 bar), medium (~160 bar) and high (~250 bar) pressures.

Alternatively, when methane from biogas is cooled to a temperature of -162 °C, it transforms into liquefied biogas (LBG). This fuel has a higher energy density, resulting in lower storage

space requirements. At atmospheric pressure, the energy density of liquid methane is approximately 600 times greater than that of gaseous methane and 2.5 times higher than that of methane at a pressure of 250 bar.

The biomethane produced needs to adhere to the following requirements and standards:

1. It must not contain any liquids throughout all the different temperatures and pressures it may encounter within the storage and dispensing system, fuel containers, engine and fuel system, and piped network.
2. It must not contain any particulate matter like dust, dirt and other similar substances.
3. The fuel delivered as biomethane must be odourized to a level comparable to that of the local distribution system.
4. The biomethane intended for use in automotive applications and piped networks must adhere to the requirements outlined in Table 10.

Table 10: Standards prescribed for bio-CNG or CBG composition

Characteristic	Requirement	Method of Test, Ref to
CH_4, per cent, Min	90.0	IS No. 5130 (Part 3)
Moisture, mg/m^3, Max	5	IS No. 15641 (Part 2)
Total sulphur (including H_2S), mg/m^3, Max	20	ISO 6326-3
CO_2+ N_2+ O_2, per cent, Max (v/v)	10	15130 (Part 3)
Only CO_2, per cent, Max (v/v)	4	15130 (Part 3)
O_2, per cent, Max	0.5	15130 (Part 3)

Source: BIS[23]

Biofertilizer production

The semi-liquid residue that is produced from the digester is referred to as bio-slurry. This by-product is an effective fertilizer for crops, as it enhances soil fertility, improves soil structure and increases crop yield. Studies have indicated that bio-slurry may even outperform traditional farmyard manure and may also decrease the need for chemical fertilizers. Additionally, bio-slurry is not harmful to the environment since it is free from weed seeds, unpleasant odours and pathogens.

After the slurry has undergone fermentation, it is separated using a solid-liquid separation device. A portion of the liquid component is combined with humic acid and additional fertilizer components to create a liquid fertilizer. This product is then packaged and sold, while any leftover water is recycled. The solid fraction obtained from separation is sent to an extruder or screw press where the fibrous material is compressed to create solid manure. This solid manure is packaged and sold similarly to the liquid fertilizer.

Equipment required: Solid and liquid separator, aeration tower, entry pump, forced-draught fan, storage tank, compost sewing machine, turners, earth mover, extruder/screw press and mating filling lines.

Table 11: Solid and liquid organic fertilizer standards

Parameters	Solid organic fertilizer	Liquid organic fertilizer
Moisture, per cent by weight	30–40	90–97
Particle size	Minimum 90 per cent material should pass through 4.0 mm IS sieve	Minimum 90 per cent material should pass through 4.0 mm IS sieve
Total organic carbon, per cent by weight, Min	14	14
NPK nutrients (Total N, P_2O_5, and K_2O, per cent), Min (For upgraded digestate-based organic fertilizer the numbers for P_2O_5 and K_2O are to be given)	1.2	1.2
C:N ratio	<20	<20
pH	6.5 to 8.0	6.5 to 8.0
Conductivity (as ds/m), Max	4.0	4.0
Pathogens	Nil	Nil
Arsenic (As)	10	10
Cadmium (Cd)	5	5
Chromium (Cr)	50	50
Copper (Cu)	300	300
Mercury (Hg)	0.15	0.15
Nickel (Ni)	50	50
Lead (Pb)	100	100
Zinc (Zn)	1000	1000

Source: BIS[24]

Factors affecting biogas production

Table 12: List of factors affecting the anaerobic digestion process

Parameter	Optimum	Description
Temperature	35°–38 °C	➢ Anaerobic organisms are most active within mesophilic (20–45 °C) and thermophilic (45–70 °C) temperature ranges. ➢ When temperature rises, the rate of gas production also increases, but the proportion of methane decreases.
Carbon to Nitrogen (C:N) ratio	25–30:1	➢ When the ratio of carbon to nitrogen is high, it indicates low nitrogen content that is not suitable for microbial growth. In such a situation, methanogens consume the available nitrogen for protein production, which ultimately results in carbon wastage and low biogas yield. ➢ If the C/N ratio is low, it can lead to the accumulation of nitrogen and ammonia, which may potentially cause inhibition in the process of anaerobic digestion.
pH	6.5 to 7.2	➢ In the event that the process causes a reduction in the pH of the substrate within the biodigester, it can be managed by addition of lime.
Loading rate	0.2 kg/m^3 of digester capacity	➢ The quantity of feed given to the digester daily is referred to as the loading rate. Both underloading and overloading can lead to a reduction in the production of biogas.
Stirring or agitation	30 rpm, intermittent	➢ Agitating the slurry aids in evenly distributing the feedstock and prevents it from settling, ensuring consistent microbial activity.
Toxic substances	Non-biodegradable waste	➢ Toxic substances such as ammonia, pesticides, detergents and heavy metals can hinder the fermentation rate since their presence is harmful to microorganisms.
Retention Time	Mesophilic: 10–40 days; Thermophilic: 14 days	➢ The time needed for the reactions to complete varies depending on the technology employed, process temperature and waste composition.
Solid concentration	TS < 15%	➢ When the solid concentrations are low, it becomes easier to mix the substrate, which, in turn, promotes the even distribution of nutrients and microorganisms within the digester. Additionally, low solid concentrations can reduce the chances of clogging.

Biogas Development and Training Centres (BDTCs) are facilities established to promote the development and use of biogas as a renewable energy resource. These centres provide training and technical support, along with disseminating information related to biogas technology to local communities, entrepreneurs and government agencies. BDTCs offer various services, such as training programmes, research and development activities, and consultancy services to help individuals and organizations learn about biogas technology, design and construct biogas plants, and operate and maintain biogas systems effectively (*see Annexure 2 for a detailed list of BDTC centres in India*).

5. KEY SITE SELECTION PARAMETERS AND REGULATORY APPROVALS

- **The overall availability of feedstock in a 15 km radius of the CBG plant shall be four times the actual plant requirement to avoid a feedstock crunch.**

- **It is crucial to map the gas infrastructure of the surrounding areas, which should include an assessment of the number of CNG pumps, availability of gas distribution grids, and CNG-fueled industries.**

- **It is necessary to have a sustained and deliberate effort to communicate the economic and environmental benefits of the project and to garner political and institutional support.**

Parameters to consider while selecting sites for CBG plants

The selection of a site for a CBG plant requires careful consideration of several parameters to ensure that the plant operates efficiently and safely. Some of the critical parameters to consider when selecting a CBG plant site include:

1) Steady and reliable supply of feedstock

Bio-CNG production requires a specific type of feedstock, which can be categorized into four main groups: agricultural waste, animal waste, industrial waste and municipal waste. Agricultural waste has a more consistent quality with fewer impurities. Due to the low energy content per unit of volume and the large quantity, transporting agricultural feedstock and stackable energy crops beyond 15 km is not economically feasible. Thus, it is recommended that a biogas plant be established within a 15 km radius of the readily available biomass. To ensure feedstock sustainability metrics, the overall availability of agricultural residue in this 15 km radius should be four times the actual plant requirement. It is recommended to secure at least 80 per cent of the feedstock supply using long-term agreements with either farmer-producer organizations or secondary biomass suppliers. The quantity and quality of the supply commitments must be specified with caution.

Ather Mehmood, a bio-CNG plant investor near Bulandshahr in Uttar Pradesh, emphasized the availability of feedstock as the most important parameter while setting up a 3.5-tonne capacity bio-CNG plant. He chose a location where multiple feedstocks such as agricultural waste, pressmud and cow dung were easily available within a 15 km radius. Additionally, he explored the possibility of cultivating Napier grass in the surrounding area.

To prevent market conflicts and fluctuations in prices due to competing interests for agricultural feedstock, it is necessary to maintain a minimum distance of 30 km between bio-CNG plants or other similar setups that consume the same biomass feedstock in a region.

2) Infrastructure for product off-take and marketability

The bio-CNG plant yields two primary products, namely compressed natural gas and organic fertilizers. To ensure the marketability of bio-CNG, a thorough analysis of a radius of 15–20 km is necessary, considering factors such as the number of CNG pumps, availability of gas distribution grid, industries that require CNG as fuel, and estimation of CNG retrofitted automobiles. The total demand in the area must exceed the production capacity to ensure a smooth selling process and determine an appropriate price for the product.

The other significant product from the plant is digestate, which also needs to be marketed and sold. It serves as an excellent soil conditioner and can be transformed into high-value organic fertilizer by enriching with crop-specific nutrients. Market research must be conducted

to identify potential customers—like private gardens, greenhouses and agricultural lands growing organic produce—to estimate the market size for biogas digestate.

3) Land ownership pattern and accessibility

Having clear and undisputed land ownership for the installation of a bio-CNG plant is advantageous as it makes it easier to obtain financing from banks and other potential investors. This also boosts the confidence of investors in the project and eliminates potential delays caused by the need to procure agreements from multiple stakeholders. Further, access to solid roads is crucial as the biogas plant requires a consistent supply of biomass, resulting in significant biomass outflow. When selecting a location for the plant, priority should be given to industrial sites rather than green areas to protect the landscape. Additionally, soil stability must be ensured to avoid unnecessary additional investments in improving underground conditions. If the plant requires 24-hour electricity due to automation, the possibility of obtaining an independent feeder line from a nearby power substation should be explored. It's also important to consider the plant's odour and noise emissions, which cannot be avoided. As a result, it's critical to choose a suitable neighbourhood that will minimize potential conflicts in the future.

4) State-specific benefits

Certain states provide special incentives for the installation of bio-CNG plants within their geographical boundaries. These states have bioenergy policies in place, which makes the regulatory clearance process for bio-CNG plant installation easier and faster. For instance, Uttar Pradesh released a new bioenergy policy in 2022 that offers Rs 75 lakh incentive per tonne of bio-CNG production. The policy also includes benefits such as free public land, tax exemptions and subsidies on farm equipment. An online bioenergy portal has also been established to increase transparency and facilitate a single-window clearance process.

5) Securing political and institutional support

Establishing a bio-CNG plant is intertwined with politics and requires significant public backing due to the considerable public and media interest in renewable energy. To gain political and institutional support, a continuous and intentional communication effort must be made to emphasize the economic and environmental advantages of the project to the region. It has been proven to be advantageous to arrange visits to bio-CNG facilities in the form of joint tours with central or regional institutes, showcasing the plant as a "Best Practice" model for clean energy generation or waste management.

Regulatory requirements

Setting up a CBG plant in India requires obtaining regulatory approvals from several government agencies (see *Table 13: List of regulatory approvals required to setup a CBG plant*).

Table 13: List of regulatory approvals required to setup a CBG plant

Sr. no.	Approvals required	Before construction (New factory)	After construction but before production/ operation	Annual renewal
1	Conversion to non-agricultural land (applicable for non-industrial land)	Conversion and registration	Not applicable	Not applicable
2	DIC (District Industry Centre)	Registration as MSME (Micro, Small & Medium Enterprises)	Not required	Not required
3	Fire	NOC	License	Required
4	Health and safety	NOC	License	Required
5	IOF (Indian Ordinance Factories) - Plan approval	NOC, BoCW (Building & Other Construction Workers) Registration	License (sub-contractor license)	Required
6	DTCP - District Town & Country Planning	Plan approval and tax	Not required	Not required
7	Local Panchayat	Plan submission, NOC and tax payment based on construction area	Yearly tax (if applicable)	Not required. Tax to be paid (if applicable)
8	BDO (Block Development Officer) - Running License	Not required	Running license	Required
9	PCB (Pollution Control Board)	Consent for Establishment	Consent for Operation	Required
10	PESO (Petroleum and Explosives Safety Organization)	Consent for Establishment	Consent for Operation	Required

Pollution category of CBG plants

The Central Pollution Control Board (CPCB) of India has categorized industries into various categories, namely Red, Orange, Green and White, based on their pollution potential and the regulatory requirements. In general, CBG plants are considered low-polluting compared to other conventional fuel plants (see *Table 14: Pollution categorization of CBG plants*).

Green category industries are those that have a minimal environmental impact and require a simplified regulatory process for obtaining pollution control clearances. White category industries are those that have no or low pollution potential, and require no pollution control clearance from the regulatory authority.

Table 14: Pollution categorization of CBG plants

Sr. no.	Category of CBG plant	Category	Pollution index score	Remarks
1	Based on municipal solid waste	Orange	41–59	If wastewater discharge is higher than 100 KLD, then the category will be red
2	Based on process waste (industrial waste, press mud, molasses, organic sludge)	Orange	41–59	If wastewater discharge is higher than 100 KLD, then the category will be red
3	Based on crop residue (paddy straw, wheat straw, corn sweet sorghum, Napier grass)	Green	21–40	If wastewater discharge is higher than 100 KLD, then the category will be orange
4	Based on animal waste (dairy farms, poultry farms, other animal waste)	Green	21–40	If wastewater discharge is higher than 100 KLD, then the category will be orange
5	CBG plants (irrespective of the type of feed) producing FOM and LFOM and not discharging any wastewater	White	<20	Subject to verification by State Pollution Control Board
6	Household biodigester/gobar gas plants (cow dung)	White	<20	Feedstock shall have a volatile organic fraction higher than 75 per cent

Source: CPCB[25]

6. CBG PLANT ECONOMICS AND AVAILABLE FINANCIAL ASSISTANCE

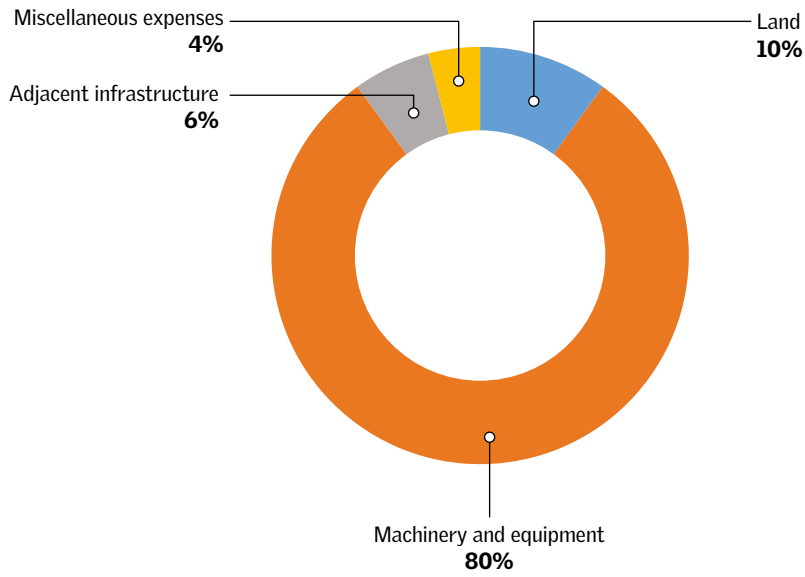
- A majority of the CAPEX cost, approximately 75–80%, is attributed to the acquisition of CBG plant machinery and equipment such as anaerobic digesters, biogas purification units and compression units
- Feedstock that necessitates extensive pre-processing steps or is harder to process generally results in higher operational costs for the CBG plant
- Under the MNRE's National Bioenergy Program, new bio-CNG plants are allocated Rs 4 crore per 4.8 tonnes of production, while existing bio-CNG plants are given Rs 3 crore per 4.8 tonnes.

CAPEX and OPEX of bio-CNG plants

The economics of a CBG plant can vary depending on various factors such as the scale of the plant, technology used, feedstock cost, government incentives and market demand for CBG. CAPEX or Capital Expenditure refers to the total amount of money that is required to set up a new project, purchase equipment and establish the infrastructure necessary for the project to operate. In the context of a bio-CNG or CBG plant, CAPEX includes the cost of land, construction, equipment and other necessary expenses to set up the plant. The cost of building a CBG plant in India can vary depending on various factors such as location, raw material availability, technology used and scale of production.

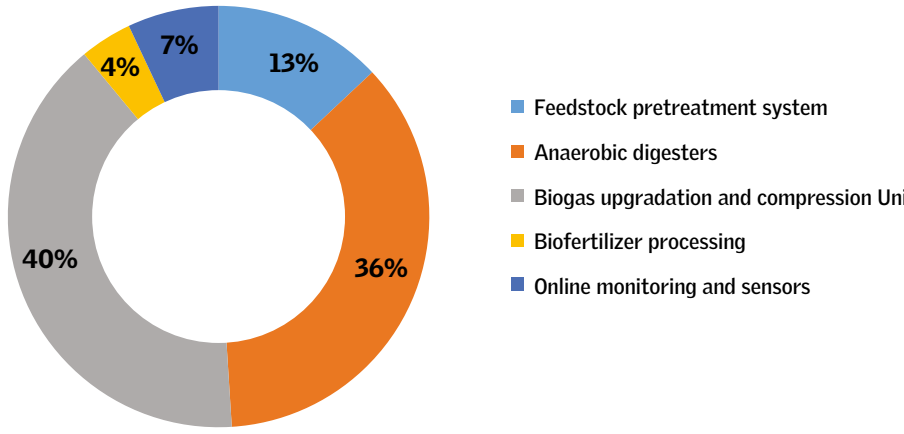
The approximate cost of installing a 5 TPD capacity CBG plant is estimated to be between Rs 20–25 crores. About 75–80 per cent of the CAPEX cost is for purchasing plant machinery and equipment (see *Graph 7: CAPEX breakdown of a CBG plant*) like anaerobic digesters and biogas purification and compression units (see *Graph 8: CAPEX break-up of equipment and machinery component*). Moreover, to be financially viable, a minimum 2 TPD capacity CBG plant needs to be planned.

Graph 7: CAPEX breakdown of a CBG plant



Source: Author analysis

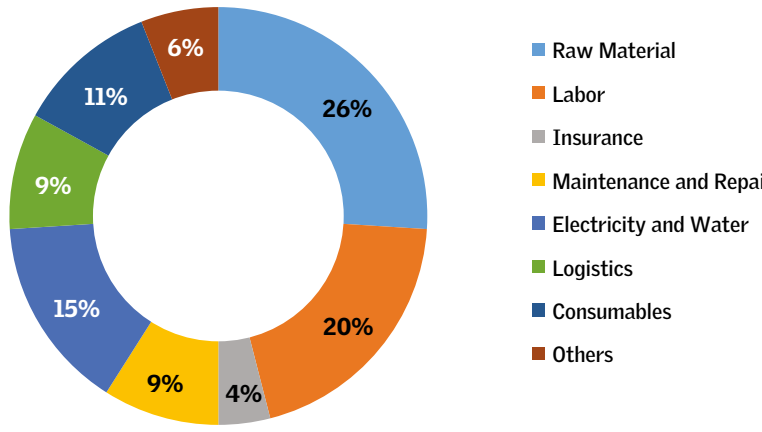
Graph 8: CAPEX break-up of equipment and machinery component



Source: Author analysis

The OPEX cost for a bio-CNG plant generally includes all the operational expenses required to run the plant on a day-to-day basis. This includes raw material, labour, electricity, water, chemicals, consumables, maintenance and repairs, logistics, waste management, and other expenses such as insurance, taxes, legal fees and administrative outlay.

Graph 9: OPEX breakdown of a CBG plant



Source: Author analysis

In general, feedstock that are more difficult to process or require more pre-processing steps before they can be fed into the bio-CNG plant tend to have higher operational costs. For example, feedstock such as agricultural residues, food waste and municipal solid waste can have higher operational costs due to their high moisture content and impurities. On the other hand, feedstock such as energy crops and dedicated energy crops such as switchgrass, corn stover and sugarcane bagasse can have lower operational costs since they are easier to process and have lower impurities.

The yearly operation cost to run a 5 TPD capacity bio-CNG plant in India can vary depending on various factors such as the cost of raw materials, labour costs, electricity costs, maintenance costs and other operational expenses. However, to give a rough estimate, the yearly operation cost for a 5 TPD capacity bio-CNG plant in India can be around Rs 2.5–4 crores.

The cost per tonne of agricultural waste in India can vary depending on the type of waste, its location and the demand for it. Generally, agricultural waste such as rice straw, wheat straw and sugarcane bagasse can be sold for around Rs 1,000–2,500 per tonne. However, prices can fluctuate based on factors such as availability, transportation costs and the use of the waste (ex. as fuel or for animal feed). Moreover, baling of agricultural residue is necessary for efficient handling and transportation of the biomass from the farm to the CBG plant. Baling involves compressing the loose agricultural residue into tightly packed bundles or bales, which reduces its volume and makes it easier to transport and store. It also reduces its surface area, making it less prone to catching fire.

Since the price of agricultural residue is a significant component of the operating costs for CBG plants, higher prices demanded by farmers can impact their profitability and viability. Furthermore, the lack of a price cap on agricultural residue can make it difficult for CBG plants to negotiate a fair price for the biomass, leading to inconsistencies in the pricing and supply of agricultural residue. In order to promote the sustainable use of agricultural residue for bioenergy production in India, it is important for the government to establish clear regulations and guidelines for pricing and procurement of biomass. This can help ensure a stable supply of biomass at reasonable prices, while also providing a fair return to farmers for their agricultural residue.

Available financial assistance and incentives

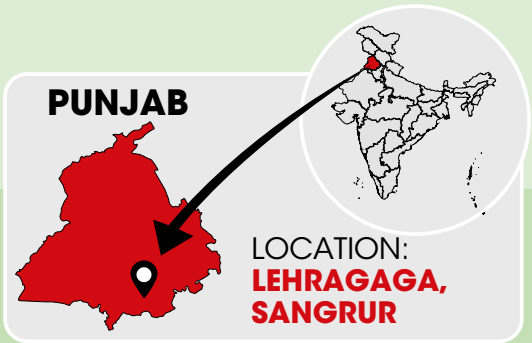
Table 15: Details of financial incentives and policies available for CBG plants

Policy/Scheme	Concerned ministry	Details of the scheme	Online portal for application/ information
Sustainable Alternative Towards Affordable Transportation (SATAT)	Ministry of Petroleum and Natural Gas (MoPNG)	The SATAT scheme was launched on 1 October 2018. This initiative aims to achieve a production target of 15 million tonnes of CBG by 2023–24, from 5,000 plants across India. Under the SATAT scheme, entrepreneurs will establish CBG plants, and produce and distribute CBG to oil marketing companies (OMCs) for use as automotive and industrial fuels. OMCs that are owned and operated by the government invite Expression of Interest (EoI) from potential entrepreneurs and in turn provide assurance of their CBG offtake at a fixed procurement price (*see Annexure 3 for EoI format*). It was decided that the minimum procurement price, which includes applicable taxes, will not fall below Rs 46 per kg until 31 March 2029. Additionally, the prices of CBG will be tied to the current retail selling price of CNG in the market. A full range of prices for CBG procurement has been established (*see Annexure 4 for more details*).	https://satat.co.in/satat/index.jsp
National Bioenergy Programme (Waste to Energy)	Ministry of New and Renewable Energy (MNRE)	The aim of the Waste to Energy Programme, which was launched on 2 November 2022, as part of the National Bioenergy Programme, is to facilitate the establishment of projects that convert urban, industrial and agricultural waste/residues into bio-CNG. Under the programme, project developers who successfully commission waste to energy plants to produce bio-CNG are eligible to receive Central Financial Assistance (CFA), while implementing/ inspection agencies are entitled to receive service charges. Provisions have been made for Rs 4 crore for new bio-CNG plants with capacity of 4,800 kg/day and Rs 3 crore for existing bio-CNG plants with 4,800 kg/day capacity (*see Annexure 5 for more details*).	**https://biourja.mnre.gov.in/**
Galvanizing Organic Bio-Agro Resources (GOBARdhan) scheme	Ministry of Drinking Water and Sanitation	The Indian government introduced the GOBARdhan scheme in April 2018 under the Swachh Bharat Mission (Grameen) as an element of the solid and liquid waste management initiative. The objective of this programme was to enhance rural sanitation while simultaneously generating energy and wealth from organic and cattle waste. It offers financial aid of Rs 50 lakh per district to establish exemplary GOBARdhan programmes. It is possible to construct biogas plants at the cluster and community levels in villages, blocks and districts.	**https://sbm.gov.in/gbdw20/**

Policy/Scheme	Concerned ministry	Details of the scheme	Online portal for application/ information
Agro-Infra Fund	Ministry of Agriculture and Farmers' Welfare	The Agriculture Infrastructure Fund (AIF) offers monetary assistance for investing in feasible initiatives connected to post-harvest management infrastructure and communal farming assets. This financing option grants an interest subvention of 3 per cent per annum for all loans up to a maximum limit of Rs 2 crores. The interest subsidy can be availed for a maximum of 7 years.	https://agriinfra.dac.gov.in/
Priority Sector Lending	Reserve Bank of India	Priority Sector Lending is a guideline introduced by the RBI that mandates banks to lend a specified proportion of their credit to sectors of the economy that are considered "priority." The RBI imposes targets for banks to attain as part of this policy, and if they do not fulfil them, they may be subject to regulatory action. The primary purpose of this policy is to foster financial inclusivity and encourage economic progress by providing support to key sectors that are crucial for India's growth.	
State-specific incentives	Specific states	Certain states which have bioenergy policies in place offer financial incentives to bio-CNG investors, such as subsidies, tax credits, free electricity and land. These incentives can help to reduce the initial investment costs and make bio-CNG projects more financially viable.	
Carbon credits		Bio-CNG plants have the opportunity to earn carbon credits by reducing greenhouse gas emissions through the creation and utilization of bio-CNG as a sustainable and eco-friendly fuel. These credits represent the removal of one metric tonne of carbon dioxide equivalent from the atmosphere and can be traded as a commodity. This earning potential can offer bio-CNG plants an extra source of income.	
CSR funds	Ministry of Corporate Affairs	According to the Companies Act 2013, companies with a net worth of Rs 500 crore or more, or an annual turnover of Rs 1,000 crore or more, or a net profit of Rs 5 crore or more are required to contribute 2 per cent of their average net profits as CSR funds which can be used to finance bio-CNG projects.	**https://www.csr.gov.in/content/csr/global/master/home/home.html**

CASE STUDY 1

Name of the plant:
Verbio AG



Plant start date:
June 2022

Bio-CNG production capacity:
33 TPD

Number of digesters: **8**

Feedstock used:
Paddy straw and other agricultural waste

Daily feedstock requirement:
300 TPD

Land requirement:
20 acres

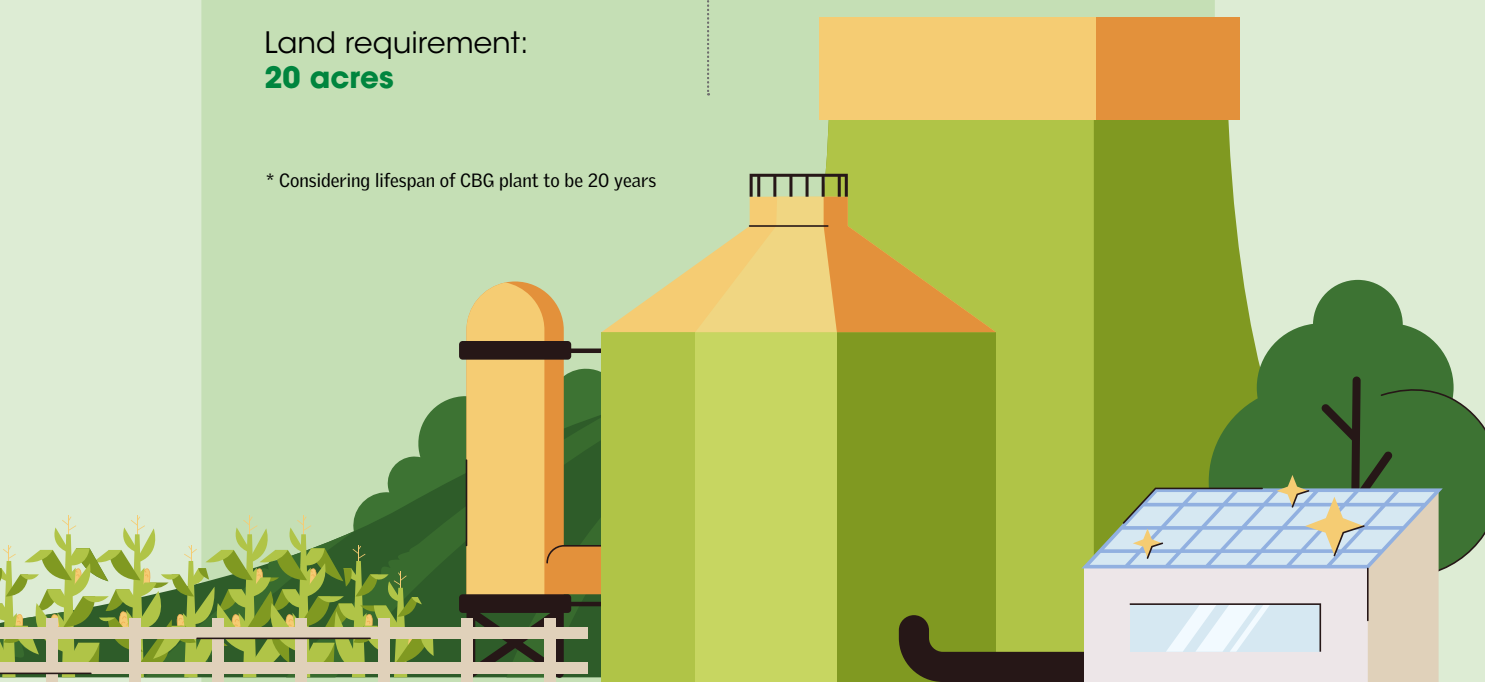
Biogas purification method:
Chemical absorption

Gas offtake method:
Dispensed at nearby CNG pumps using cascades

Biodigestate production:
600–650 TPD

CAPEX:
Rs 230 crore (Rs 9,550/ tonne)*

* Considering lifespan of CBG plant to be 20 years



Verbio bio-CNG plant, (Weather monitoring system) ▲

Inhouse farm equipment for feedstock procurement ▲

The benefits of this project aimed at reducing air pollution and improving the lives of farmers have been immense. With a consumption of 100,000 tonnes of agricultural residues per year, the project has brought significant relief to air pollution caused by stubble burning in a radius of at least 10–15 km. What's more, the entire stubble collection process is conducted at no cost to farmers, leading to considerable cost savings for them. The project has created a self-owned and operated agro-residue supply chain that includes the integration of processes and infrastructure for the aggregation, transportation, storage and security of feedstock. As a result, it has created jobs and spurred economic development in rural communities.

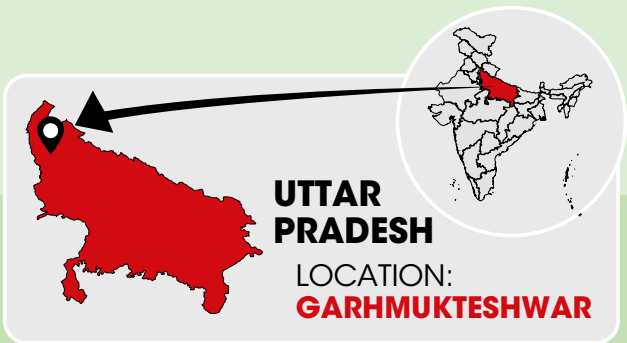
Biogas digesters ▲

Moreover, the project's introduction of bio-manure in nearby farms has also offered a realistic prospect of improving soil health, further benefiting farmers. The development of a climate-friendly and cost-effective fuel that is now dispensed at all nearby CNG pumps for automotive consumers has been another significant outcome of the project. Overall, the project is an innovative solution that benefits the environment, farmers and the entire community.

Paddy straw bales (400 kg each) ◀

CASE STUDY 2

Name of the plant:
Mittal Enterprises



Plant start date:
1 January 2023

Bio-CNG production capacity:
8 TPD

Number of digesters: **2**

Feedstock used:
Pressmud (sugarcane industry waste)

Daily feedstock requirement:
200 TPD

Land requirement:
6-8 acres

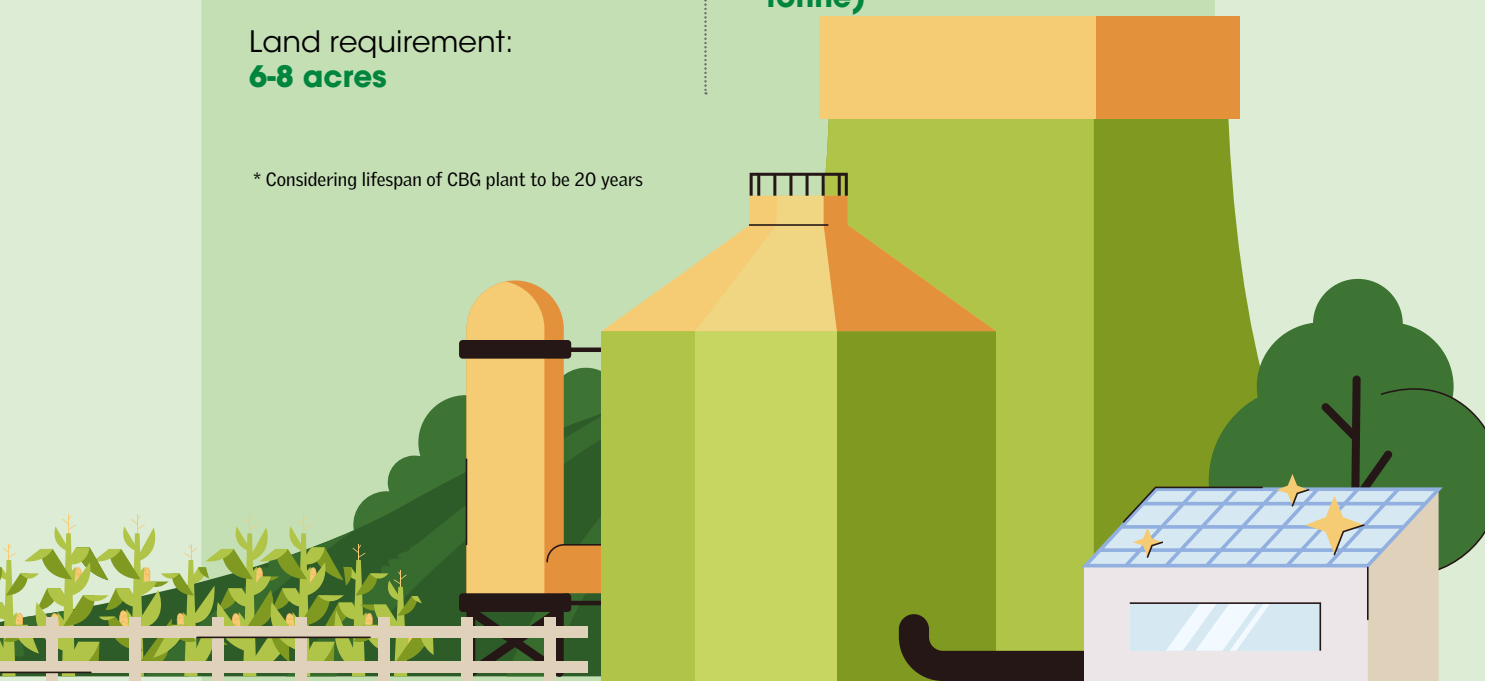
Biogas purification method:
Water scrubbing technology

Gas offtake method:
Agreement with Indraprastha Gas Limited (Cascades)

Biodigestate production:
33 TPD solid, 40,000 l per day liquid

CAPEX:
Rs 26 crore (Rs 4,450/ tonne)*

* Considering lifespan of CBG plant to be 20 years



Biogas digester (Capacity: 4 TPD) ▲

Water scrubbing unit ▲

The impact of sugarcane processing on the environment has been a longstanding concern, with the waste of the industry—pressmud—often burned or dumped in landfills. A solution has been found with the establishment of a CBG plant that converts this waste into a clean fuel, thereby reducing its impact on the environment.

Located near five sugar mills, the CBG plant takes advantage of the abundance of pressmud generated during sugarcane processing. The waste produced by a single sugar industry is sufficient to meet the plant's fuel demand, making it an effective solution to reduce waste.

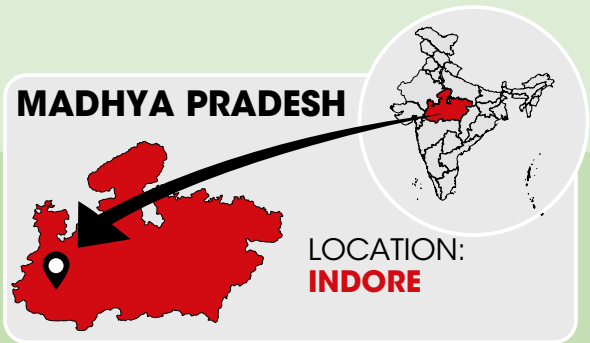
What sets this plant apart is its use of advanced water scrubbing technology to purify biogas into high-quality biomethane. The process involves passing biogas through a water scrubber that removes impurities like carbon dioxide, hydrogen sulphide and other trace gases, resulting in a high-purity methane gas stream of up to 98 per cent. This makes the plant one of the few facilities in the country employing such advanced technology.

Biogas digestate solid-liquid separator ◀

CASE STUDY 3

Name of the plant:

EverEnviro Resource Management Private Limited



Plant start date:
19 February 2022

Bio-CNG production capacity:
17-18 TPD

Number of digesters: **4**

Feedstock used:
Biodegradable municipal waste

Daily feedstock requirement:
500 TPD

Land requirement:
15 acres

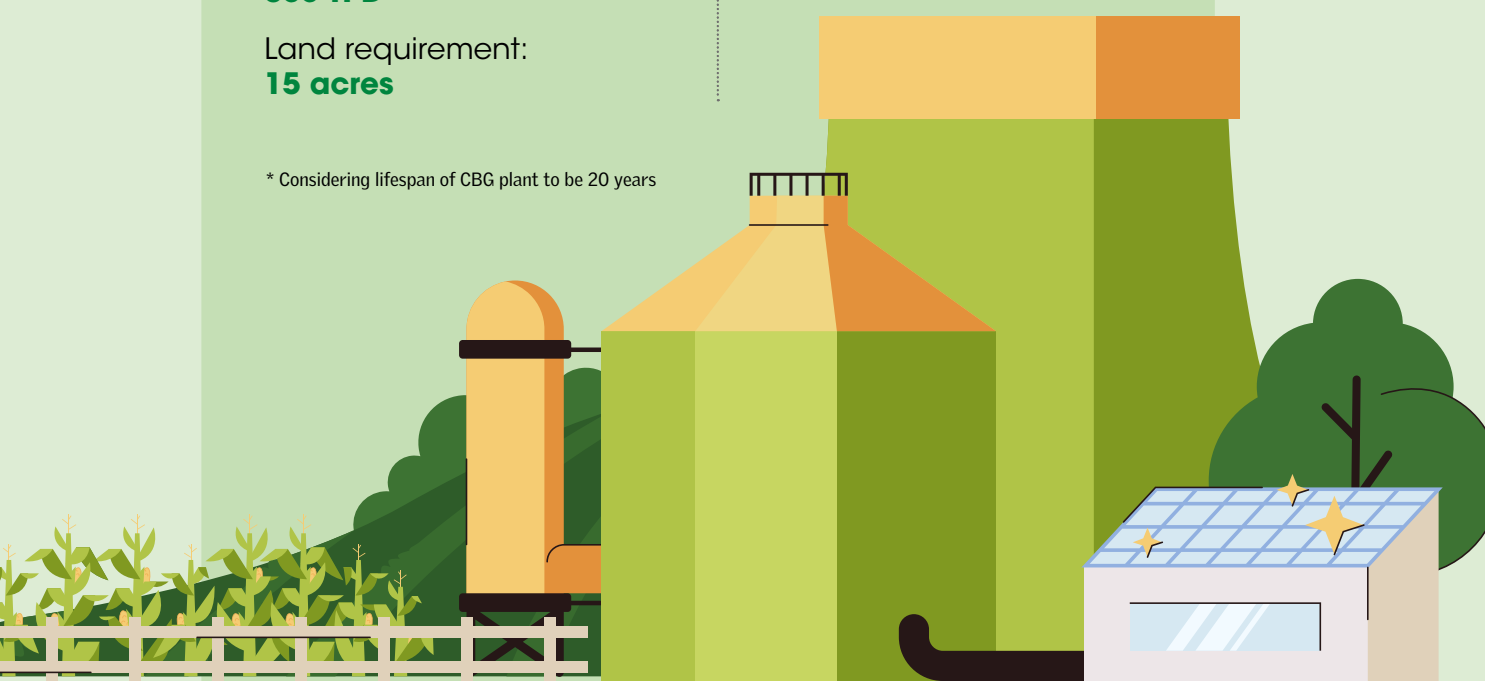
Biogas purification method:
Pressure Swing Adsorption

Gas offtake method:
50% to IMC city buses; 50% for industrial and commercial uses

Biodigestate production:
100 TPD

CAPEX:
Rs 150 crore (Rs 11,400/ tonne)*

* Considering lifespan of CBG plant to be 20 years



Overview of the Indore CBG plant ▲

Anaerobic digestion units ▲

The Indore plant is a testament to the power of public-private partnerships, with the Indore Municipal Corporation (IMC) joining forces with EverEnviro to make this venture a reality. With a capital investment of Rs 150 crore, EverEnviro has made it possible to turn the waste that once blighted Devguradiya into a valuable commodity. The IMC supplies 90 per cent segregated waste to the plant, and in return, EverEnviro pays them an annual royalty of Rs 2.5 crore.

The contract between the IMC and EverEnviro stipulates that 50 per cent of the bio-CNG produced is to be allocated to power Indore's city buses, priced at Rs 5 per kilo less than the market rate of CNG. The plant is currently fuelling 146 buses and has plans to expand to 400 buses by the end of 2023. The remaining bio-CNG is sold to Avantika Gas Ltd, the CNG and PNG supplier of the Indore region.

What sets the Indore plant apart is the city's impressive waste segregation at source, which has been a crucial factor in its success. IMC employs 600 vehicles for waste collection, and their efforts have paid off, with the cost of production of bio-CNG being as low as Rs 35–40 per kilogram. The plant generates 20 per cent of its 13,000 units of power requirement from rooftop solar, while the rest is taken from the power grid. The company also sells their manure at a net rate of Rs 1,800 per tonne.

The Indore plant's innovative approach to waste management has shown that turning trash into treasure is possible, and it's a model that could inspire other cities to follow suit. The transformation of Devguradiya from a garbage dump to a clean fuel hub is a success story that deserves to be celebrated.

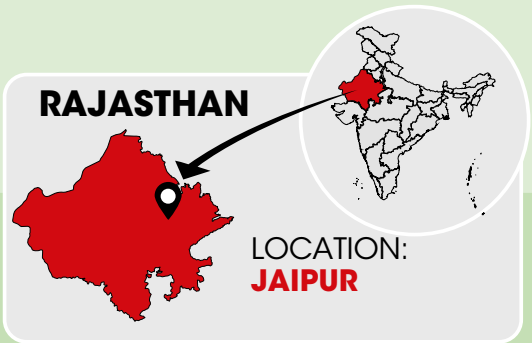
Gas storage balloon ▲

City buses using CBG as fuel ▲

CASE STUDY 4

Name of the plant:

Hingonia Gaushala (IOCL)



Plant start date:
January 2023

Bio-CNG production capacity:
6 TPD

Number of digesters: **2**

Feedstock used:
Cattle dung

Daily feedstock requirement:
250 TPD

Land requirement:
5 acres

Biogas purification method:
Pressure Swing Adsorption

Gas offtake method:
Gas grid to Akshaya Patra foundation's kitchen to prepare meals

Biodigestate production:
50 TPD

CAPEX:
Rs 38 crore (Rs 8,700/ tonne)*

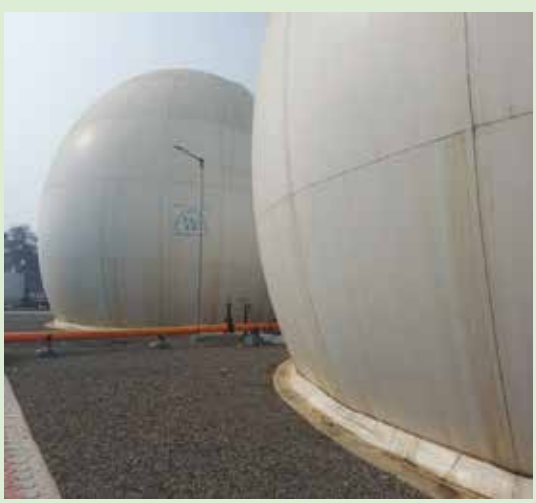
* Considering lifespan of CBG plant to be 20 years

The establishment of a CBG plant in Jaipur is a remarkable development brought about by the Indian Oil Corporation Ltd's CSR initiative. The plant is situated in the premises of the Hingonia Cow Rehabilitation Centre, and its construction commenced in 2020. With a capacity of 100 TPD, the plant is capable of producing up to 6 tonnes of gas per day. Currently, it is running on a trial basis and functioning at 30 TPD, yielding 1.5 tonnes of gas per day.

Interestingly, this 1.5 tonne of gas is being used to cook meals for 150,000 students every day by the Akshaya Patra Foundation, a renowned non-profit organization dedicated to serving mid-day meals to school children across India. By doing so, the foundation has set a remarkable example of sustainability and social responsibility. This project not only reduces the dependence on non-renewable resources but also has a positive impact on the environment by curbing the emission of greenhouse gases. This project is a win-win for everyone, as it ensures that the students receive healthy and nutritious meals while also promoting sustainable practices. With this successful initiative, the Indian Oil Corporation Ltd is paving the way for other corporations to follow suit and make a positive difference in society.

Cattle dung feedstock ▲

Pre-digestion units ▲



Biogas pipeline near digesters ▲

Bio-CNG digesters ▲

CASE STUDY 5

Name of the plant:

IIT Delhi Biogas Plant

Plant start date:
2004

Bio-CNG production capacity:
25 m^3/day

Number of digesters: **1**

Feedstock used:
Kitchen waste

Daily feedstock requirement:
250 KG

Land requirement:
1,500 m^2

Biogas purification method:
Water scrubbing

Gas offtake method:
2-wheeler, 4-wheeler, and research

Biodigestate production:
25 kg/day

CAPEX:
Rs 40 lakh (Rs 22/m^3)*

* Considering lifespan of CBG plant to be 20 years

Pulverization unit ▲

Mixing tank ▲

Biogas digester ▲

The IIT Delhi campus is leading the way in sustainable waste management with its innovative community-based CBG plant. The plant collects kitchen waste generated on the campus, pulverizes it, and feeds it to anaerobic digesters, generating biogas that is upgraded to CBG using advanced water scrubbing technology developed in-house. Not only does this effectively manage organic waste on the campus, but it also provides a clean and renewable source of fuel for the campus community.

The bio-CNG produced is directly used to power four- and two-wheelers. It is used for research purposes, reducing air pollutants and promoting sustainable transportation. In addition, the biogas generated is also converted into electricity using a combined heat and power unit, powering the lights of the building and reducing the campus's carbon footprint.

This successful model could be replicated in various institutes, residential societies, and rural communities to manage organic waste and promote sustainable energy. With the integration of bio-CNG equipped 2-wheelers, there is potential for increased demand in rural areas, ensuring guaranteed offtake of the produced product and promoting a cleaner environment.

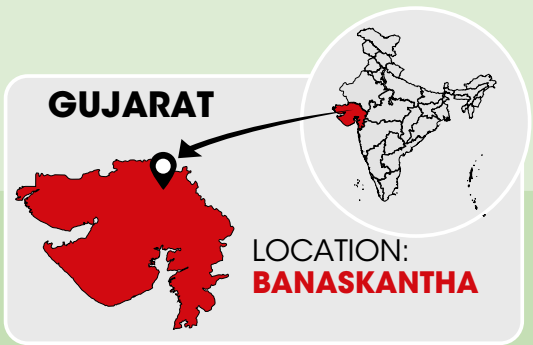
Direct offtake of bio-CNG using 4-wheeler ▲

2-wheeler integrated with bio-CNG kit ▲

CASE STUDY 6

Name of the plant:

Banaskantha Bio-CNG Plant



Plant start date:
August 2020

Bio-CNG production capacity:
800 kg/day

Number of digesters: **1**

Feedstock used:
Cow dung and potato waste

Daily feedstock requirement:
40 tonnes

Land requirement:
1 acre

Biogas purification method:
Pressure Swing Adsorption

Gas offtake method:
Dispensed at nearby CNG pumps using cascades

Biodigestate production:
8 TPD solid and 72,000 l/ day liquid

CAPEX:
Rs 8 crore (Rs 13,700/ tonne)*

* Considering lifespan of CBG plant to be 20 years

Overview of the Banaskantha CBG plant ▲

Gas holder ▲

The Banaskantha bio-CNG plant, situated in Banaskantha, Gujarat, is managed by the Banaskantha District Co-operative Milk Producer's Union Ltd. This innovative project involves the collection of cow dung from around 250 households in 12 villages, which is then utilized to produce bio-CNG. To ensure accuracy in the collection process, tractors equipped with weighing scales are dispatched to collect the cow dung from these households daily. The beneficiaries are compensated for their contributions, with Rs 1/kg credited to their accounts every 15 days, in addition to payment for milk.

The Banaskantha bio-CNG plant produces an impressive 800 kg of bio-CNG per day, which is purified and dispensed to vehicles through a modern dispensing system. The gas station can fill up to 100 vehicles, with each vehicle receiving 8 kg of bio-CNG. In addition to the fuel production, the solid part of the slurry is transformed into vermicompost or phosphate-rich organic manure, which is then marketed to farmers. The liquid part of the slurry is recycled for treatment purposes.

This project is a noteworthy environmentally-friendly initiative, given that methane emissions from cow dung are a leading contributor to global warming. By capturing methane and converting it into fuel, the Banaskantha bio-CNG plant provides a sustainable solution to waste management while simultaneously producing fuel for transportation. The Banaskantha bio-CNG plant is an exemplary model for sustainable fuel production and waste management in the agricultural sector.

Biogas purification system ▲

Bio-CNG dispensing unit ▲

8. CHALLENGES AND POSSIBLE RECOMMENDATIONS

- **Linking bio-CNG plants with city gas distribution networks is crucial for their expansion and success.**
- **It is e ssential to implement a policy which mandates fertilizer companies to procure CBG plant fertilizer at a fixed price, similar to the SATAT program for CBG procurement.**
- **There is an urgent need to install a pool of advanced and decentralized biomass management equipment at the village level, along with mechanisms to regulate feedstock prices.**
- **Sustainable financing and timely regulatory approvals are absolutely necessary to achieve CBG installation targets.**

Challenge 1: Incomplete off-take of CBG

At present, oil marketing companies acquire bio-CNG from plants based on a 'best endeavour' approach, which puts plant owners at a disadvantage as they may be left with unsold product. To address this issue, entering into long-term agreements that guarantee 100 per cent off-take of bio-CNG could provide potential investors financial stability and confidence in a favourable product market. Such agreements would also help reduce the risks associated with investing in technology, machinery installation and maintenance costs.

Ashish Kumar, Managing Director of Verbio India, stated that the largest paddy straw-based CBG plant in India, which has a capacity of 33 TPD, is currently only operating at 5 TPD due to insufficient off-take demand from oil and gas marketing companies.

Recommendation: The expansion of city gas distribution (CGD) networks and their linkage with bio-CNG plants could offer great benefits. It would provide a reliable market for CBG producers, ensuring that their product is utilized efficiently, reducing transport losses and the cost of unsold inventory.

Challenge 2: No procurement of biogas fertilizer

The residue produced from the anaerobic digestion process, commonly known as slurry or digestate, accounts for a significant portion of the by-product. Although digestate is a valuable source of carbon and nitrogen that can enhance soil health by increasing water retention and improving soil structure, it is not being fully utilized due to the absence of fixed procurement prices and regulatory guidelines, and low demand from fertilizer companies.

Recommendation: There is a need to establish a policy requiring fertilizer companies to purchase bio-CNG fertilizer at a fixed price, like the SATAT program for CBG procurement. Moreover, policies should be implemented to promote the use of bio-fertilizer instead of synthetic fertilizers like urea. Such measures could significantly enhance the marketability and demand for bio-CNG fertilizer and reduce the reliance on chemical fertilizers, resulting in several environmental benefits.

Additionally, the improvement and enrichment of digestate is another option to improve its marketability. To support both high and low-capacity plants, the government must intervene and offer incentives or common enrichment facilities at a subsidized cost. These facilities would enable the upgrading of digestate either in-situ or ex-situ, allowing for the effective utilization of nutrient-rich residues from anaerobic digestion.

Challenge 3: Unregulated biomass supply chain

The consistent availability of high-quality raw materials is an essential factor that impacts the profitability and effectiveness of a bio-CNG facility. However, the limited timeframe of 30–40 days for gathering agricultural feedstock and the unpredictability of feedstock prices create challenges in maintaining the financial sustainability of the plant. Tractor, raker, baler, loaders and trailers are farm machinery used for harvesting agricultural residue. There is a dearth of machinery on the ground to harvest and transport the feedstock to biogas plants. Moreover, bio-CNG investors are not equipped enough to collect this massive waste by themselves.

Recommendation: There is an urgent requirement to establish more sophisticated and decentralized biomass management equipment at the village level. An alternative approach could involve engaging biomass aggregators and supply chain management companies, who would be responsible for managing the biomass value chain through standardized contracts. Additionally, the equipment used for collecting agricultural feedstock needs to be more efficient and technologically advanced. It should be equipped with artificial intelligence sensors to analyse the quality of feedstock, enable vehicle tracking and facilitate data transfer. Capping the price of agricultural feedstock may be a potential solution but it is important to carefully consider the potential implications and to implement any pricing policies in a way that is balanced and sustainable for all stakeholders involved.

Challenge 4: Financing bio-CNG initiatives at a high cost

Establishing a bio-CNG plant requires a significant amount of capital investment. Despite being categorized as a priority sector for lending by the Reserve Bank of India, banks offer high-interest rates for loans related to bio-CNG. Additionally, only a limited number of private-sector banks are willing to provide loans for these projects.

Recommendation: Lower rates of interest from both public and private banks need to be ensured. It can help biogas producers access financing for their projects more easily and at lower costs. This can reduce the financial burden of investing in biogas projects and make them more attractive to potential investors. Additionally, exempting plant equipment and machinery from GST and customs duty can help biogas producers reduce their upfront costs, making projects more financially viable.

Challenge 5: Inefficient source segregation of feedstock

Inefficient source segregation of municipal solid waste is a problem for biogas plants because it can lead to the contamination of the feedstock used in the biogas production process. When waste is not properly sorted, it may contain non-biodegradable materials, such as plastics and metals, which can damage the equipment used in the biogas plant and reduce the efficiency of the biogas production process. In addition, organic waste that is mixed with non-organic waste may not be able to produce high-quality biogas, which can affect the overall output of the biogas plant.

Recommendation: Governments can incentivize households and businesses to properly sort their waste by providing benefits such as tax breaks or reduced waste collection fees. Conversely, penalties can be imposed on those who do not comply with waste segregation requirements. Education and awareness campaigns can help inform the public about the importance of waste segregation and how to properly sort waste at the source.

Public-Private Partnership (PPP) models can be implemented in waste segregation in municipalities. PPP models often involve performance-based contracts, where the private partner is incentivized to meet certain waste segregation targets. This ensures that waste segregation is implemented effectively and efficiently and that the private partner is held accountable for their performance. Moreover, it allows for risk-sharing between the municipality and the private partner.

Challenge 6: Low in-house manufacturing of plant equipment

Most of the equipment and machinery required for bio-CNG plants, such as digester fabrics, biogas upgrading units, storage tanks, compressors, dispensers, and monitoring and control systems or software, are often imported and may have limited availability. This can pose a challenge for the establishment and operation of bio-CNG plants, particularly in regions like India where the local manufacturing industry for such equipment is not well-developed. The importation of these components may also lead to increased costs, longer lead times and potential supply chain disruptions.

Recommendation: It is important to plan for and ensure the availability of these components when establishing bio-CNG plants, either through strategic partnerships with international suppliers or by developing local manufacturing capabilities.

Challenge 7: Lack of single-window clearance

The process of setting up a bio-CNG plant is impacted by the need for a large set of regulatory approvals and the involvement of multiple ministries including the Ministry of Environment, Forest and Climate Change, Ministry of New and Renewable Energy, Ministry of Petroleum, and Natural Gas, Ministry of Agriculture and state-level pollution control boards, among others. This can result in a longer and more complex process for obtaining the necessary permits and clearances required for establishing and operating a bio-CNG plant. The need for approvals from multiple agencies creates challenges for investors and operators of bio-CNG plants, including delays and increased costs associated with compliance and coordination with regulatory authorities.

Recommendation: Initiative to simplify and digitize regulatory approvals with the creation of a single window clearance integrated with subsidy disbursement.

Challenge 8: Lack of CNG consumers in rural setup

One of the challenges facing the adoption of bio-CNG in rural areas is the lack of CNG consumers. Unlike urban areas where there is a high demand for CNG as a transportation fuel, rural areas may not have sufficient demand for CNG due to the lower population density and limited availability of CNG vehicles. This can limit the economic viability of bio-CNG plants in rural areas, as the costs of producing and distributing CNG may not be offset by the revenue generated from sales.

Recommendation: There is a need to develop new markets and increase the demand for CNG in rural areas. This can be done by promoting the use of CNG as a transportation fuel for agricultural and rural development activities, such as for powering tractors, irrigation pumps and two-wheelers. Additionally, there may be opportunities to develop new industries and value chains around CNG, such as through the production of CNG-based chemicals or the use of CNG for power generation.

Challenge 9: Political and institutional challenges

The absence of a long-term bioenergy strategy with no clear mandates and obligations can create significant barriers for the growth and development of the biogas industry. For example, policies like SATAT have their tenure ending in 2023, with no clear roadmap in place about what to do after it.

Recommendation: Governments can help address these challenges by developing clear policies and regulatory frameworks that provide stability and support for the biogas industry, encouraging investment and market development on a long-term basis. For example, 5 per cent CBG blending with CNG called upon by the union finance minister in the budget this year shall have fixed timelines attached to it.

Challenge 10: Export of biomass under the "Free" category

The Directorate General of Foreign Trade issued a notification (No. 58/2015-2020) on 14 February 2023 that allowed the export of agricultural residue biomass under the free category. If high-quality biomass is exported, it may lead to domestic shortages, increasing the price of biomass for local bioenergy producers. This could make it more difficult for the domestic bioenergy industry to compete with international markets, leading to a decline in investment and job opportunities.

Recommendation: The government should impose export restrictions or taxes on agricultural biomass to discourage exports and ensure that enough biomass remains available for domestic use. This approach can help ensure that local bioenergy industries have access to affordable feedstock.

Annexures

Annexure 1

भारतीय मानक IS 9478 : 2023

Indian Standard

बायोगैस (बायोमिथेन) प्लांट का डिजाइन, निर्माण, संस्थापन और प्रचालन — रीति संहिता

(तीसरा पुनरीक्षण)

Design, Construction, Installation and Operation of Biogas (Biomethane) Plant — Code of Practice

(Third Revision)

ICS 75.160.40

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भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुर शाह ज़फर मार्ग, नई दिल्ली - 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110002
www.bis.gov.in www.standardsbis.in

February 2023 Price Group 11

DIFFERENT TYPES OF DIGESTERS USED IN BIOGAS PLANTS

E-1 CONTINUOUS STIRRED TANK REACTOR (CSTR) TYPE DIGESTERS (HORIZONTAL/VERTICAL DESIGN)

CSTR digester consists of continuous stirred tank reactor where continuous mixing of effluent and biomass takes place with the help of central and lateral agitators. The essential feature is that the wash out of the active anaerobic bacterial biomass from the reactor is controlled by a sludge separator recycle system. The basic idea underlying the anaerobic contact process is to:

a) provide contact between the active biomass and feed;
b) utilize the digester volume effectively;
c) prevent stratification and temperature gradient; and
d) minimize the formation of scum layer and the deposition of sludge solids.

E-1.1 CSTR Digester Process

a) Raw effluent is collected in a buffer tank which maintains the temperature around 38 °C to 42 °C . Some quantity of treated spent wash (digester outlet) is also mixed in buffer tank to raise the *p*H;
b) From buffer tank raw spent wash feed is at the top in a centre shaft of the digester;
c) There will be one central agitator and two to five numbers of lateral agitators available to make uniform distribution of biomass and substrate for uniform degradation;
d) The effluent travels to the bottom and contacts with active anaerobic culture in the reactor by the rotation of central agitator and lateral agitators;
e) The re-circulated sludge also mixed with raw effluent in a central shaft of the digester;
f) The treated spent wash collected through overflow pipe and passed through degassing tower for removal of dissolved gases to achieve better settling of sludge in further process;
g) Biogas is collected at the top of the digester and will be stored in gasholder. Biogas from the biogas holder will be compressed and sent to boiler for burning; and
h) Biogas is also used for gas engine to generate the power; here H_2S shall be removed from the biogas before using in the gas engine.

E-2 UP-FLOW ANAEROBIC SLUDGE BED (UASB)

UASB reactor is based on the so-called three-phase separator, which enables the reactor to separate gas, water and sludge mixtures under high turbulence conditions. This allows for compact and cheaper designs. The reactor has multiple gas hoods for the separation of biogas. As a result, the extremely large gas/water interfaces greatly reduce turbulence, making relatively high loading rates of 10 kg/m to 15 kg/m^3 per day possible. Separation in the UASB reactor requires only 1.0 m of height, which prevents flotation effects and, consequently, floating layers. Generally, during the treatment of UASB reactor, the substrate passes through an expanded sludge bed containing a high concentration of biomass first. After that, the remaining part of substrate passes through a less dense biomass named the sludge blanket. The influent is pumped to the UASB reactor from bottom of it by peristaltic pump. The influent moves upwards and gets in contact with the biomass in sludge bed, then continues to move upwards and the rest substrates act with the biomass again in the sludge blanket which has a less concentration of biomass compared with the sludge bed below. The volume of sludge blanket must be sufficient to conduct the further treatment to wastewater by-passed from the lower layer of sludge bed by channeling. At the same time, it will help to ensure a stable effluent quality. A three phases [gas-liquid-solid (GLS)] separator located above the sludge blanket to separate the solid particles from the mixture (gas, liquid, and solid) after treatment and hence allowing liquid and gas to leave the UASB reactor. After the treated wastewater is collected by the effluent collection system via number of launders distributed over entire area discharging, it passes to main launder provided at periphery of the reactor and the biogases generated will be collected as the valuable fuel or for deposal.

E-3 FLOATING DRUM PLANT WITH A CYLINDRICAL DIGESTER (KVIC MODEL)

This type of plant has an underground well-shaped digester having inlet and outlet connections through pipes located at its bottom on either side of a partition wall. An inverted drum (gas holder) made of mild steel is placed in the digester which rests on the wedge shaped support and the guide frame at the level of the partition wall and moves up and down

along a guide pipe with the accumulation and use of gas. The weight of the drum applies pressure on the gas to make it flow through the pipelines to the points of use. The gasholder alone is the costliest component which accounts for about 40 percent of the total installation cost of biogas plant. It also needs to be painted regularly for protecting it against corrosion. These plants can be of any size to cater the needs of the users.

E-4 FLOATING DRUM PLANT WITH A HEMISPHERE DIGESTER (*PRAGATI* MODEL)

In *Pragati* Design Biogas Plant is floating drum plant with the depth of pit is less than KVIC biogas plant and is cheaper. It can be constructed in hilly area and high water table areas.

The digester of *Pragati* design plant start from the foundation in dome shape thereby reducing the constructional area, for same digester volume, thus reducing the cost of construction of the plant. The wall thickness of digester is kept 75 mm only. Dome shape construction takes place up to a collar base, where a central guide frame is provided. The digester wall above guide frame is constructed in cylindrical shape.

E-5 FLOATING DRUM PLANT MADE UP OF ANGULAR STEEL AND PLASTIC FOIL (*GANESH* MODEL)

It is basically a KVIC plant constructed with bamboo and polythene sheet. The digester is made of an angle iron frame, bamboo and polythene sheet. The KVIC gas holder and guide frame are used in this design also. The cost of this plant is 70 percent of KVIC plant.

E-6 FLOATING DRUM PLANT MADE OF FIBRE GLASS REINFORCED POLYESTER

This type of digester, which is widely used on a household scale, uses fiberglass so it is more efficient in handling and changing the biogas plant site. This digester consists of one part that functions as a digester and gas storage, each mixed in one chamber without insulation. Digester from fiberglass material is very efficient because it is very impermeable, lightweight and strong. If there is a leak, it is easily repaired or reshaped as before, and the more efficient is that the digester can be moved at any time if the farmer does not use it anymore. The main advantage of fiberglass digester is its ease of implementation and handling, low investment cost and being more environmentally friendly.

E-7 PLUG FLOW REACTOR

Plug flow reactors, also known as tubular reactors, consist of a hollow pipe or tube through which reactants flow. The plug flow reactor can be in the form of a tube wrapped around an acrylic mould that is encased in a tank. Water at a controlled temperature is circulated through the tank to maintain a constant reactant temperature. Plug flow reactors, consist of a cylindrical pipe with openings on each end for reactants and products to flow through. Plug flow reactors are usually operated at steady-state. Reactants are continually consumed as they flow down the length of the reactor. Plug flow reactors may be configured as one long tube or a number of shorter tubes. They range in diameter from a few centimeters to several meters. The choice of diameter is based on construction cost, pumping cost, the desired residency time, and heat transfer needs. Typically, long small diameter tubes are used with high reaction rates, and larger diameter tubes are used with slow reaction rates.

E-8 EXTERNAL CIRCULATION SLUDGE BED (ECSB)

Ii is high-rate anaerobic digestion system uses granular biomass to treat wastewater. This technology is ideal for urban areas and facilities with limited space availability. Wastewater with high concentrations of soluble organics can be easily treated in the compact ECSB system, making this technology an ideal choice for breweries, beverage plants, biofuel processors, or the pulp and paper industry. It can be constructed from various materials such as steel, concrete, or fibre/glass-reinforced plastic (FRP/GRP). This technology continuously meets discharge requirements and eliminates wastewater surcharges, converts organic waste to recoverable green energy (heat and power). Its pressurized system design eliminates odour emissions and sealed headspace, eliminating the potential for tank corrosion.

E-9 BIOGAS INDUCED MIXING ARRANGEMENT (BIMA) DIGESTER

The Biogas induced mixing arrangement (BIMA) system is the original among the self-mixing hydraulic digester systems. It doesn't require any mechanical equipment such as agitator, circulation pumps or gas injection for mixing the digester. The 2-chamber system uses the produced biogas to create a level difference in the chambers and in this way builds up a mixing pressure of up to 5 N/mm^2. The turbulent mixing occurs against the biogas production in intervals of 4 time to 10 time a day.

The system is extremely low-maintenance and has lower operational costs than conventional systems. Ideal applications of this system are high solid sludge and waste, such as in the sewage sludge treatment, treatment of organic solid wastewater, manure, organic household and industrial waste, etc.

E-10 FIXED-DOME PLANT WITH A BRICK MASONRY, MOULDED DOME (*JANTA* MODEL, 6 m^3/day TO 25 m^3/day)

The main feature of the fixed-dome biogas plant or *Janta* model biogas plant is that the digester and the gas holder are integrated parts of brick masonry structure. The digester is made of a shallow well having a dome-shaped roof on it. The inlet and outlet tanks are connected with the digester through large chutes which are called displacement chambers. The gas pipe is fitted on the crown of the masonry dome and there is an opening on the outlet wall of the outlet displacement chamber for the discharge of spent digested slurry. The size of this plant is limited to 25 m^3 per day.

E-11 FIXED-DOME PLANT WITH A HEMISPHERE DIGESTER (*DEENBANDHU* MODEL, UPTO 6 m^3/day)

This plant is designed on the principle that the surface area of biogas plants is reduced (minimized) to reduce their installation cost without sacrificing the efficiency of the plant. The design consists of segments of two spheres of different diameters, joined at their bases. The structure thus formed, acts as the digester, as fermentation chamber, as well as the gas storage chamber. The higher compressive strength of the brick masonry and concrete makes it preferable to go in for a structure which could always be kept under compression. A spherical structure loaded from the convex side will be under compression and therefore, the internal load will not have any residual effect on the structure. The digester is connected with the inlet pipe and the outlet tank. The upper part above the normal slurry level of the outlet tank is designed to accommodate the slurry to be displaced out of the digester with the generation and accumulation of biogas and is called outlet displacement chamber. The size of these plants is recommended up to 6 m^3/day.

E-12 FIXED-DOME PLANT WITH A BRICK MASONRY, MOULDED DOME (MODIFIED PAU *JANTA* MODEL, UPTO 500 m^3/day)

Fixed-dome plant with a brick reinforced, moulded dome or modified PAU *Janta* model biogas plant is a large capacity biogas plant developed to cater to the needs of dairy farmers. This essentially, is a 'Janta' design but of a higher capacity. The gas-holder is hemispherical in shape and is structurally safe and crack-resistant. The construction of this type of plant is easy and is not very different from the method for the *Deenbandhu* Biogas Plant. This plant can be constructed with around 50 percent to 60 percent cost as compared to the cost of other conventional floating drum type (KVIC) biogas plant. The biogas plant is an all brick masonry structure. Reinforced cement concrete is not used for construction of either the digester or the dome of the plant. The design is suitable for all regions of the country. The plant may be designed for any rated capacity from 20 m^3/day to 500 m^3/day for the hydraulic retention period of 40 days or more depending upon total solid concentration (TSC) of the influent slurry. Normally cattle dung mixed with equal quantity of water is used as feed for the plant having TSC of 9 percent to 10 percent. The plant may also work satisfactorily for higher TSC of upto 12 percent. This means water consumption may be cut by upto 50 percent depending upon the season and physical status of the cattle dung used at the time of feeding. Maintenance requirements of this plant are far lesser than the floating drum biogas plants.

E-13 FLOATING-DRUM PLANT MADE OF PRE-FABRICATED FERROCEMENT COMPOUND UNITS

The ferro-cement type of construction can be applied either as a self supporting shell or an earth-pit lining. The vessel is usually cylindrical. Very small plants (volume under 6 m^3) can be prefabricated. As in the case of a fixed-dome plant, the ferro-cement gas holder requires special sealing measures (proven reliability with cemented on aluminium foil).

E-14 FIXED FILM REACTOR

Fixed-film activated sludge (FFAS) technology/package provides for additional biomass within a wastewater treatment facility in order to meet more stringent effluent parameters or increased loadings without the direct need for additional tank capacity. Industry practice for upgrading wastewater treatment plants usually focuses on increasing the bioreactor volume to provide the additional bacterial population required to meet the system kinetic needs. FFAS systems such as moving bed biofilm reactor (MBBR) allow for the additional bacterial population to exist on a fixed surface, thereby eliminating the need to increase the suspended growth population. FFAS systems add the benefits of fixed film systems into the suspended growth activated sludge process. Activated sludge has process flexibility and provides a high degree of treatment. Fixed film processes are inherently stable and resistant to organic and hydraulic shock loadings. Placing Fixed Film media into activated sludge basins combines the advantages of both of these approaches.

E-15 FLOATING FILMS REACTORS

The moving bed biofilm reactor (MBBR) process is based on the aerobic biofilm principle and utilizes the advantages of activated sludge and other biofilm systems without being restrained by their disadvantages. The basis of the process is the biofilm carrier elements that are made from polyethylene. The elements provide a large protected surface area for the biofilm and optimal conditions for the bacteria culture to grow and thrive. The biofilm that is created around each carrier element protects the bacterial cultures from operating excursions to yield a very robust system for those industrial facilities loaded with process fluctuations. The biofilm also provides a more stable home for the bacteria to grow, so there is less space required compared to other biological systems and far less controls. Essentially nutrient levels and DO levels are the only control points for the system. MBBRs can be designed for new facilities to remove BOD/COD from wastewater streams or for nitrogen removal. Existing activated sludge plants can be upgraded to achieve nitrogen and removal or higher BOD/COD capacity (up to 500 percent increases have been obtained).

E-16 BAG TYPE DIGESTERS

A balloon plant consists of a plastic or rubber digester bag, in the upper part of which the gas is stored. The inlet and outlet are attached direct to the skin of the balloon. When the gas space is full, the plant works like a fixed-dome plant, that is the balloon is not inflated; it is not very elastic. The fermentation slurry is agitated slightly by the movement of the balloon skin. This is favourable to the digestion process. Even difficult feed materials, such as water hyacinths, can be used in a balloon plant. The balloon material shall be UV-resistant. The advantages of this biogas plants are its low cost, ease of transportation, low construction (as it is important if the water table is high), high digester temperatures, and non-complicated cleaning, emptying and maintenance. The disadvantages of this biogas plant are its short life (about five years), and it is easily damaged. Balloon plants can be recommended wherever the balloon skin is not likely to be damaged and where the temperature is even and high. One variant of the balloon plant is the channel-type digester with *folia* and sunshade.

E-17 HIGH RATE SOLID DIGESTERS

Anaerobic Digestion systems can be operated at a wide range of total solids (TS) contents depending on the feedstock TS content and process design. Anaerobic digestion for high strength wastewater can be carried out at a very low TS content (< 1.0 percent) using high-rate anaerobic reactors, such as an anaerobic biofilter, UASB or expanded/fluidized bed reactor. For slurry feedstocks, such as sewage sludge, animal manure, and liquid food waste, Anaerobic digestion systems are usually designed to operate at low TS contents (< 15 percent) and are referred to as liquid anaerobic digestion systems. Another type of anaerobic digestion that operates at TS contents higher than 15 percent and digests solid organic wastes, such as the organic fraction of municipal solid waste (OFMSW) and crop residues, is defined as solid-state anaerobic digestion. High TS contents will reduce the mass transfer rate in anaerobic digestion and result in a retarded reaction rate and slow diffusion of intermediate products and inhibitors. The changes of volumetric reaction rate of lignocellulosic biomass in anaerobic digestion increase with TS content due to the increase of organic loading but then decrease at TS of around 20 percent due to the slow mass transfer and accumulation of inhibitors.

Annexure 2

LIST OF BIOGAS DEVELOPEMNT & TRAINING CENTER (BDTCS)

1. Head, BDTC, Department of Mechanical Engineering, Indian Institute of Technology, Guwahati-781039, Assam. Email: lopab@iitg.ac.in

2. Head, BDTC, Centre for Rural Development & Technology (CRDT), Indian Institute of Technology, Delhi-110016. Email: vkvijay@rdat.iitd.ernet.in; ram.chandra6dec@gmail.com

3. Head, BDTC, Department of Civil Engineering, Punjab Agricultural University (PAU), Ludhiana- 141004, Punjab. Email: sssooch@rediffmail.com

4. Head, Coordinator, BDTC, Deptt. Of Renewable Energy Engineering, College of Technology & Engineering (CTAE), Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur- 313001. Email: nlpanwar@rediffmail.com

5. Head, BDTC, Centre of Energy Studies and Research (CESR), Devi Ahilya Vishwavidyalaya (DAVV), Indore-452017, Madhya Pradesh Email: cesrdirector@gmail.com

6. Head, BDTC, School of Biotechnology, Kalinga Institute of Industrial Technology (KIIT) University, Campus-XI, Bhubaneswar-751024. Email: smishra@kiitbiotech.ac.in,

7. Head, BDTC, Department of Agricultural Engineering, University of Agricultural Sciences (UAS), Gandhi Krishi Vignana Kendra (GKVK), Bangalore- 560065, Email: hod.agengg.uasb@gmail.com; vkgouda@gmail.com

8. Head, BDTC, Department of Bio Energy, Agricultural Engineering College & Research Institute, Tamil Nadu Agricultural University (TNAU), Coimbatore-641003, Tamil Nadu. Email: bioenergy@tnau.ac.in ,

Annexure 3

INDIAN OIL CORPORATION LIMITED
BHARAT PETROLEUM CORPORATION LIMITED
HINDUSTAN PETROLEUM CORPORATION LIMITED

Invite

Expression of Interest (EOI)

From

ENTREPRENEURS / SOLE PROPRIETORSHIPS / PARTNERSHIPS /
LIMITED LIABILITY PARTNERSHIPS / COMPANIES/ COOPERATIVE SOCIETIES /
TECHNOLOGY PROVIDERS

For

PRODUCTION & SUPPLY OF COMPRESSED BIO GAS (CBG)

Under

SATAT

(Sustainable Alternative towards Affordable Transportation)

Indian Oil Corporation Ltd.
SCOPE Complex, Core-6,
5th Floor,
7- Institutional Area,
Lodhi Road,
New Delhi -110003

Bharat Petroleum Corporation Ltd.
Admin Building,
Mumbai Refinery,
Mahul, Chembur,
Mumbai- 400074

Hindustan Petroleum Corporation Ltd.
Richardson & Crudas Building
Sir JJ Road, Byculla
Mumbai - 400008

	EOI No: CBG56, dated 1st Mar 2023 Tender ID 2023_BD_163569_1
	EOI FOR PRODUCTION & SUPPLY OF COMPRESSED BIO GAS (CBG) TO OIL MARKETING COMPANIES (OMCs) ACROSS INDIA

ANNEXURE – I

FORMAT FOR SUBMISSION OF EOI

(to be printed on the official stationery / letterhead of the APPLICANT)

To,
(Name & Address of respective OMC as applicable)

Dear Sir,

Subject: Submission of Expression of Interest for "**Production & supply of Compressed Bio Gas (CBG) to Oil Marketing Companies (OMCs) across India**".

With reference to your EOI inviting notice Ref. No: (mention EOI number) dated (mention EOI date) and after examining the detailed documents, selection criteria and other details mentioned in the EOI document for "**Production & supply of Compressed Bio Gas (CBG) to Oil Marketing Companies (OMCs) across India**", I/We hereby offer to submit my / our Expression of Interest in providing technology / partnering the said project.

1. All the schedules and documents necessary in this connection are enclosed hereto. All the documents/ photocopies of the documents have been self-attested by me/us and OMCs is free to reject our candidature if any of the documents/photocopies of the documents is/are found to be false or forged.
2. I/we, hereby also declare(s) that my/our organisation/firm is not debarred/ blacklisted by any Central/State Govt. department, agency, PSUs/ Institution/ Agencies/ Autonomous organization.
3. The information sought from me as per the EOI notice is enclosed in **Annexure-IA** to this letter.

Yours Faithfully,

(Signature & Stamp of Authorised Signatory)

Designation:

Date:

Place:

	EOI No: CBG56, dated 1st Mar 2023 Tender ID 2023_BD_163569_1
	EOI FOR PRODUCTION & SUPPLY OF COMPRESSED BIO GAS (CBG) TO OIL MARKETING COMPANIES (OMCs) ACROSS INDIA

Annexure – IA

Name of the Project	**Production & supply of Compressed Bio Gas (CBG) to Oil Marketing Companies (OMCs) across India**		
1.0 General Information			
Name of the APPLICANT submitting EOI			
Nature or legal status of the APPLICANT			
Structure of the APPLICANT	Entrepreneurs / Sole Proprietorships / Partnerships / Limited Liability Partnerships / Companies/ Cooperative Societies / Technology Providers		
Name and address of associated companies to be involved in the project with relationship and role, if any			
Details of Registration document of the APPLICANT *(provide details & submit copy of the company / organisation's registration)*			
Registered Address of APPLICANT			
Name, Designation and address of authorized Contact person: Mobile Number Landline number Fax Number			
Email (of individual and common e-mail of APPLICANT, if available)			
Name, Designation and address of authorized Signatory			
PAN Details (copy to be attached)			
GST Number (copy to be attached)			
CIN Number (if applicable)			
Turnover of the APPLICANT during last three financial years (Please enclose copy of audited Balance Sheet & Profit & Loss Statements)	Year	Turn Over (Rs Crore)	
	Financial Year-1		
	Financial Year-2		
	Financial Year-3		

In case APPLICANT is a subsidiary company, indicate the role of parent company			
Has APPLICANT have ever been debarred or blacklisted? If so, please provide details.			
2.0 Technology & Experience Information			
2.1 Past Experience in preceding 10 years (As on date of application) of project execution including supply, installation, commissioning of Facilities to produce biogas or past experience in any other project work in energy/ healthcare / social welfare/ infrastructure / power / biomass/ transport	*Insert additional rows for additional projects Documentary evidence Work Orders/ Completion Certificate / any other document in support of execution of the Plant to be submitted alongside*		
Name of Project			
Type of Project			
Location of Project Site			
Client Name			
Date of Award of Work Order/LOA or Date of initiation of Work			
Date of Commissioning			
Value of Work executed (INR in crore)			
2.2 Technology available with APPLICANT	*APPLICANT to submit relevant technical documents including documents proving in-house technology*		
Digester			
Purification system			
Compressor			
2.3 Technology tie-ups of APPLICANT	*APPLICANT to submit relevant technical documents including documents proving technology tie-ups like MOUs, Commercial Agreements, etc.*		
Digester			
Purification system			
Compressor			
Total nos. of CBG plants owned / has provided technology/ services / license by the APPLICANT with capacity	Demo/Pilot	Commercial	
Details of existing/planned individual Plants from which CBG is to be supplied to OMCs			
Name of plant			
Type of plant (demo / pilot / commercial)			

EOI No: CBG56, dated 1st Mar 2023 Tender ID 2023_BD_163569_1
EOI FOR PRODUCTION & SUPPLY OF COMPRESSED BIO GAS (CBG) TO OIL MARKETING COMPANIES (OMCs) ACROSS INDIA

Type of ownership	Own	Others (only technology provided)
Plant Location (Town/City, State, Country)		
Operational, since (date of commissioning in DD/MM/YYYY format)	(Applicable for existing plants only. Existing plants are those which are installed as on date of application and producing biogas for its further utilisation in power production, CBG production or direct sale to end consumers etc)	
Plant Capacity	Installed: Operational: Average working days per year:	
Brief details on Technology deployed		
Feedstock used		
Annual Capacity: • Biomass/waste processed • CBG • Other by-products	.....(ton per day) .....(ton per day) .....(ton per day)	
Total plant area (in Acre)		
Min. Commercial Scale Plant Capacity	.....MT/day of biomass processed	
Details on Technology to be used	• Process Flow Diagram • Feedstock which may be used • Main products & by-products • Utilization of by-products • Recycling of water • Effluent discharge yield and its treatment / Zero liquid discharge/ water reuse • Whether technology is flexible to scale up • Energy efficiency initiatives • Overall material balance (@ 1 tonne of biomass processed) Other significant information	

	EOI No: CBG56, dated 1st Mar 2023 Tender ID 2023_BD_163569_1
	EOI FOR PRODUCTION & SUPPLY OF COMPRESSED BIO GAS (CBG) TO OIL MARKETING COMPANIES (OMCs) ACROSS INDIA

The prospective APPLICANTS shall clearly specify Plant-wise the name of the concerned OMC viz. IndianOil, BPCL & HPCL through which they choose to market the CBG and CBG generation per Plant However, the APPLICANTS can choose to apply to different OMCs for marketing their CBG produced from different Plants located at different locations. (for more than 4 CBG Plants, additional lines should be added detailing their location and the CBG quantity to be produced in tonnes)	S. No.	CBG Plant Location	**Name of OMC through which CBG will be retailed**	CBG Quantity (in tonnes per day)
	1			
	2			
	3			
	4			
Authorized Signatory Designation Stamp Date Telephone/ email of authorized signatory				

Note:

1. The APPLICANT must submit all relevant documentary evidence with reference to above.
2. **All the documents to be submitted by the APPLICANT should be self-attested.**
3. Please provide the description in details for clear understanding. Attach separate sheets, if required.

	EOI No: CBG56, dated 1st Mar 2023 Tender ID 2023_BD_163569_1
	EOI FOR PRODUCTION & SUPPLY OF COMPRESSED BIO GAS (CBG) TO OIL MARKETING COMPANIES (OMCs) ACROSS INDIA

Annexure II

(On APPLICANTS letterhead)

AFFIDAVIT

I_____, the *Director / Proprietor / Partner / Authorized signatory of_____(mention name of firm/company and its complete address) do here by solemnly affirm and declare as under:-

1. That our Firm / company i.e._____(mention name of *firm/ company) is registered vide Registration No._____under the provisions of_____(mention the name of the Act).
2. That our Firm / company i.e._____(mention name of *firm/ company) has applied in response to the Expression of Interest for Production & supply of Compressed Bio Gas (CBG) to Oil Marketing Companies (OMCs) across India.
3. That_____(mention name of firm/company) is eligible to submit the aforesaid application as it not is under liquidation, court receivership or similar proceedings.
4. That all the information, documents and declarations submitted in/with our application are correct to the best of our knowledge and understanding.
5. That if any information, document or declaration submitted in/with our application, is found to be incorrect at a later date, we indemnify_____(OMCs name) against any loss due to this and_____(OMCs name) may take any action as deemed fit.

Place: **(Sign. & Seal of Authorized Signatory)**
Date:

	EOI No: CBG56, dated 1st Mar 2023 Tender ID 2023_BD_163569_1
	EOI FOR PRODUCTION & SUPPLY OF COMPRESSED BIO GAS (CBG) TO OIL MARKETING COMPANIES (OMCs) ACROSS INDIA

Annexure III

UNDERTAKING BY THE APPLICANT

NAME OF WORK: EOI FOR PRODUCTION & SUPPLY OF COMPRESSED BIO GAS (CBG) TO OIL MARKETING COMPANIES (OMCs) ACROSS INDIA

NIEOI No. : _____

We confirm that we have submitted our EOI considering Inter-alia the

1. **EOI Document(s)**
2. **Annexures I to IX of EOI document**
3. **Additional Document(s) (if any)**
4. **Corrigendum (if any)**
5. **Pre Bid Meeting Minutes (if any)**

We_____(Name of the Tenderer) hereby certify that we have fully read and thoroughly understood the tender requirements and accept all terms and conditions of the tender including all corrigendum/addendum issued, if any. Our offer is in confirmation to all the terms and conditions of the tender including all corrigendum/addendum, if any and minutes of the pre- bid meeting. In the event our offer is found acceptable and contract is awarded to us, the complete tender document shall be considered for constitution of Contract Agreement.

SIGNED FOR AND ON BEHALF OF TENDERER(S)

Name of Tenderer(s)

Date : _ _/_ _/_ _ _ _

Place :

Seal & Signature of Tenderer

NOTE:

This declaration should be signed by the Tenderer's authorized representative on COMPANY LETTERHEAD who is signing the Bid and scanned copy to be uploaded.

Annexure 4

स्वच्छ भारत
एक कदम स्वच्छता की ओर

इंडियन ऑयल कॉर्पोरेशन लिमिटेड
कॉर्पोरेट कार्यालय : स्कोप कॉम्प्लेक्स, कोर–2
7, इंस्टिट्यूशनल एरिया, लोधी रोड, नई दिल्ली–110 003
Indian Oil Corporation Limited
Corporate Office : SCOPE Complex, Core-2
7, Institutional Area, Lodhi Road, New Delhi-110 003
Website : www.iocl.com

इंडियनऑयल

कॉर्पोरेट कार्यालय
Corporate Office

Ref: CO/AE&SD/01
Date: 20.05.2022

To
Stakeholders of SATAT Scheme

Sub: Purchase price of Compressed Bio-Gas (CBG) under SATAT scheme

You are kindly aware that, 'SATAT' (Sustainable Alternative Towards Affordable Transportation) scheme on CBG was launched on 1.10.2018. As per the scheme, procurement price of CBG purified as per IS 16087: 2016 standards, compressed at 250 bar pressure and delivered to OMC Retail Outlets in cascades (up to 25 km one way distance from CBG Plant) was fixed at Rs. 46/kg + applicable taxes for period from 1.10.2018 to 31.3.2024. It was also informed that minimum procurement price will not be lower than Rs. 46/kg + applicable taxes up to 31.3.2029.

To facilitate entrepreneurs for financial closure of the projects as well as promote setting up of CBG Plants, it has been decided that the CBG prices shall be indexed to the prevalent Retail Selling Price (RSP) of CNG in the market (or CBG RSP for markets where CNG is not available).

Accordingly, the following revised procurement pricing of CBG shall be implemented:-

1.0 The minimum procurement price of CBG will not be lower than Rs. 46/kg + applicable taxes for the period up to 31.3.2029.

2.0 The Retail Selling Price of CBG in a market shall be at par with RSP of CNG (as provided by the authorized CGD entity).

3.0 **The following slabs for CBG procurement price have been decided, which will be the procurement price of CBG delivered at IndianOil Retail Outlet situated at any distance (up to 75 km one way) as per IS 16087 2016 specification (or its latest version) and compressed at 250 bar pressure:** -

S No	Lower Retail Selling Price of CBG in Slab including tax	Higher Retail Selling Price of CBG in Slab including tax	Procurement price of CBG Without GST	Procurement price of CBG With GST
	Rs./kg	Rs./kg	Rs./kg	Rs./kg
1	**Retail Selling Price of CBG up to 70**		**54.00**	**56.70**
2	70.01	75.00	55.25	58.01
3	75.01	80.00	59.06	62.01
4	80.01	85.00	62.86	66.01
5	85.01	90.00	66.67	70.01
6	90.01	95.00	70.48	74.01
7	95.01	100.00	74.29	78.01

Note: The above table is applicable strictly for supply of CBG at a one-way distance up to 75 km from the CBG Plant. For distance beyond 75 km, the price will be first adjusted as defined in para

पंजीकृत कार्यालय : इंडियन ऑयल भवन, जी–9, अली यावर जंग मार्ग, बान्द्रा (ई.), मुम्बई – 400051, महाराष्ट्र (भारत)
Regd. Office : IndianOil Bhawan, G-9, Ali Yavar Jung Marg, Bandra (E), Mumbai - 400051, Maharashtra (India)
CIN : L23201MH1959GOI011388

5.0 to bring it to 75 km distance table as above and then procurement price shall be fixed as per the table. For further increase in slabs beyond Rs. 100/kg, procurement price will be extrapolated as per the above. If the RSP of CBG falls below Rs. 70/kg, there will be immediate revision in the procurement pricing.

4.0 The upward and downward movement of CNG price will change the slab for a particular market at any point in time and the rate applicable for CBG procurement will change accordingly.

5.0 Additional transportation cost for transportation of CBG beyond 75 km (one-way distance) from CBG Plant shall be considered separately, at mutually discussed & agreed rates. This additional transportation costs shall be recovered from the market through inclusion in the Retail Selling price (RSP) build-up of CBG. If the recovery from market is not possible for additional transportation, the same shall not be paid.

6.0 This revised procurement price of CBG is being offered considering in view that presently RSP of CNG is greater than Rs. 70/kg in nearly all markets. If there is a reduction in CNG RSP from these levels, there will be revision in the price as agreed by Oil & Gas Company committee. The minimum procurement price of CBG as announced earlier will not be lower than Rs. 46/kg + applicable taxes for the period up to 31.3.2029.

7.0 The revised procurement pricing of CBG as detailed above shall form part of the Expression of Interest (EOI), Letter of Intents (LOIs) issued by IndianOil and Commercial Agreements executed by IndianOil under SATAT scheme with due acceptance by both parties.

The above pricing shall be effective from 1.6.2022 for one year or subsequent revision, whichever is earlier.

For Indian Oil Corporation Ltd.

20/05/2022

(Shantanu Gupta)
Executive Director (AE&SD)

Annexure 5

Guidelines for implementation of

Waste to Energy Programme

"Programme on Energy from Urban, Industrial and Agricultural Wastes/Residues"

सत्यमेव जयते

Government of India

Ministry of New and Renewable Energy

New Delhi – 110003

November - 2022

1. INTRODUCTION

1.1. Name of the Programme: "Programme on Energy from Urban, Industrial and Agricultural Wastes/Residues". It may also be referred as "Waste to Energy Programme".

1.2. Objective: The objective of the programme is to support the setting up of Waste to Energy projects for generation of Biogas/ BioCNG/ Power/ producer or syngas from urban, industrial and agricultural wastes/residues.

1.3. Scope: The programme provides Central Financial Assistance (CFA) to project developers and service charges to implementing/inspection agencies in respect of successful commissioning of Waste to Energy plants for generation of Biogas, Bio-CNG/enriched Biogas/Compressed Biogas, Power/ generation of producer or syngas.

2. FUNDING PATTERN

2.1. Standard CFA pattern: Standard pattern of CFA for grant of 'In-principal Approval' to Waste to Energy projects under the programme is as follows:

S.No.	**Type of project**	**Standard CFA rate @ installed capacity of the plant**
1	Biogas	Rs 0.25 Cr per 12000cum/day (maximum CFA of Rs. 5.0 Cr/project)
2	BioCNG / Enriched Biogas/ Compressed Bio Gas	-Rs 4.0 Cr per 4800 kg/day *(for BioCNG generation from new biogas plant)* -Rs 3.0 Cr per 4800 kg/day *(for BioCNG generation from existing Biogas plant#)* -Maximum CFA of Rs. 10.0 Cr/project for both cases.
3	Power *(based on Biogas)*	-Rs 0.75 Cr/MW *(for power generation from new biogas plant)* -Rs 0.5 Cr /MW *(for power generation from existing Biogas plant#)* -Maximum CFA of Rs. 5.0 Cr/project for both cases.
4	Power based on bio & agro-industrial waste (other than MSW through incineration process).	Rs 0.4 Cr/MW (maximum CFA of Rs. 5.0 Cr/project)
5	Biomass Gasifier for electricity/thermal applications	○ Rs. 2,500 per kW_e with dual fuel engines for electrical application ○ Rs. 15,000 per kW_e with 100% gas engines for electrical application ○ Rs. 2 lakh per 300 kW_{th} for thermal applications.

#***Note:*** *In case Developer is setting up a new BioCNG/ Power plant based on Biogas already available or generated from already commissioned/operational/existing biogas plant or have already availed financial assistance from Government of India for Biogas plant, then CFA will be provided only for conversion of biogas to BioCNG (@*Rs 3.0 Cr per 4800 kg/day*) or biogas to power (*Rs 0.5 Cr /MW*), as mentioned in the table above.*

2.2. Special CFA pattern

i) Special Category States: In case the Waste to Energy plants are set up in Special Category States (NE Region, Sikkim, Himachal Pradesh and Uttarakhand), Jammu & Kashmir, Ladakh, Lakshadweep and Andaman & Nicobar Islands, the eligible CFA would be 20% higher than Standard CFA pattern given in para 2.1 above.

ii) Biomethanation plants set up in registered Gaushala/Shelter: Biogas/BioCNG/Power (biogas based) generation plants based on cattle dung as main feedstock set up by Gaushalas independently or through joint ventures/partnerships will be eligible for 20% higher CFA than Standard CFA pattern given in para 2.1 above. These Gaushalas (Shelters) should be registered with the respective State Government.

2.3. Service Charge to Implementing Agency and Inspection Agency

i) Implementing agency (IA) shall be provided a service charge @1% of total CFA (minimum of Rs 50,000/-) for receiving and processing the applications. Indian Renewable Energy Development Agency Limited (IREDA) shall be the implementing agency. However the Ministry of New and Renewable Energy (MNRE) may change the IA by way of a suitable notification.

ii) Inspection Agency would be provided service charge @ Rs 1% of the eligible CFA (minimum of Rs 50,000/-) towards monitoring of implementation progress, performance inspection and verification of generation record, and post installation monitoring of the plants.

3. TERMS & CONDITIONS

i) Developers shall share plant generation data with MNRE or any other agency designated by MNRE, except in the case of Biomass Gasifiers, through installation of SCADA System/remote monitoring system. (This is applicable for project proposals submitted after notification of this guideline).

ii) Expansion of Plants: Grant of CFA to plants which intend to add capacity to the existing plants shall also be considered. CFA for such plants will be considered only for the enhanced capacity by way of installation of new plant and machinery. Applications received for

expansion projects will be processed as per guidelines existing at the time of submission of the application for expansion.

iii) Central financial assistance from any other Central Govt. Ministry should not be claimed for proposed plant for which application has been submitted to this Ministry.

iv) Waste to Energy (WtE) plants based on waste heat, waste plastics, waste tires or such other polymer waste shall not be eligible for CFA.

v) Biogas plants of size upto 250 kW capacity for power generation and upto 2500 m3/day for Biogas generation capacity are covered under Biogas Programme and shall not be eligible under this programme.

vi) Plants installed with new equipment/machinery only shall be eligible for CFA under this programme.

vii) Municipal Solid Waste (MSW)/Refused Derived Fuel (RDF) to power projects based thermal technologies (Incineration, Gasification, Pyrolysis etc.) are not supported under the Waste to Energy programme.

4. PROCEDURE FOR AVAILING CFA

4.1. Submission of proposal:

i) The proposal for grant of "In-Principle" approval of CFA will be accepted through BioURJA Portal (https://biourja.mnre.gov.in) before commissioning of the proposed plant [except for the projects mentioned in clause 4.1(iii)]. **The last date for submitting the applications under these guidelines shall be 31.12.2025**. List of documents to be submitted is placed at **Annexure-I (Stage-I).**

ii) ***Proposals submitted to the Ministry on or before 31.03.2021 under Waste to Energy Programme (notified vide letter no. 22/222/2016-17-WTE dated 30.07.2018 & 28.02.2020) but 'In-principle' approvals could not be accorded thereafter as the programme was continued only for clearing committed liabilities:*** 'In-principle' approvals and subsequent release of CFA to such proposals, except Municipal Solid Waste (MSW)/Refused Derived Fuel (RDF) to power projects based thermal technologies, shall be governed by the relevant guidelines prevailing at the time of the receipt of the concerned proposals.

iii) ***Proposals received in the Ministry from 01.04.2021 till the issuance of these guidelines for Waste to Energy Programme:*** Eligible proposals falling under this category shall be governed by these guidelines. Waste to Energy projects which have been commissioned during

aforementioned period, shall also be considered as eligible for grant of CFA under this programme. The applications of such projects should be submitted within three months of date of notification of these guidelines.

iv) Incomplete proposal in any form and without requisite approvals/documents will be rejected. The rejection of the proposal will be intimated preferably within 60 days of submission of the proposal in the BioURJA Portal. However, fresh proposal doing away with all shortcomings may be resubmitted before commissioning of the plant or 31.12.2025 whichever is earlier.

4.2. "IN-PRINCIPLE" APPROVAL:

i) **For projects with debt/loans from FIs/Banks**: In case loan drawn by the developer of Waste to Energy plant is equal or more than from eligible CFA, the Implementation Agency shall receive the applications through BioURJA portal, examine the applications and shall forward the consolidated proposal to Ministry on bimonthly basis. The Ministry shall issue an "In-Principle" approval with the concurrence of IFD and approval of Secretary, MNRE. For projects with loan, Ministry/ implementing agency will go by the appraisal of the project by the lending bank/FI.

ii) **For projects without debt/loan or projects wherein loan drawn by the developer of Waste to Energy plant is less than the eligible CFA**, the Implementation Agency shall receive the applications through BioURJA portal, examine the applications and thereafter the applications will be put up to Project Appraisal Committee (PAC). Only PAC recommended applications will be forwarded to Ministry in a consolidated manner on bimonthly basis. The Ministry shall issue an "In-Principle" approval with the concurrence of IFD and approval of Secretary, MNRE.

iii) The "In-Principle" approval will preferably be accorded to the proposals forwarded by IREDA preferably within 40 days of forwarding the proposal to Ministry.

4.3. Commissioning of the plant:

i) The time period for commissioning is 24 months for WTE plants and 12 months for Biomass Gasifiers from the date of "In-Principle" approval.

ii) After submission of application in the BioURJA portal, if developers intend to commission the plant before "In-Principle" approval of CFA is accorded, prior intimation of commissioning the plant to IA is mandatory. However, accord of "In-Principle" approval for grant of CFA shall be subject to fulfillment of the eligibility conditions as mentioned in these guidelines.

iii) In case of delay for reasons not attributable to the developer, a suitable extension of time over the original period of commissioning may be granted by Secretary, MNRE provided an application is made by the developer, with supporting documents, 30 days before the

original date of commissioning. If no such application is received by Implementing Agency and commissioning does not happen within the stipulated period (including the extended period), the "In-Principle" approval of CFA shall be treated as cancelled and no CFA shall be released.

4.4. Plant performance:

i) Inspection team will visit the plant for performance inspection based on request from the developer. The performance inspection of the plant will have to be carried out within 18 months from the date of commissioning beyond which "In-Principle" approval will be cancelled except in those cases where reason(s) of delay in inspection is (are) beyond the control of Developer. For such cases, an extension of suitable period over the original performance inspection period can be granted by Secretary, MNRE provided an application is made by the developer, with supporting documents, before the completion of original inspection period of 18 months as given above.

ii) The developer may choose any one of the following agencies for inspection of the plant:-

(a) Concerned State Nodal Agencies for Renewable Energy (SNAs); **or**
(b) Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE); **or**
(c) Biogas Technology Development Centre (BTDC) (*List at **Annexure-VIII***).

iii) Performance testing of the plant would inter-alia imply the following:-

a) Waste to Energy Plants: The condition of successful commissioning of the Waste to Energy plants would imply operation of the plants for atleast 3 consecutive months, including continuous operation for at least 72 hours at an average of 80% of the rated capacity of the plant.

In case of biomethanation plants (Biogas, BioCNG, Power based on biogas), continuous operation of the plant implies continuous operation of digester (raw biogas generation) for 72 hours.

Based on the performance of the project for at least three consecutive months, following graded structure for release of CFA based on average PLF over a period of atleast three months shall be applicable: -

Average PLF achieved during minimum 3 consecutive months	**% of eligible CFA**
≥80%	100%
≥ 60% and < 80%	80%
≥ 50% and < 60%	60%
<50%	0%

b) Biomass Gasifiers: The condition of successful commissioning for Biomass gasifier would imply operation of the Gasifier for atleast 3 consecutive months, including continuous operation for at least 3 consecutive days at an average PLF of 60% of rated capacity (taking 12 Hrs per day as standard operating hours).

In case of Biomass Gasifier, data of consumption/saving of conventional fuel can also be accepted for release of CFA.

4.5. Submission of documents for release of CFA:

i) Claim for release of CFA by developer should be made in the BioURJA portal within 3 months of the inspection of the plant by Inspection Team. List of documents to be submitted is placed at **Annexure-I** (**Stage-II**).

ii) The implementing agency shall then examine the proposals for release of funds and shall forward the consolidated demand, in respect of all projects eligible for release of CFA as per scheme guidelines, to MNRE on monthly basis.

4.6. Disbursement of CFA

i) Disbursement after plant commissioning (Standard process): Applicable for all types of projects except BioCNG plants under SATAT Initiative.

a) In case of Self-financed Projects or projects wherein loan drawn by the developer of Waste to Energy plant is less than the eligible CFA, the CFA shall be disbursed to developer's bank account.

b) Bank financed: In case loan drawn by the developer of Waste to Energy plant is equal or more than from eligible CFA, CFA shall be disbursed to developer's loan account maintained in the lending FI/bank.

ii) Advance disbursement during Construction Phase: BioCNG plants which have signed BioCNG (CBG) purchase agreement with Government Oil Marketing Companies (OMCs) under SATAT Programme of Ministry of Petroleum & Natural Gas and have also availed project loan of atleast 50% of the total project cost from FI(s)/Bank(s) shall be eligible for advance disbursement of CFA during construction phase. The CFA will be released by the Ministry in two installments as below:

a) First installment of upto 50% of "In-Principle" approved CFA may be released during the construction phase to the lending FI(s)/Bank(s) subject to disbursement of at least 50% of loan amount by the FI/Bank. This may be treated as interest free loan until the release of second instalment of CFA. Documents required for availing advance disbursement of CFA during construction phase is given as below:

1) MNRE's "In-Principle" Approval letter.
2) Request letter for advance disbursement of CFA from lending Bank/FI.**#**
3) Loan disbursement letter indicating loan amount disbursed by lending bank/FI.
4) Furnishing of Bank Guarantee to the IA for an amount equal to the advance CFA for which the project is eligible. The bank guarantee should initially be valid for a period of four years from the date issue. Thereafter the project developer will have to extend the validity of the bank guarantee as required by the IA so as to cover the period permissible for successful performance testing, commissioning and release of CFA. The bank guarantee will be enchased if the project developer fails to adhere to the permissible timelines for successful commissioning & performance testing or submission of documents for release of CFA. The bank guarantee will be released along with the disbursement of CFA. **#**
5) Mandate form for payment transfer duly certified by FI/Bank for loan account.**#**
6) High resolution Photographs of the plant site showing progress of installation.
7) Consent to Establish (CTE) from State Pollution Control Board for the plant.
8) EIA clearance, if applicable.
9) Approval for storage & filling of Bio-CNG Plant from Petroleum and Explosives Safety Organization (PESO), Nagpur, if applicable.
10) Non-NPA certificate from the lending banks/FIs if loan availed.**#**

#Documents (marked with #) are also required to be submitted in original to Implementing Agency.

(b) Second instalment of balance CFA shall be released after commissioning of the plant and submission of documents as per **Annexure-I** **(Stage-II)**. Second installment will be settled as per standard process described under clause 4.3 to 4.6(i). The amount disbursed during construction phase will be adjusted during disbursement of second installment and any surplus amount in lieu of under performance of the projects that could have been disbursed to developer shall be recovered from the Bank/FI.

(iii) The service charge to implementing agencies and inspection agencies shall be released at the time of release of CFA after commissioning and performance testing of the plant.

(iv) The above disbursements of CFA to eligible projects will be done by MNRE/Implementing Agency in accordance with procedure specified for release of funds by Ministry of Finance.

5. PROJECT MONITORING MECHANISM

Developers shall share plant generation data with MNRE or any other designated agency, except in the case of Biomass Gasifiers, through installation of SCADA System/remote monitoring system.

The aforesaid programme is subject to change(s) and modification(s) as may be decided by the MNRE, Govt. of India from time to time, and subject to availability of funds. The Ministry shall in no way be liable for expenditure incurred by promoters for pre-project preparation or other activities, merely on the basis of this circular and / or related announcement by the Ministry. In case of any ambiguity on interpretation of any provisions of the programme, the decision of the Ministry shall be final and binding. It is clarified that mere submission of the proposal should not be construed as "In-Principle" approval of the project for grant of CFA.

***

References

1 https://www.indiaenergyweek.com/visit/why-india/

2 Anon 2021. *India Energy Outlook 2021*, IEA, Paris. Accessed at https://www.iea.org/reports/india-energy-outlook-2021 on 3 April 2023

3 Anon 2022. *Renewables 2022*, IEA, Paris. Accessed at https://www.iea.org/reports/renewables-2022 on 3 April 2023

4 Anon 2022. *India's Updated First Nationally Determined Contribution Under Paris Agreement, 2021–2030*, Government of India. Accessed at https://unfccc.int/sites/default/files/NDC/2022-08/India%20Updated%20First%20Nationally%20Determined%20Contrib.pdf on 25 March 2023

5 Anon 2022. *Bioenergy for the Transition: Ensuring Sustainability and Overcoming Barriers*, IRENA. Accessd at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Aug/IRENA_Bioenergy_for_the_transition_2022.pdf on 3 April 2023

6 Ibid.

7 Anon 2021. *Net Zero by 2050*, IEA, Paris. Accessed at https://www.iea.org/reports/net-zero-by-2050 on 3 April 2023

8 Anon 2022. "The role of biogas and biomethane in pathway to net zero", *IEA Bioenergy Task 37: 12*. Accessed at https://www.ieabioenergy.com/wp-content/uploads/2022/12/2022_12_12-IEA_Bioenergy_position-paper_Final2.pdf on 3 April 2023

9 K. Obaideen, M.A. Abdelkareem, T. Wilberforce, K. Elsaid, E.T. Sayed, H.M. Maghrabie and A.G. Olabi 2022. "Biogas role in achievement of the sustainable development goals: Evaluation, Challenges, and Guidelines", *Journal of the Taiwan Institute of Chemical Engineers 131*. Accessed at https://doi.org/10.1016/j.jtice.2022.104207 on 3 April 2023

10 K. Yadav and A. Sircar 2022. "Fundamentals and developments of compressed biogas in city gas distribution network in India: A review", *Petroleum Research Vol. 7 Issue 3*. Accessed at https://doi.org/10.1016/j.ptlrs.2021.12.003 on 3 April 2023

11 P. Singh and A.S. Kalamdhad 2022. "Environmental Technology & Innovation Biomethane plants based on municipal solid waste and wastewater and its impact on vehicle sector in India — An Environmental-economic-resource assessment", *Environmental Technology & Innovation 26*. Accessed at https://doi.org/10.1016/j.eti.2022.102330 on 3 April 2023

12 V. Venkatramanan, Shachi Shah, Shiv Prasad, Anoop Singh and Ram Prasad 2021. "Assessment of Bioenergy Generation Potential of Agricultural Crop Residues in India," *Circular Economy and Sustainability*, Springer.

13 Anon 2021. Landscape analysis on Biofuels in India, GGGI. Accessed at https://gggi.org/wp-content/uploads/2021/10/Landscape-Report-of-BioCNG-in-India-GGGI-1.pdf on 3 April 2023

14 P. Singh and A.S. Kalamdhad 2022. "Biomethane plants based on municipal solid waste and wastewater and its impact on vehicle sector in India — An Environmental-economic-resource assessment", *Environmental Technology & Innovation (26)*. Accessed at https://doi.org/10.1016/j.eti.2022.102330 on 3 April 2023

15 Ibid.

16 https://www.statista.com/statistics/887402/india-mill-sugar-production-volume-by-state/

17 Ibid.

18 P. Singh and A.S. Kalamdhad. 2021. "A comprehensive assessment of state-wise biogas potential and its utilization in India", *Biomass Convers. Biorefinery*. Accessed at https://doi.org/10.1007/s13399-021-02001-y

19 Anon 2021. Landscape analysis on Biofuels in India, GGGI. Accessed at https://gggi.org/wp-content/uploads/2021/10/Landscape-Report-of-BioCNG-in-India-GGGI-1.pdf on 3 April 2023

20 P. Singh and A.S. Kalamdhad. 2021. "A comprehensive assessment of state-wise biogas potential and its utilization in India", *Biomass Convers. Biorefinery*. Accessed at https://doi.org/10.1007/s13399-021-02001-y

21 M.J. Black, A. Roy, E. Twinomunuji, F. Kemausuor, R. Oduro, M. Leach, J. Sadhukhan and R. Murphy 2021. Bottled Biogas — An Opportunity for Clean Cooking in Ghana and Uganda", *Energies 14(13)*. Accessed at https://www.mdpi.com/1996-1073/14/13/3856 on 3 April 2023

22 Anon 2022. *Environmental Guidelines for Compressed Biogas Plant (CBG)/bio-CNG Plants*", CPCB. Accessed at http://bspcb.bihar.gov.in/Environmental%20Guideline%20For%20CBG.pdf on 3 April 2023

23 Anon 2023. *Design, Construction, Installation and Operation of Biogas (Biomethane) Plant — Code of Practice*, Bureau of Indian Standards.

24 Ibid.

25 Anon 2022. *Environmental Guidelines for Compressed Biogas Plant (CBG)/bio-CNG Plants*", CPCB. Accessed at http://bspcb.bihar.gov.in/Environmental%20Guideline%20For%20CBG.pdf on 3 April 2023

India is expected to experience a great increase in energy demand over the next few decades, with its share of global energy consumption doubling by 2050. Increased use of modern bioenergy is essential for transitioning to less carbon-intensive energy sources and usage of compressed biogas (CBG) within bioenergy is needed for spreading the benefits of the transition locally.

This report presents a comprehensive view of India's current CBG strategy and its future course. It engages with the challenges the country faces in adopting CBG at a large-scale and gives recommendations to overcome those challenges.

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