COMPRESSED BIOGAS (CBG)

A NATIONAL BLUEPRINT FOR UPSCALING POLICY AND PRACTICE

CASE STUDIES FROM PUNJAB, GUJARAT AND HARYANA

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Executive Summary

India's substantial dependence on imported natural gas, which currently accounts for about 50 per cent of domestic consumption at an estimated cost of US $14,908 million, highlights a significant energy security challenge. The Sustainable Alternative Towards Affordable Transportation (SATAT) initiative, launched in 2018 with an ambitious target of setting up 5,000 compressed biogas (CBG) plants, has experienced stagnant implementation, with only 162 operational units documented as of late 2025. This sector represents a critical intersection of waste management and non-fossil-based energy production, converting agricultural residues and municipal waste into clean fuel and organic fertilisers to foster a circular economy.

In Punjab, despite the vast availability of agricultural feedstock like paddy straw, the sector faces systemic barriers due to an outdated regulatory framework that lacks specific provisions for CBG. Key challenges include the highly seasonal nature of feedstock availability, a critical shortage of storage land during harvest periods, and the absence of a structured market for fermented organic manure. To address these gaps, this report recommends the adoption of a dedicated bioenergy policy that incorporates financial incentives, specialised storage infrastructure and broad scale farmer awareness programmes to ensure a consistent and reliable supply chain.

Gujarat is one of the front runners with 22 functional plants — yet developers continue to encounter obstacles related to high land acquisition costs and delayed grid connectivity for gas injection. Besides this, it faces the same national issue of inconsistent segregation of municipal waste at source, which ultimately compromises the quality of feedstock for municipal solid waste-based CBG plants. The state's strategy should prioritise the integration of one-stop approval systems to facilitate faster land allocation and infrastructure links, while simultaneously implementing a comprehensive bioenergy framework to streamline the administrative processes for private investors.

Haryana currently operates 17 plants but remains limited by the brief seasonal window available for collection and baling of agricultural residues (as is the case in Punjab). The state requires a more robust logistical network to prevent frequent interruptions in production. Recommendations for Haryana focus on establishing designated collection zones to minimise land use conflicts and

providing technical training to farmer producer organisations (FPOs) to manage centralised aggregation hubs, thereby stabilising feedstock pricing and availability.

The financial viability of the national CBG sector is severely constrained by high capital expenditure, largely driven by a dependence on expensive imported machinery. Currently, many plants operate at less than 50 per cent capacity utilisation, resulting in persistent financial losses and unsustainable maintenance costs. Moreover, the logistics of transporting gas via truck cascades are significantly more expensive and less efficient than direct pipeline injection. Improving the sector's economic outlook requires a transition towards indigenous technology and the urgent expansion of gas grid connectivity to reduce operational overheads.

The national blueprint for the CBG sector identifies a clear path toward achieving the 5 per cent gas blending mandate through coordinated state and Central action. CSE recommends that state governments set their production targets and harmonise local renewable energy policies with national objectives to ensure regulatory consistency across the country.

CSE also suggests the creation of a centralised support hub to monitor technical standards and provide real-time problem-solving assistance to plant operators. To mitigate the burden of high project costs, CSE recommends prioritising the research and development of cost-effective domestic technologies and the publication of detailed technical handbooks to guide developers.

Finally, CSE advises the implementation of long-term feedstock supply agreements featuring pricing escalation clauses to provide mutual contractual security for both manufacturers and suppliers.

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INTRODUCTION

India imports 50 per cent of the natural gas that it consumes. To cut down on the import bill, the Central government has introduced schemes and initiatives to increase domestic production, and adapted strategies for promotion of biofuels

Compressed biogas (CBG) is emerging as a promising alternative to natural gas and a means of reducing India's dependence on imports. It also offers substantial environmental and economic benefits

However, the sector has not moved at the required pace due to multiple challenges: the government's SATAT scheme had a target production of 15 million tonne of CBG by 2023 from 5,000 plants. But till January 2026, only 1,550 plants have been registered across the country — a mere 188 of these are commissioned or functional.[1]

This CSE study — which does a deep-dive into three states of Punjab, Haryana and Gujarat — tries to understand the CBG ecosystem in India, its current status, challenges and opportunities and presents a set of recommendations (a 'national blueprint') for upscaling the sector

India imports 50 per cent of the natural gas that is consumed in the country. According to the Union Ministry of Petroleum and Natural Gas (MoPNG), India sources its natural gas from domestic production as well as from imports. In 2024-25, the total consumption was around 71,000 million standard cubic metre (SCM): the country spent around US $14,908 million on importing 50 per cent of this figure.[2]

The Central government has taken several steps and launched various policy initiatives to increase the domestic production of natural gas. It has also adopted strategies for promotion of biofuels: these include support for compressed biogas (CBG), a national gas grid for pipeline infrastructure, city gas distribution networks, and development of LNG regasification terminals to ensure availability of gas to all demand centres. CBG, in fact, is emerging as a promising alternative to natural gas and a means of reducing India's dependence on imports.

In 2015, the Union Ministry of Road Transport and Highways (MoRTH) had notified the use of CBG or bio-CNG in vehicles. This move was complemented by the MoPNG's Sustainable Alternative Towards Affordable Transportation (SATAT) scheme on CBG, launched in 2018. The scheme had envisaged a target production of 15 million tonne (MT) of CBG by 2023 from 5,000 plants at an investment of Rs 1.7 lakh crore[3]. However, with only about 188 operational CBG plants across the country and 312 more under construction till January 2026[4], the progress has been slow (*see Box: The SATAT scheme: A long way to go*). The demand for CBG is expected to rise in the coming years owing to gas off-take — city gas distribution entities favourably considering CBG under domestic gas procurement and expansion of the pipeline infrastructure.

The SATAT initiative is also aimed at better use of agricultural residues, cattle dung and municipal solid waste, as well as at providing additional revenue sources to farmers and more affordable transport fuels to the country as a whole. The environmental and economic benefits of CBG, in fact, are substantial. The sector can act as a sink for different types of waste, including municipal solid waste, agricultural waste, animal dung, vegetable waste, chicken litter, industrial waste like press mud etc. The production process yields two valuable products: one, clean-burning CBG and two, fermented organic manure (FOM)/liquid fermented organic manure (LFOM), which can enhance soil health while reducing dependence on chemical fertilisers. This dual-output system has the potential to create a truely circular economy where different kinds of waste become the feedstock for new value chains.

Economically, development of the CBG sector can create new income streams for farmers through the sale of agricultural residues and animal waste, and

can generate rural employment opportunities in the collection, processing and distribution network.

But the sector's promise has been stalled by a number of technical, operational and financial challenges. The sector's concerns can differ from plant to plant based on location and feedstock. The three major aspects that need to be looked into are feedstock security, off-take management of CBG, and the management of FOM/LFOM (fermented organic manure/liquid fermented organic manure, which are by-products of CBG plants).

In 2024, CSE had done a study on the CBG landscape in Uttar Pradesh[5], highlighting the challenges faced by the sector in the state. Some of the major concerns that were observed included integration of the supply chain, poor off-take of organic manure because of lack of awareness among farmers, and low CNG demand in rural areas, among other things.

THE SATAT SCHEME: A LONG WAY TO GO

Launched on October 1, 2018, by the Union Ministry of Petroleum and Natural Gas, the Sustainable Alternative Towards Affordable Transportation (SATAT) scheme seeks to create a robust nation-wide ecosystem for the production of CBG from diverse waste and biomass sources. Under it, entrepreneurs can establish CBG plants; the produced CBG is distributed to oil marketing companies (OMCs) for use as automotive and industrial fuel. The scheme encourages OMCs to enter into long-term agreements for assured off-take of CBG at a minimum procurement price that will not fall below Rs 46 per kilogram until March 31, 2029.

The Reserve Bank of India (RBI) has also included CBG projects under its 'priority sector lending', facilitating easier access to financing. The Ministry of Agriculture has recognised digested biogas slurry (DBGS), a by-product of CBG plants, as "fermented organic manure (FOM)" under its Fertiliser Control Order (FCO). The oil and gas marketing companies had issued 3,694 letters of intent (LoIs) to potential entrepreneurs for procurement of CBG up to October 31, 2022.[6]

As of now, a total of 1,550 CBG/bio-CNG plants have been registered across the country — which falls short of the target of 5,000 plants by 2023[7]. Out of these, 188 plants are currently functional; 10 more have been fully completed. Construction is in progress at 312 sites, whereas construction is yet to begin for 1,050 registered plants. This indicates that while progress has been made, a large number of projects are still in the early or planning stages.[8]

Why this study

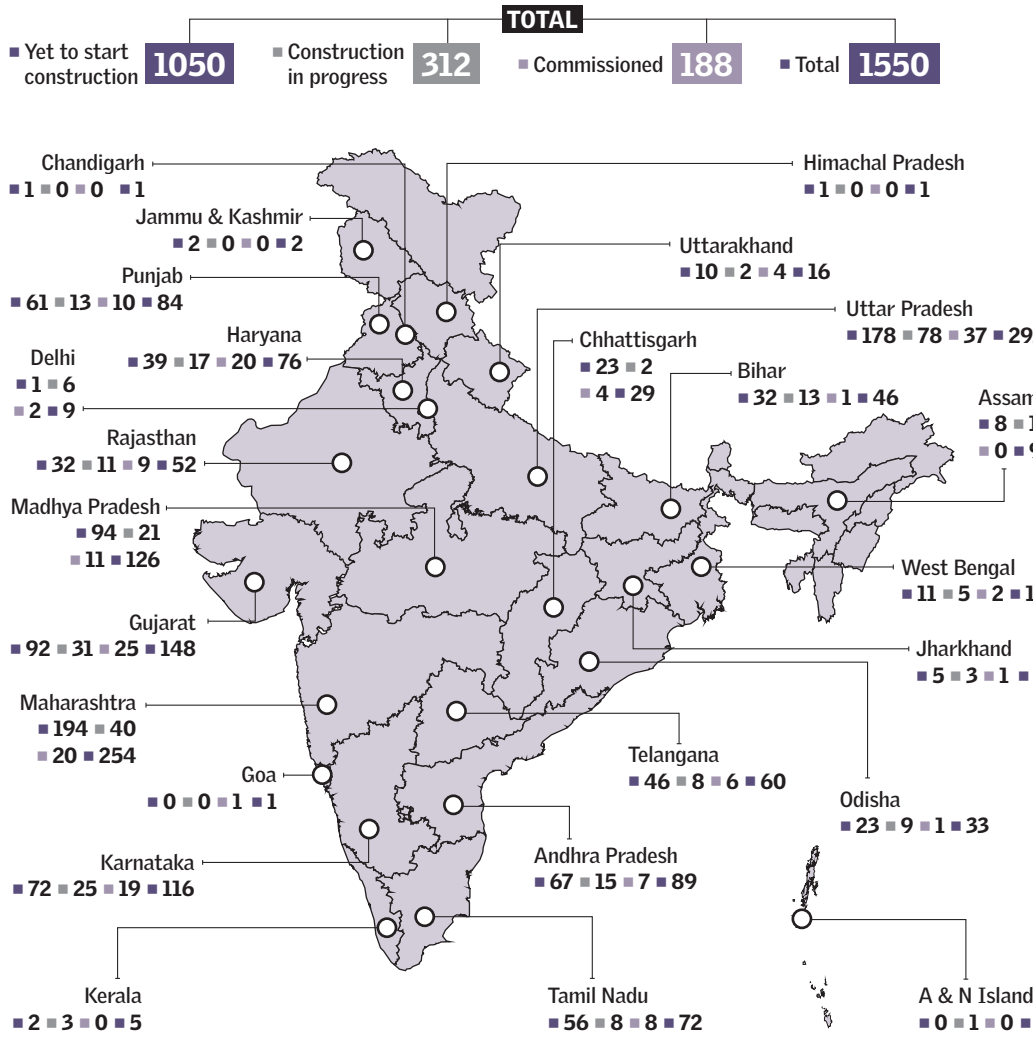
Realising CBG's full potential requires us to address several systemic challenges. Feedstock security remains a critical bottleneck, with concerns such as seasonal availability, inconsistent quality, lack of organised collection systems and inadequate storage infrastructure for agricultural residues. To add to this, in many states, policy frameworks have not kept pace with technological developments; some states do not even have a CBG/bioenergy policy, while in others there are no clear incentives, streamlined approvals or guaranteed off-take mechanisms. There are financial barriers as well, with high capital cost of equipment.

At the same time, different states point to contrasting experiences that highlight both opportunities and lessons for scaling up CBG. Uttar Pradesh's focused bioenergy policy, with dedicated funding and clear implementation guidelines, has encouraged successful projects utilising the sugar industry's by-products. Madhya Pradesh's ambitious programme to establish biofuel plants in every development block demonstrates how a coordinated policy can drive rapid adoption, whereas Punjab, despite its enormous agricultural residue potential, lags due to lack of policy framework and implementation challenges. In terms of number of operational CBG plants, Uttar Pradesh leads with 37, followed by Gujarat (25), Haryana (20), Maharashtra (20), Karnataka (19) and Punjab (10)[9] (*see Map 1: State-wise registered CBG/bio-CNG plants*).

This study by Centre for Science and Environment (CSE) is an attempt to understand the complete CBG ecosystem in India — its current status, challenges and opportunities — with the aim of presenting a set of recommendations (a 'national blueprint') for upscaling the sector keeping in mind its potential. The selection of the three states — Punjab, Haryana and Gujarat — for a deep-dive was based on ground truths. Punjab and Haryana, where agriculture is dominant, face the issue of biomass or stubble burning every year: CBG plants can ensure biomass utilisation in these states, thus helping reduce open stubble burning. Gujarat was shortlisted as it is one of India's leading states in terms of functional CBG plants and offers models and success stories that can be replicated in the rest of the country.

CSE researchers have studied the CBG ecosystem in these states, including the state policies (if available), status of operational plants, issues and challenges related to feedstock, CBG off-take, and bio-digestate management. They have also examined the cost economics and feasibility aspects of the operational plants, and documented the good practices.

Map 1: State-wise registered CBG/bio-CNG plants



Source: GOBARdhan portal as viewed on January 20, 2026

The policy framework in the focus states

Gujarat

Gujarat's State Biotechnology Policy was introduced in 2022 by the Gujarat State Biotechnology Mission (GSBTM), under the Department of Science and Technology. The Mission has been designated as the nodal agency responsible for implementation, support and coordination between various government departments to ensure the policy's effective execution.

The policy covers biofuels as they come under the umbrella term of 'biotechnology products'. Biofuel projects have been considered as 'special projects' — the policy defines them as "projects of strategic importance, in challenging areas and in emerging technologies". The policy aims to support 500 biotechnology units and create over 1.2 lakh jobs in the biotechnology sector, including in areas such as biofuels and bio-fertilisers.

The policy offers incentives under two packages based on gross fixed capital investment (GFCI). The first package covers incentives for units with GFCI of less than Rs 200 crore; the second offers incentives for units with GFCI of over Rs 200 crore and covers mega or special projects (biofuels included). Capital assistance is provided as per basic investment promotion assistance for a project; this is calculated on the basis of a formula given under the policy, which considers the eligible fixed capital investment (EFCI) as a factor along with a number of incentive multipliers such as export multiple, gross supply multiple etc. The capital assistance offered makes up 25 per cent of the capital investments, with a ceiling of Rs 200 crore for special projects, disbursed in 20 quarterly instalments over five years.

Gujarat also provides an operational assistance at 15 per cent of expenses, capped at Rs 5 crore per annum. This is important for the biofuels sector, as there are significant costs involved in the operation and maintenance of biofuel projects. This initiative from the government of Gujarat is a benchmark for all other states.

To streamline the establishment of new units, a 'single window clearance mechanism' has been established to grant the necessary approvals and clearances. The policy also includes a 100 per cent reimbursement of electricity duty on power purchased from state electricity distribution companies or power distribution licensees for a period of five years. Interest subsidies on term loans are available at 7 per cent for borrowings of up to Rs 100 crore, with a ceiling of Rs 7 crore per annum, and an additional 3 per cent for borrowings above Rs 100 crore, with an overall ceiling of Rs 20 crore per annum or the actual interest paid, whichever is lower.

The policy introduces an employment generation incentive as well, titled 'AatmaNirbhar Gujarat Rojgar Sahay', offering benefits of up to 50 per cent of the CTC (cost to company), with a maximum of Rs 50,000 per male employee and Rs 60,000 per female employee. This incentive is available to applicants for local employees who have completed at least one year of employment with the unit.

Presently, the state government — along with the Gujarat Energy Development Agency (GEDA) — is in the process of developing a specific bioenergy policy for the state.

Punjab

Punjab produces large amounts of agricultural waste, especially paddy straw, which is often burned, causing severe air pollution. CBG can offer a sustainable solution to this problem by converting this waste into clean energy, while boosting rural incomes. The state has significant potential for CBG production due to its abundant agricultural residues, animal waste and other organic feedstocks — but Punjab's policy framework remains underdeveloped.

The state's New and Renewable Sources of Energy Policy (NRSE) of 2012 lacks specific provisions on biofuels, including CBG – Punjab is working towards developing a dedicated bioenergy policy. At present, investments in bioenergy and biomass utilisation are governed by the Industrial and Business Development Policy, 2026. The policy identifies the processing of agro-waste (biomass) into energy, bioenergy or manure as a priority sector, allowing such projects to access fiscal incentives under the industrial policy framework.

Capital expenditure support

Capital expenditure support is essential for attracting investment into bioenergy projects because plant infrastructure, machinery and land acquisition constitute major upfront costs. The Punjab policy provides some incentives that can support bioenergy projects indirectly.

- **Capital subsidy of up to 20 per cent of eligible fixed capital investment**, subject to a maximum of Rs 10 crore. This subsidy can be accessed by new units or by existing industries undertaking modernisation or expansion. Biomass processing and bioenergy projects classified under priority sectors can, therefore, benefit from this provision.
- **100 per cent exemption or reimbursement of stamp duty** on the purchase or lease of land or buildings required for industrial projects. This reduces the initial financial burden for investors and encourages industrial establishment within the state.
- **Reimbursement of net SGST**, which allows eligible units to recover up to 75 per cent of the tax paid on incremental production. While this incentive is linked to production rather than capital investment, it improves project viability and indirectly supports capital deployment.

However, several capex-related provisions typically found in dedicated bioenergy policies are absent in the Punjab policy. There is no provision for government land leasing at concessional rates, a waiver of land conversion fees or infrastructure support, such as approach roads, for bioenergy plants. The policy also does not

define biomass catchment areas, which states often use to ensure a reliable feedstock supply for bioenergy plants.

Operational expenditure support

Operational support is particularly important for the biofuel sector because these projects have high recurring costs. Feedstock procurement, logistics, labour and plant operations often account for a large share of the total project expenditure.

The Punjab policy provides limited support in this area:

- It offers **exemption from electricity duty**, which reduces the cost of electricity consumption for industrial units. Since bioenergy plants require electricity for various operational processes, this exemption offers some financial relief.
- **Employment-generation subsidy**, under which industries can receive financial assistance to hire workers. Eligible units can receive subsidies of approximately Rs 3,000 per employee per month for male workers and Rs 4,000 per employee per month for female or special-category employees for a period of five years. This incentive reduces labour costs and indirectly supports operational expenditure.

Despite these provisions, the policy does not provide several forms of support critical to bioenergy projects. There is no interest subvention on loans, direct operational subsidy, or support for biomass aggregation machinery such as balers and rakers. Similarly, there is no mechanism to strengthen the feedstock supply chain or facilitate long-term biomass procurement contracts.

Another gap is the lack of provisions for organic manure or digestate management, a key by-product of CBG plants that can contribute to plant profitability when integrated into agricultural markets.

Ease of doing business provisions

The policy performs strongly in terms of ease-of-doing-business mechanisms. It introduces a digital Common Application Form (CAF) system that allows industries to apply for incentives and approvals through a single online platform. This reduces administrative complexity and improves transparency.

In addition, the policy provides a single-window clearance mechanism, enabling investors to obtain approvals from multiple government departments through an integrated system. This significantly reduces the time required for project approvals and facilitates faster establishment of new industrial units.

These provisions strengthen Punjab's investment environment and can encourage industries, including those working in the bioenergy sector, to set up operations in the state.

The Punjab Industrial and Business Development Policy, 2026 provides a broad industrial incentive framework that can support investments in biomass-based industries. The inclusion of agro-waste processing into energy and bioenergy as a priority sector is an important step that acknowledges the role of biomass in the state's industrial and energy strategy.

Compared to states that have introduced dedicated bioenergy policies—such as Uttar Pradesh, Haryana and Gujarat—Punjab's policy framework remains largely generic rather than sector-specific.

Haryana

The Haryana Bioenergy Policy was introduced in 2018 to encourage the generation of energy from the surplus biomass. The policy designates the Haryana Renewable Energy Development Agency (HAREDA) as the nodal body responsible for facilitating bioenergy projects and implementing the policy.

Due to surplus biomass availability, Haryana has a great potential to produce clean energy/biogas/bio-CNG/bio-fuels etc by using crop residues. To harness clean power and for a safe environment, Haryana is encouraging the production of biomass projects, and is providing various incentives for it. The state allows the use of agricultural land for setting up biomass projects, and the government is also providing the panchayat land on lease or rent at a reasonable price directly (through the panchayat) for 35 years.

To support efficient collection of biomass for approved projects, the policy offers reapers, balers and trawlers either on rent or through an upfront subsidy. To ensure a consistent and continuous supply of biomass, the Department of Agriculture and Farmer Welfare has been designated to carry out area demarcation, making sure that proposed projects do not conflict with other agricultural initiatives. The capacity of these projects has been capped at 80 per cent of the feedstock availability in the district, as determined by a biomass assessment report.

The policy offers exemptions from land use approval, external development charges, scrutiny fees and infrastructure development charges. Additionally, there is a 100 per cent exemption from entry tax on all supplies, including capital goods, structures and raw materials necessary for setting up and for trial operations of the projects.

The Agriculture and Farmer Welfare Department, along with state agriculture universities, will promote organic fertilisers produced by these projects, provided they meet specified standards. State agriculture universities will conduct trials to document results without charging any fees. The State Transport Department will encourage the use of biofuels in public transport vehicles. The policy includes an offline application system with an associated application fee, a non-refundable scrutiny fee, and a performance security fee.

HAREDA, the nodal agency, provides the clearances for and from various departments (whichever is required by the Act) as a 'single window'. Under the policy, projects have been made eligible for Central and state financial assistance as well as for exemptions like excise duty and customs duty, etc.

Haryana has also introduced a scheme for 'Renewable Energy Projects for all category enterprises' in May 2023, with the objective of boosting the use of renewable energy in the state. Under the scheme, a capital subsidy of 25 per cent up to Rs 1 crore per MW equivalent, capped at Rs 2.5 crore, has been provisioned for bio-energy units based on agricultural residue.

2

GOOD PRACTICES

This CSE study documents and assesses good practices in different aspects of the CBG production sector — these include feedstock management, gas off-take, management of by-products (organic solid and liquid manure), and financial management.

This chapter documents practices from 10 selected CBG manufacturing plants.

These plants have been slotted in terms of how they fare in functions such as management of their feedstock supply chain, use of municipal solid waste in CBG production, off-take of the CBG to the gas grid, and their management of digestates/by-products.

Some of these case studies have been covered because they can be replicated; some others make the cut because they can help build the capacity of stakeholders. Besides the good practices, the team has also identified a few more cases to estimate the cost economics of operational plants.

CASE STUDY 1

FEEDSTOCK SUPPLY CHAIN

Agriculture Produce Market Committee, Surat

AKSAR BIOTECH

A model which can be replicated in other APMC markets in the country

Feedstock used

VEGETABLE WASTE AND COW DUNG

CBG production

3.2 TPD capacity

Feedstock and operations

The CBG plant at APMC Surat is situated within the APMC premises, which allows it to directly source vegetable waste from the *mandi*, creating a robust waste-to-energy model. The plant has a processing capacity of 60-65 tonne per day (TPD) of waste, but it currently operates at 45-55 TPD and produces approximately 1.8-2 tonne of CBG daily. The production process involves anaerobic digestion of the waste, producing both compressed biogas and digestates (FOM and LFOM). The plant also has a storage infrastructure for 100,000 litre of liquid digestate.

Feeding of vegetable and animal waste at feeding zone (on left) and the CBG storage facility

Utilisation of CBG and digestates

The CBG produced is supplied to Gujarat Gas up to 60 km away, transported in vehicles. Each vehicle carries 600 kg of gas per trip, and the transportation cost is Rs 2 per kg. The gas is sold at Rs 60 per kg. Depending on the mode of off-take, profitability for the plant varies — 4-5 per cent profit when sold via cascades to industries, and 15-20 per cent when connected to pipelines.

As for the digestates, about 95 per cent is LFOM and the remaining 5 per cent is FOM. LFOM is sold in bulk at Rs 1.5 a litre, and FOM at Rs 2.5 per kg. Farmers are willing to pay for the organic manure as using 150 litre of LFOM per acre has resulted in yield increases of up to 1.25 times, compared to using chemical fertilisers like urea. However, the FOM is currently stored in the open due to a lack of proper infrastructure, which affects its quality.

CBG storage area (on left) and the filtration area

The challenges

One major challenge is the regulatory barrier in FOM/LFOM sales. The government penalises farmers for using FOM/LFOM unless it is sold by a licensed vendor. Under the Centre's Market Development Assistance (MDA) scheme, the Union Ministry of Agriculture and Farmers Welfare allows only authorised CBG manufacturers to sell FOM/LFOM directly in bulk. At present, of the 150 operational plants, only about 90 are authorised to sell organic manure directly. This discourages farmers from adopting organic inputs despite their benefits.

Another challenge is limited land availability for *mandis*, which makes it difficult to replicate the APMC model in other regions.

The economics

According to plant officials, the feedstock procured by the plant costs Re 0.50 per kg for both vegetable waste as well as cow dung. The plant uses about three-four tonne of cow dung as feedstock at the rate of Rs 500 per tonne. It earns approximately Rs 40-42 lakh per month from the sale of CBG (about Rs 30-32 lakh) and FOM/LFOM (Rs 8-10 lakh). The monthly operating expenses, including labour and transportation, are around Rs 8-9 lakh. Profitability improves significantly when CBG is connected to pipelines instead of being transported by cascade vehicles.

Digestate sales also contribute to the revenues, especially as farmers begin to see benefits in yield and cost savings from using LFOM and FOM in the place of chemical fertilisers — and are willingly paying for it (*see Table 1: The economics*).

Table 1: The economics

S No	Category	Quantity	Rs/month
1	Feedstock	Cow dung: 4 tonne/day @ Rs 0.50/kg	60,000
2		Vegetable waste: 45 tonne/day @ Rs 0.50/kg	675,000
3	Operations	330 days average	850,000
4	Gas off-take (monthly)	1,800 kg per day @ Rs 60/kg	3,252,420
5	FOM (solid fertiliser)	175 tonne/month	437,500
6	LFOM (liquid fertiliser)	375 kl/month	562,500
7	FOM enrichment cost		250,000
8	Total FOM and LFOM revenues		1,000,000
9	Total expenses (1+2+3+8)	Feedstock + operations	1,835,000
10	Total revenues (4+8)	Gas + FOM/LFOM	4,252,420
11	Total profit (10-9)		2,417,420

CASE STUDY 2

FEEDSTOCK SUPPLY CHAIN

Verbio, Sangrur (Punjab)

An example of seamless feedstock supply chain management

Feedstock used

PADDY STRAW

CBG production

33 TPD capacity

Verbio is recognised as one of the most successful paddy-based CBG plants in the country. While the plant faces some typical industry challenges, its management has successfully developed a robust and sustainable ecosystem for feedstock supply chain management.

Feedstock and operations

Verbio maintains a self-owned and operated agro-residue supply chain that fully integrates the processes and infrastructure for aggregation, transportation and storage. This efficient management structure ensures feedstock security for the plant.

As a paddy-based facility, the plant's operational security relies on its ability to collect feedstock — paddy straw — within a narrow 15-20 day window after harvest. Verbio has taken a significant lead in this critical area by establishing formal associations with nine-10 local farmers for collection of feedstock.

The entire collection process is done at no cost to the farmers, providing them with an incentive while simultaneously resulting in cost efficiencies for Verbio. The company has also invested in and operates its in-house biomass aggregation machinery.

For storage, the 400-kg bales are kept within the premises on raised platforms and are properly covered. This protocol is crucial for preventing feedstock degradation due to moisture and rain, ensuring the quality of the raw material.

Utilisation of digestates

In a practice that strengthens community relations and promotes sustainability, the plant supplies LFOM in bulk. This by-product is distributed to associated and other farmers in the nearby region free of cost, closing the resource loop and providing local agricultural benefits.

In-house farm equipment for feedstock procurement

Neatly stacked paddy straw bales (400 kg each)

CASE STUDY 3

MSW-BASED CBG PRODUCTION

Biofics, Surat, Gujarat

An example of a made-in-India initiative

Feedstock used
MUNICIPAL SOLID WASTE

CBG production
5 TPD capacity

Feedstock and operations

This is a plant in which 80-90 per cent of the machinery and equipment are self-manufactured, not imported. Due to this reason, the total cost of this 5-TPD plant stands at Rs 25 crore — this includes its auto segregation system, which itself, if imported, would have come for nothing less than Rs 45-50 crore. Biofics, which started operations in October 2025, holds multiple patents for its indigenously developed technologies.

The plant is using segregated municipal solid waste as feedstock, with around 60-70 per cent segregation achieved at source. The waste collection costs approximately Rs 1,500 per tonne. To ensure efficient collection, 15 special purpose vehicles (SPVs) have been deputed on the ground. The processing system includes two automatic segregation systems which extract the organic waste from mixed waste; one pre-digester where the waste is hydrolysed for three to four days; and three main digesters with a total capacity of 12,000 m^3.

The anaerobic digester is equipped with an integrated process system comprising of internal heating coils, long shaft mechanical agitators, feed distribution system, enzyme/bio-culture dosing (done as per digester health, which is continuously monitored in a dedicated laboratory), complete instrumentation (to measure temperature, pH, pressure and gas composition), gas dome with safety devices, recirculation loops, digestate discharge section, and the necessary electrical safety devices.

Utilisation of CBG and digestates

The produced CBG is intended to be supplied to Gas Authority of India Limited (GAIL) and Gujarat Gas. The plant focuses on enhancing the value of the liquid fraction of organic manure (LFOM) by increasing its carbon content from 20-25 per cent to about 41 per cent. Both FOM and LFOM are promoted as alternatives to chemical fertilisers like DAP.

As the plant has been commissioned recently, it is yet to achieve its full capacity. Currently, it is running at 30 tonne input of feedstock and increasing by 25 per cent each month, after monitoring the bacterial condition. The plant is expected to achieve its full capacity by mid-2026.

The challenges

Biofics has faced several regulatory challenges. Approvals often took a long time, and the Gujarat Pollution Control Board (GPCB) currently places such projects under the *orange category* (with moderate pollution potential) instead of *blue*. Different rules, documentation, technical compliances, multiple rounds of clarifications, and the need for coordination at different levels by various OMCs and financing institutions have also created a lot of confusion. Agreements with buyers and financiers need to be signed beforehand and should be flexible enough to adapt to future rule changes.

On the financial side, hidden costs such as boundary walls, pipelines and other infrastructure are not clearly addressed in the detailed project reports (DPRs). There is no government support for providing basic infrastructure like roads and electricity. In addition, there is a lack of awareness about standardisation of plant equipment across the sector.

Another issue relates to waste collection and tipping fees. Currently, the Surat Municipal Corporation tenders waste collection to third party agencies and pays them a tipping fee; but in the case of MSW-based CBG plants, the manufacturers also collect the waste, incurring a cost of about Rs 1.5-2 per kg — they do not get any direct support from the municipal corporations. A provision of offering a minimum tipping fee (collection fee) to registered CBG manufacturers could help them in recovering their costs to an extent.

CASE STUDY 4

MSW-BASED CBG PRODUCTION

Blueplanet, Greater Noida, Uttar Pradesh

Delhi-NCR's only MSW-based plant

Feedstock used

MUNICIPAL SOLID WASTE

CBG production

0.3 TPD capacity

Feedstock and operations

Located in the National Capital Region (NCR), this plant has an agreement with the Greater Noida Authority to collect and use segregated municipal solid waste as feedstock, with around 60 per cent segregation achieved at source. The waste costs about Rs 1,500 per tonne. To ensure efficient collection, 12 SPVs have been deployed on ground. The processing system includes one 11-TPD digester, where the waste is digested for 35-40 days.

Utilisation of CBG and digestates

The plant has its own CBG dispensing station just outside its premises, from where the gas is sold to vehicles. The plant, which generates about 24 tonne of FOM in a month, also focuses on enhancing the value of the 800-1,000 kg per day of liquid manure (LFOM) that it produces.

The challenges and the economics

Source segregation is a challenge — when left undone, it involves humanpower cost for segregating the waste. Frequent withdrawal of collection and segregation staff from the segregation tasks is another setback that the plant faces — this leads to mixed collection, and results in low recovery of recyclables and presence of impurities in the organic waste.

Table 2: The economics

S No	Category	Quantity	Sellable quantity (kg)	Rate (Rs/unit)	Annual cost (Rs)
1	Feedstock	Organic waste: 7 TPD	Used for gas production	1,500/tonne (additional 4 tonne)	21,90,000
2	Operations	Electricity, labour, maintenance			60,00,000
3	Gas off-take (kg/ month)	9,000	7,200	75	64,80,000
4	FOM (solid fertiliser) kg/month	24,000	24,000	2	5,76,000
5	Dry waste revenue	60,000	60,000	5	36,00,000
6	Total FOM and dry recyclable revenues				41,76,000
Total expenses (1+2): Feedstock + operations					81,90,000
Total revenues (3+4): Gas + FOM/LFOM					1,06,56,000
Profits: {(3+4)-(1+2)}					24,66,000

CASE STUDY 5

CBG OFF-TAKE TO THE GAS GRID

MEPL Bioenergy LLP, Punjab

Seamless integration into the gas grid

Feedstock used

PRESS MUD AND COW DUNG

CBG production

5.6 TPD capacity

The MEPL Bioenergy LLP offers an example of how a CBG plant can effectively integrate into the existing gas grid. This case focuses on the plant's approach to CBG off-take and the significant role that proper infrastructure plays in improving efficiency and cost- effectiveness. Direct injection into the gas grid is considered one of the most economical and sustainable ways to utilise CBG.

MEPL Bioenergy LLP's CBG facility claims to be among the first plants in the state to achieve direct gas grid connectivity; the company (MEPL Bioenergy LLP) has taken innovative steps to ensure better energy distribution through grid injection.

The plant uses a mixture of organic waste materials as feedstock. The main inputs are press mud (40 TPD), cow dung (30 TPD) and chicken manure (20 TPD). The cow dung is collected directly from local farmers, promoting rural participation and strengthening the local economy. This community-based model helps ensure a regular and sustainable supply of raw materials.

The environmental, economic and social impacts of the plant have been noteworthy. It helps convert large amounts of agricultural and animal waste into clean fuel and organic fertiliser, reducing pollution and landfill stress. It also supports farmers through direct purchase of cow dung and by supplying organic manure, which lowers their dependence on chemical fertilisers.

The challenges

Initially, the plant faced operational challenges and was producing only about 10-12 per cent of its total capacity. After significant upgrades to the pipeline system, production has risen to around 35 per cent of the capacity. The plant produces roughly 15 TPD of FOM and 35-40 TPD of LFOM as by-products.

The off-take partner for the plant is Gujarat Gas: the CBG is supplied through direct injection into its gas pipeline grid. At first, the plant used a plastic (PD) pipeline that could handle a pressure of 4.5 bar, sufficient only for household gas supply. However, for grid injection, a much higher pressure of 28 bar was needed. Gujarat Gas resolved this issue by replacing the low-pressure system with a stronger one capable of handling 28 bar. This upgrade became a key factor in improving the plant's operations and serves as a best practice example for other CBG producers.

Financially, the plant is still facing losses, mainly due to underproduction. While the grid injection method is efficient and reduces costs related to transportation and cylinder filling, low output has prevented the plant from reaching full profitability.

Nevertheless, the company distributes its FOM and LFOM free of cost to farmers, which benefits local agriculture and helps build long-term goodwill. As awareness about organic fertiliser use increases, the plant plans to start charging a minimal amount for these products.

There are some other operational challenges. Weather-related problems — such as heavy rainfall — sometimes leads to feedstock and fertilisers getting wet, forcing temporary shutdowns and affecting production efficiency. But despite these challenges, it is a fact that direct grid connectivity can ensure a cost-effective and reliable way to deliver biogas to consumers. The future outlook is promising as the plant continues to improve its performance and expand its production capacity.

CASE STUDY 6

CBG OFF-TAKE TO THE GAS GRID

Sainsons Paper Industries Pvt Ltd, Haryana

Feedstock used

SLUDGE FROM EFFLUENT TREATMENT PLANT

CBG production

3 TPD capacity

Sainsons Paper Industries runs a unique CBG plant that uses waste from the paper mill's effluent treatment plant (ETP). The plant has a 4.5 million litre per day treatment capacity and efficiently converts high-COD effluent into three TPD of CBG with 96 per cent purity. The gas that is produced is injected into a pipeline at 5 bar pressure. The plant also generates six TPD of organic manure, but it cannot sell it.

The plant operates at near 100 per cent gas production efficiency and has achieved a significant 25 per cent reduction in operating costs. Earlier challenges such as flaring of 1–1.5 TPD of gas due to limited demand have been partially addressed through improved offtake, including supply to retail outlets and pipeline injection.

However, despite strong technical performance and efficient resource utilisation, the inability to commercialise the 6 TPD of organic manure produced as a by-product remains a key constraint on overall profitability. This highlights a broader industry challenge where bioenergy projects are optimised for fuel production, but supporting markets for by-products are underdeveloped.

To unlock the full economic and environmental potential of such projects, greater focus is required on creating viable market linkages for organic manure, supported by policy incentives, awareness among end-users, and integration with agricultural value chains.

Sainsons' initiative stands as a progressive model for waste-to-energy conversion in the industrial sector, while also underlining the need for a more holistic ecosystem to ensure long-term sustainability and financial viability.

The compression unit at the plant

Cascade for CBG off-take

CASE STUDY 7

CBG OFF-TAKE TO THE GAS GRID

Rama Green Energies, Karnal, Haryana

Feedstock used

PRESS MUD, POULTRY WASTE, AGRICULTURAL WASTE AND ANIMAL DUNG

CBG production

6 TPD capacity

Rama Green Energies operates a large-scale CBG plant that converts organic waste into clean, renewable energy through anaerobic digestion. The facility is equipped with two high-capacity digesters, together producing approximately six tonne of biogas per day. The plant processes a diversified monthly feedstock mix around 2,000 tonne of press mud, 1,000 tonne of poultry waste, and 1,000 tonne of agricultural waste and animal dung – thus reducing dependence on any single raw material and ensuring consistent gas yields. The generated CBG is supplied through a dedicated pipeline network, enabling continuous and reliable offtake without the logistical complexity of cylinder-based distribution.

A notable feature of the plant is its near-zero freshwater consumption, achieved through a closed-loop slurry recycling system that reuses process water for digestion preparation. This not only reduces the facility's environmental footprint but also lowers operating costs, demonstrating how industrial efficiency and sustainability can reinforce each other. Beyond biogas, the plant produces significant quantities of treated digestate marketed FOM and LFOM through a dealer network at approximately Rs 2,000 per tonne. While the distribution network is well-established, the prevailing manure price is lower than initially projected, moderating overall revenue performance and pointing to an unrealised opportunity in by-product value enhancement.

The plant's monthly operations and maintenance expenditure stands at approximately Rs 30 lakh, covering humanpower, plant maintenance, power and utilities and feedstock logistics. Within this cost structure, several challenges have tested commercial viability. Securing feedstock at stable and economical rates remains difficult, compounded by seasonal supply fluctuations and high transportation costs for procuring raw materials from dispersed sources. On the technical side, variations in feedstock quality affect biogas yields and require constant monitoring to maintain optimal digester performance, adding to the operational burden on the management team.

Among the most significant challenges faced by the plant are the institutional and regulatory bottlenecks that hamper access to government support. Obtaining Market Development Assistance (MDA) from the concerned department has been a prolonged and cumbersome process, with delays in processing and disbursement directly affecting cash flows and financial planning. Accessing subsidies and incentives available under national bioenergy programmes has been equally difficult, owing to complex documentation requirements, slow approvals and poor inter-agency coordination. These procedural difficulties are a widely shared pain point across the CBG sector in India and represent a systemic challenge that, if addressed, could substantially improve the financial viability and long-term scalability of projects like Rama Green Energies.

CASE STUDY 8

CBG OFF-TAKE TO THE GAS GRID

Demeter Agro Energies Pvt Ltd, Kaithal, Haryana

Feedstock used

PRESS MUD, ANIMAL DUNG AND SPENT WASH

CBG production

10 TPD capacity

The Demeter Agro Energies plant is located in Kaithal, Haryana. It can produce 10 tonne of CBG every day using agricultural waste as fuel, mainly sourced from a nearby sugar mill. The plant uses around 250 tonne of this waste daily, which costs between Rs 500 and Rs 1,200 per tonne. It has three large digesters and currently runs at 70-85 per cent of its full capacity.

Apart from CBG, the plant also produces two types of organic fertilisers – FOM (about 10 tonne/day) and LFOM (about 200-250 tonne/day) as useful by-products.

The challenges

The plant's biggest challenge is finding buyers for the gas it produces. Some nearby companies simply refuse to purchase it, which is the most common reason CBG plants struggle. On the fertiliser side, FOM and LFOM are not yet widely accepted by farmers and are still being sold on a trial basis, even though the government offers Rs 1.5 per kg as support to promote them. The plant is also waiting for electricity subsidies or rebates, which have not been granted yet.

Building a stable foundation — infrastructure, subsidies, and smart alliances

The biggest win for the plant has been its partnership with IGL (Indraprastha Gas Limited). IGL leased a small piece of land from the plant, set up its own compressor and gas filling station, and connected the plant through steel and MDPE pipelines all at IGL's own cost. This means the plant has a guaranteed, long-term buyer for its gas. Currently, it sells around eight tonne of CBG per day to IGL at Rs 78-83 per kg. This successful model is now being replicated at their upcoming Ambala plant as well.

Financial support and future prospects

The plant has received strong financial support from both state and Central governments, including a Rs 2.5 crore state subsidy, Rs 8.35 crore from the MNRE, and waivers on stamp duty and land use charges, adding up to over Rs 10.83 crore in total assistance. The plant is also working towards earning income from carbon credits, which could open up a new revenue stream soon. With IGL's pipeline already in place, the plant can easily scale up to 15-20 TPD in the future without worrying about finding new gas buyers.

CASE STUDY 9

MANAGEMENT OF FOM-LFOM

Glow Green Biotech,
Surat, Gujarat

Feedstock used

COW DUNG AND VEGETABLE WASTE

CBG production

2 TPD capacity

Feedstock and operations

Though Glow Green Biotech has an installed capacity of two TPD, it currently operates at a much lower feedstock load of around 0.03 TPD. This includes an average of 2.74 TPD of cow dung sourced from nearby villages at Rs 1,000 per tonne, and about 0.14 TPD of vegetable waste procured at Rs 3,000 per tonne.

The plant began operations in August 2020 and runs for nearly 300 days in a year. Despite having the capacity to process 100 TPD as per GOBARdhan estimates, the plant is functioning at only 2.9 per cent of that capacity due to low demand for its organic manure products.

The plant processes slurry made from cow dung and water mixed in a 1:1 ratio, which is stored in an underground tank and then fed into two digesters (each with a capacity of 1,600 m^3). After anaerobic digestion, the raw biogas is passed through a water scrubber to remove hydrogen sulphide, followed by further purification to decrease the carbon dioxide content to below 4 per cent and remove all the water vapour. The purified gas is stored in gas balloons and then compressed to 220 kg/ m⁂, before being transported via cascades to a nearby fuel outlet.

FOM/LFOM management

The plant currently produces around 30 kg (0.03 TPD) of CBG every day, well below its two-TPD capacity. This low capacity utilisation is due to limited market demand for its FOM and LFOM. Glow Green produces approximately 5,000 litre of LFOM and 250 kg of FOM a day. These are stored separately in vessels after multi-stage enrichment, which begins immediately after digestion in two storage pits of one lakh litre capacity each.

Initially, when the LFOM was directly applied to fields, farmers had mixed experiences. However, after enrichment (value addition) — raising organic carbon to around 40 per cent, nitrogen to 4 per cent, phosphate to 3-5 per cent, and adding micronutrients (3-1,000 ppm) — the response improved significantly.

Farmers have used these products on various crops such as sugarcane, wheat, paddy, turmeric, chillies, soybean and vegetables. In many cases, they have reduced or eliminated the use of chemical fertilisers. Demonstrations have shown promising results: for example, one paddy farmer reported an increase in yield from 22-23 quintals per acre to 30, by using a combination of LFOM, FOM and foliar spray.

The use of enriched FOM/LFOM by farmers for increasing crop yield and enhancing land productivity has been successfully demonstrated in different regions of the country. Field trials have been conducted on six major crops — okra, banana, pointed gourd, marigold, brinjal and green chilli. Farmers and FPOs were actively engaged in the process in order to instil confidence in the farming community. The results revealed significant improvements across different locations: early maturity and tripling of yields in okra, complete revival of failed pointed gourd crops, enhanced flowering in marigold, accelerated fruiting in brinjal, and drought recovery in green chilli crops.

Glow Green products are now actively sought after by states — the government of Meghalaya is seeking assistance from the company on the development and growth of turmeric, while the Assam state government has bought 15,000 litre of LFOM and distributed it among marginal farmers in the state.

The challenges

The primary challenge faced by Glow Green is the limited market for FOM and LFOM. Since these by-products are essential for financial viability and waste circularity system of the plant, the lack of uptake forces the plant to operate at

Results of enriched LFOM application: Before (on left) and after

reduced feedstock input and CBG production levels. The management has deliberately chosen to scale down gas production until there is consistent demand for enriched organic manure.

Farmers' initial lack of awareness, psychological dependence on chemical fertilisers, and the need for easy-to-apply, ready-to-use bio-fertilisers further limits the adoption of the plant's products. Glow Green is currently focused on farmer outreach and product improvement to address these challenges.

The economics

Glow Green sells its FOM for Rs 55 per kg, while the LFOM, after enrichment, is priced at Rs 300 per litre. A 20 per cent enrichment typically costs Rs 25-30 per litre and involves using a mix of 33 different materials (*see Table 3: The economics*).

The enrichment process starts with an analysis of the LFOM, followed by circulation and agitation to balance microbial activity. The retention period ranges from seven to 30 days, and the final product has a moisture content of 96.5-97 per cent.

Farmers applying LFOM through drip irrigation have reported reduced input costs and improved yields. For example, in the cultivation of turmeric, the cost of fertilisers and nutrients has dropped from Rs 20,000-25,000 per crop to about Rs 10,000. There is another case where use of 70 per cent LFOM and 30 per cent chemical fertilisers has seen an increase in yields: from 28-30 tonne per *bigha* to 40-42 tonne; annual input costs have also been documented to have gone down in this case from Rs 40,000 to Rs 25,000. These outcomes demonstrate the potential of enriched LFOM and FOM to transform farm economics and support sustainable agriculture.

Table 3: The economics

S No	Category	Quantity	Cost/revenue (Rs per month)	Remarks
1	Feedstock (cow dung)	4 tonne/day	1.0 lakh	
2	Operations (humanpower, maintenance and electricity)	—	2.2-2.5 lakh	
3	Gas off-take	1.8 tonne/month	1.0-1.06 lakh	Rs 59 per kg
4	FOM and LFOM enrichment cost	96 tonne/kl per month	2.5 lakh	
5	FOM (solid fertiliser) revenue	6 tonne/month	1.5 lakh	Rs 25 per kg
6	LFOM (liquid fertiliser) revenue	90 kl/month	4.5 lakh	Rs 5 per litre
7	Total FOM and LFOM revenue	—	6 lakh	
8	Total expenses (1+2+4)	—	6 lakh	Feedstock + operations
9	Total revenue (3+7)	—	7-7.06 lakh	Gas + FOM/LFOM
10	Profit (9–8)	—	1-1.06 lakh	

CASE STUDY 10

MANAGEMENT OF FOM-LFOM

Sampurn Agro Industry
Fazilka, Punjab

Developing sensitisation on fermented organic manure management through demo farms

Feedstock used
PADDY STRAW

Biogas to power
50 TPD processing capacity

Feedstock and operations

Sampurn Agro is a biogas-to-power plant and not a CBG manufacturing unit. The company is planning a shift toward CBG production. However, it has been included in the study owing to the initiatives taken by it on FOM and LFOM management.

The facility spans over 13 acre, with a dedicated area of about six-seven acre for storing agricultural feedstock. The plant primarily utilises paddy straw, harvested during September-October, which is well-suited for biogas production. Wheat straw, harvested in April, is also available but is mainly used as animal fodder due to its lower gas yield. The feedstock is procured at Rs 1.7 per kg, and the cost increases to Rs 2 per kg after adding handling charges.

The plant has an installed processing capacity of 50 tonne per day, but it currently operates at 20 tonne a day, with plans to scale up to 40 tonne per day. The operational process involves size reduction of straw, followed by bag filtration to control dust emissions. The paddy straw is mixed with water in a 1:9 ratio, and animal dung is mixed separately in a 1:1 ratio. Both are then combined in equal parts and fed into a 3,600-m^3 digester. The digestion cycle lasts 35-40 days, and

The plant's FOM storage and packing area

the resultant slurry is transferred to a continuous stirred tank reactor (CSTR) where biogas is generated and stored in a balloon.

The facility has an electricity generation capacity of 1.2 MW. With an estimated biogas yield of 250 m^3 per tonne of feedstock, it produces 1,800-2,000 kg of biogas daily, which translates to 7,500-8,000 units of electricity a day.

Utilisation of digestates

Alongside biogas, the plant produces approximately nine-11 tonne a day of FOM and 5,000 litre a day of LFOM. All organic outputs are sterilised and enriched with microbial cultures to create organic fertilisers and bio-based pesticides. These are certified by the ICAR and Punjab Agricultural University (PAU), and the FOM is sold at Rs 3 per kg. Farmers have been willingly using these products and have reported a reduction in chemical fertiliser use by up to 66 per cent, thus cutting their input costs from Rs 4,000-5,000 per acre to Rs 1,500 per acre.

Sampurn Agro officials informed the CSE team that initially, the company had limited success on bio-fertilisers. Its association and collective efforts with ICAR — which focused on integrating FOM, LFOM, bio-fertilisers and recommended

Application of FOM on a farm: Before (on left) and after

BENEFITS OF FOM/LFOM UTILISATION

- Higher efficiency compared to conventional composted manure: 1 kg of FOM = 5 kg of traditional compost
- Rich in humic acid (6 per cent in FOM, 12 per cent in LFOM) that enhances nutrient uptake
- Promotes microbial activity, boosting nutrient efficiency and plant immunity and reducing the need for pesticides and fungicides
- Can reduce chemical fertiliser use by up to 75 per cent

dose of fertiliser (RDF) — has proven to be highly effective for higher yields and soil health. Field trials by PAU, Ludhiana and the Central Institute of Post-Harvest Engineering and Technology (CIPHET) in Abohar have demonstrated about 20 per cent higher yield with FOM compared to yield with only chemical fertilisers.

With ICAR, Sampurn Agro has also developed demo farms to highlight the impacts of FOM/LFOM on agricultural yield. The integrated model adopted by the company showcases and highlights how demand for FOM/LFOM can be scaled up among farmers through pilot projects in its own farms.

The challenges

One of the key challenges faced by the plant is related to seasonal availability and storage of feedstock, particularly paddy straw, which is only available for 30-40 days a year. Despite having sufficient land for storage, supply chain management and logistics require continuous optimisation.

Looking ahead, Sampurn Agro plans to:

- Begin CBG production
- Manufacture bio-fertiliser pellets
- Install two additional digesters to scale up its operations

3

STATE PROFILE

PUNJAB

Punjab has registered 82 CBG projects — 10 of which were operational as of August 2025. The total capacity of these 82 is about 1,700 tonne per day (TPD). The existing installed CBG production capacity stands at about 110 TPD.

About 50 per cent of the functional plants operate with paddy straw as their feedstock. Despite the availability of large amount of municipal solid waste, none of these plants use it to generate gas.

All the surveyed plants suffer from low capacity utilisation. Inconsistent availability of affordable biomass feedstock has been one of the major challenges. Lack of pipeline infrastructure, biomass storage and aggregation facilities etc have been identified as the other major concerns.

CSE has recommended a set of measures under two heads — policy initiatives and infrastructure development. These include, among other things, development of a dedicated state CBG policy with the focus on paddy straw as feedstock; initiation of long-term off-take agreements between CBG manufacturers and oil and gas companies; putting in place a single-window clearance system; and making farmers the stakeholders in CBG manufacturing facilities.

Feedstock availability and potential for CBG production

It is important to understand the current availability as well as utilisation of different feedstocks in Punjab. The existing management status of paddy straw, animal waste and press mud has been highlighted in this section.

Paddy straw

Punjab is one of the largest producers of paddy in the country: it generates an estimated 19 million tonne (MT) of paddy straw and about 53 MT of biomass every year.[10] In 2023, as per available estimates of paddy straw utilisation[11], about 11.5 MT was managed through *in-situ* techniques, while about 4.66 MT was used up through *ex-situ* management; another 0.7 MT was utilised as fodder. The total, therefore, amounted to about 15.86 MT.

As per the Kapurthala-based Sardar Swaran Singh National Institute of Bioenergy, about 19 MT is the annual average surplus in Punjab. Potential CBG production with the existing surplus biomass is about 1.9 MT a year. This clearly highlights the significant potential for development of the CBG sector in the state — Punjab has been unable to tap this till now.

The major applications under *ex-situ* management in the state are briquetting/pelleting plants: the state government has issued notifications under Section 5 of the Environment (Protection) Act for mandatory co-firing of 20 per cent coal with paddy straw-based pellets in brick kilns with effect from May 1, 2023. Other applications are being seen in bio-ethanol plants, biomass-based power plants, CBG plants and cardboard-manufacturing factories.

This large volume of straw, left behind after paddy harvest, has become a major environmental challenge, particularly during the post-*kharif* season (October–November). With only a short window to prepare fields for the *rabi* crop that follows, many farmers resort to burning the residue in open fields due to high disposal costs and limited alternatives.

As per the Punjab Energy Development Agency (PEDA), as of September 2025, a total of 65 CBG projects with a combined capacity of 846 TPD are under execution or in the pipeline, where paddy straw will be used as feedstock. The total estimated paddy straw consumption in upcoming CBG plants is estimated at about 10,550 TPD — this is considering each plant operates for 330 days in a year; the estimated paddy consumption is about 3.5 MT per year; and it is expected that these plants will produce about 0.35 MT of CBG every year.[12]

Paddy straw storage by Ever Enviro, Dhuri

Animal waste as feedstock in TR Megafoods, Punjab

This is in addition to the current capacity of 90 TPD CBG produced from paddy-based operational plants in the state. The estimated total paddy straw consumption in already operational plants in Punjab is about 0.2-0.3 MT per year.

Animal waste

As per the Basic Animal Husbandry Statistics-2023[13], Punjab had a livestock population of about seven million heads which generates a substantial amount of animal waste, particularly from cattle and buffaloes. The state has approximately 2.5 million cattle and four million buffaloes. Together, they produce an estimated 90,000-100,000 tonne of dung daily, which translates to around 33 to 37 MT annually.

With an estimated potential for manufacturing about 0.6-0.75 MT CBG per year if fully utilised, this vast quantity of animal waste plays and can play a significant role in the state's rural economy, and offers both challenges and opportunities in terms of management and utilisation.

As per the GOBARdhan portal, there are four cow dung-based plants (major feedstock) under construction in the state, with a combined capacity of about 14 tonne of CBG production and estimated potential of using about 130,000 tonne a year of cow dung. Other than that, many of the under-construction or yet-to-start construction plants are also expected to use animal dung in some percentage as feedstock to enhance the enzymatic activities, which will increase the cow dung utilisation to an extent. With effective planning, technological support and investment, animal waste in Punjab can be transformed from a sanitation burden into a valuable resource for clean energy, sustainable agriculture and rural livelihood generation.

Press mud

Press mud is a waste material produced by sugar mills during the process of making sugar from sugarcane. Punjab has about 15 sugar mills, crushing about 700 lakh quintal (seven million tonne) of sugarcane per season: these are estimated to produce about two million tonne (MT) of press mud. At present, only two plants are using press mud as part of their feedstock, with one plant using it as a major feedstock.

Municipal solid waste (MSW)

Punjab has an estimated MSW generation of about 4,000-5,000 TPD, which translates to approximately 1.5-1.8 MT in a year.[14] However, the state does not yet have a single functional MSW-based CBG plant.

There are two plants with a combined capacity of about 21 TPD (not functional yet); another 20 (with a total capacity of about 1,100 TPD) are in the pipeline — construction has not started yet.

Table 4: Feedstock availability and CBG potential of Punjab

Feedstock	Waste available (million tonne/year)	CBG production potential (million tonne/year)
Paddy straw	19	1.9
Animal waste	33-37	0.6-0.75
Press mud	2	0.08
Municipal solid waste	1.5-1.8	0.03-0.035
Total CBG production potential		2.6-2.8*

Note: *The analysis is based on complete utilisation of available feedstock — 70-80 per cent potential can be tapped based on mapping of availability of feedstock in different districts and the collection efficiency

It is estimated that the organic waste fraction available in the state is about 0.75-0.9 MT per year (considering 50 per cent organic waste component in the total MSW generated). Accordingly, Punjab has a potential to manufacture about 30,000-35,000 tonne of CBG every year.

CBG projects in Punjab: Current status

The GOBARdhan portal is the only source of information on operational status of plants in the country. As per the portal, Punjab has about 84 CBG projects lined up, totalling to a capacity of about 1,700 TPD. As of January 2026, 10 plants were comissioned in the state, ranking it sixth among Indian states in terms of operational plants (*see Table 5: Operational plants in Punjab*). The existing installed CBG production capacity in the state stands at about 110 TPD.

There are about 13 plants in the construction phase, with a combined CBG production capacity of about 100 TPD. The Ludhiana CBG plant-II, of Reliance Industries, is the one with the highest gas production capacity of 20 TPD; it is in the under-construction category.[15]

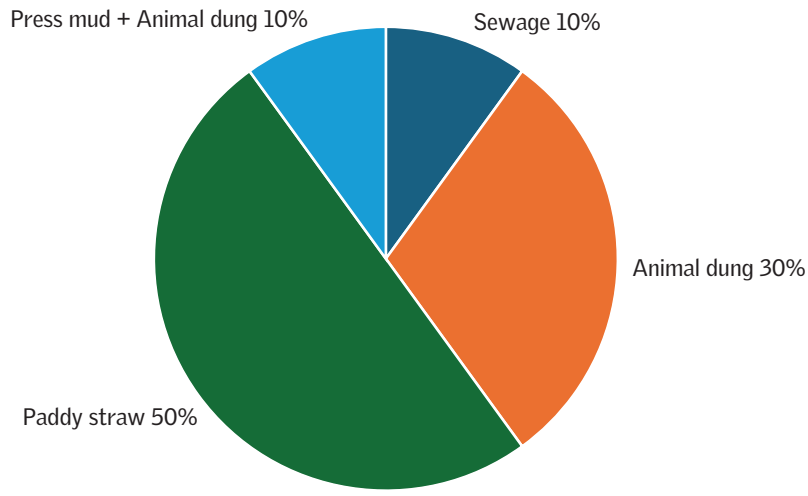
Out of all the planned projects, 61 are still waiting to begin construction. Of the functional plants, about 50 per cent are based on paddy straw. Animal dung-based plants are about 30 per cent. The remaining 20 per cent include mixed feedstock-based plants (press mud, animal dung and sewage)[16]. In spite of the significant potential of MSW as a feedstock, there is no MSW-based CBG plant operational in the state as of now (*see Graph 1: Feedback-wise distribution of operational plants*).

Table 5: Operational plants in Punjab

Name of the plant	Name of the entity	Gas production capacity (TPD)	Feedstock capacity (TPD)	FOM production capacity (TPD)	LFOM production capacity (KLD)
Verbio Lehra BioCNG Project	Verbio India Private Limited	33	367	770	575
T R Mega Foods and Beverages LLP (PEDA Biogas Plant, Ludhiana)	T R Mega Foods and Beverages LLP	5	423	70	200
Farm Gas, Khanna, Ludhiana	Farm Gas Private Limited	12	120	30	0
Dhuri	Sangrur RNG Private Limited	14.84	100	72	0
Patran	Patiala RNG Private Limited	14.8	100	72	0
Arc Bio Fuel Pvt Ltd	Arc Bio Fuel Pvt Ltd	2	100	20	50
MEPL Bio-Energy LLP	MEPL Bio-Energy LLP	5.6	140	21	7
Hoshiarpur CBG Plant	Reliance Chemicals and Materials Ltd	20	165	120	40
Anand Energy	Anand Energy	0.2	15	3	7
111-MLD STP, Bhattian	Khilari Infrastructure Pvt Ltd	3	0	0.5	0

Source: Gobardhan portal, CSE survey

Graph 1: Feedstock-wise distribution of operational plants



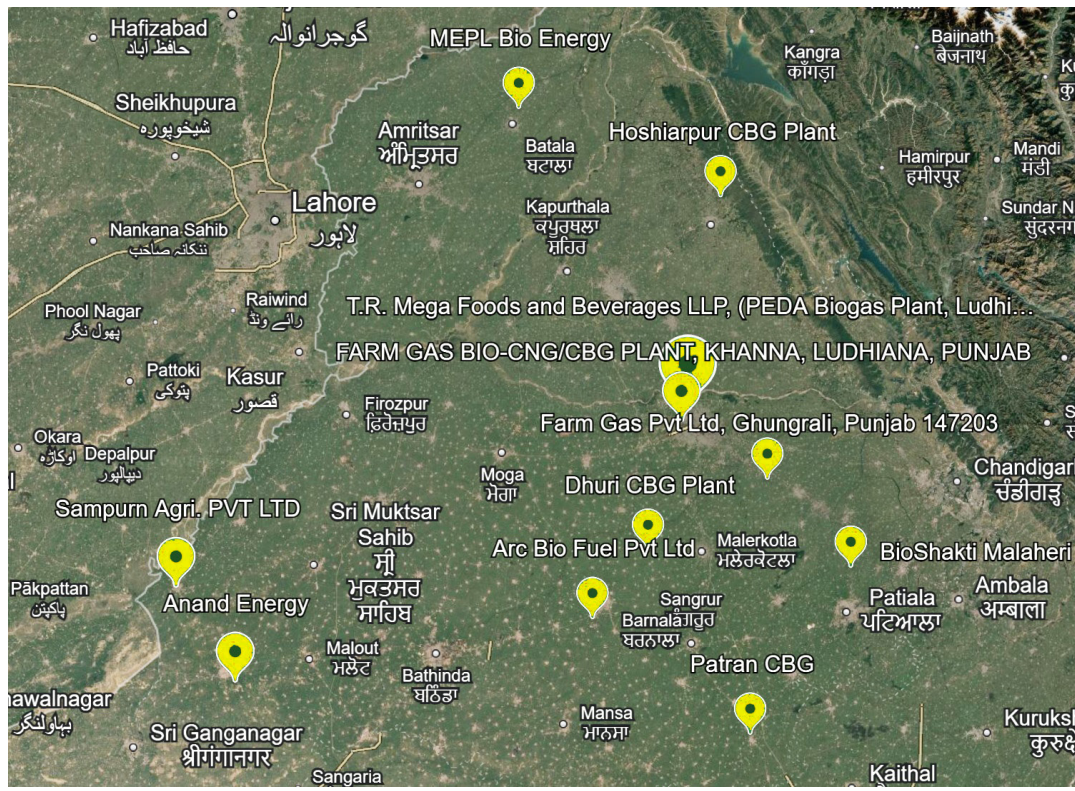
Source: CSE analysis

The CSE survey

CSE has done extensive ground-level surveys in Punjab, visiting functional CBG plants and interacting with the relevant stakeholders to understand the operational status as well as issues and challenges in the sector (*see Map 2: Location of operational CBG plants in Punjab and Table 6: Operational CBG plants covered in the CSE survey*). The feedstock distribution of the operational as well as surveyed plants was analysed too (*see Graph 1 and Graph 2: Feedstock-wise distribution of surveyed plants*).

The operational plants in the state use different types of feedstock — paddy straw (five), animal dung (three), press mud and animal dung (one) and sewage-based (one). Apart from these, there is also a biogas-to-power generating plant named Sampurna Agro located in Fazilka. Though the plant does not manufacture CBG, the CSE survey included it in the study to highlight its good practices on FOM/LFOM management.

Map 2: Location of operational CBG plants in Punjab



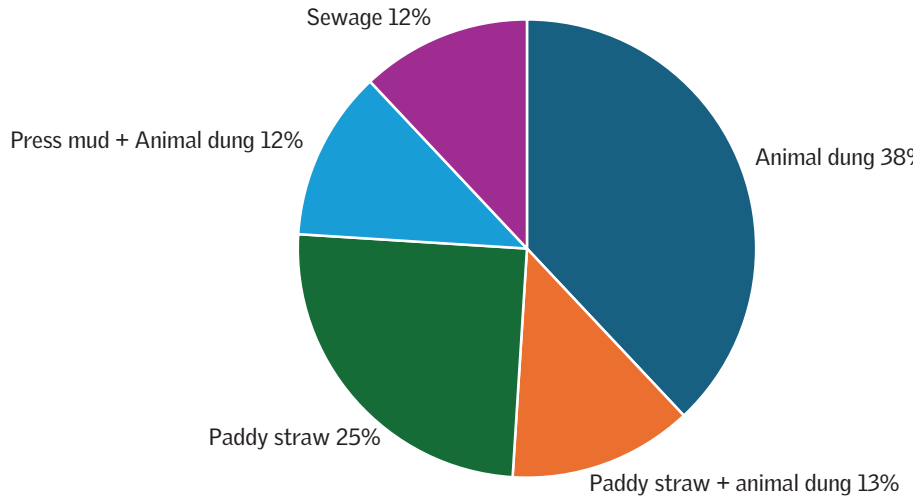
Source: Google Earth

Table 6: Operational CBG plants covered by the CSE survey

Plant	Location	Feedstock	Installed capacity (TPD)	Actual output of CBG (TPD)
Ever Enviro	Dhuri	Paddy straw	12.84	6
Ever Enviro	Patran	Paddy straw	12.80	6
MEPL Bio Energy LLP	Amritsar	Press mud + animal dung	5.6	0.56
STP	Ludhiana	Sewage	70 MLD	1.2
Anand Energy	Fazilka	Animal dung	0.2	0.07
TR Mega Foods	Ludhiana	Animal dung	5.0	2.5
ARC CBG Ltd	Barnala	Animal dung	2	1.2
Sampurna Agro*	Fazilka	Paddy straw + animal dung	2.0	1.8

*Sampoorna agro is producing biogas which is used to generate power.

Graph 2: Feedstock-wise distribution of surveyed plants



Source: CSE survey

CASE STUDY 1

OPERATIONAL PLANTS SURVEYED IN THE STATE

Ever Enviro, Dhuri

Feedstock used
PADDY STRAW

CBG production
12.84 TPD capacity

Feedstock and operations

The plant uses paddy straw collected from nearby farms as its feedstock. One acre of farmland generates about 2.5-three tonne of stubble. Around 20 local aggregators supply the straw. For example, aggregator Ramgopal Singh collects straw from 30-40 farmers using a combination of owned and rented machinery.

Since the primary focus of farmers is to vacate their land after harvesting and get it ready for sowing the next crop within a span of 10-15 days, they mostly pay the biomass collectors and aggregators for collecting and clearing their land using aggregation machinery. In most cases, paddy straw is collected by aggregators from farmers without the payment of any charges. Aggregators invest in deploying machinery for collection and baling, and sometimes spend on infrastructure for storage and transportation. They can then sell the straw to CBG plants at a certain price to cover these costs.

Ever Enviro procures paddy straw from aggregators at Rs 1,600-1,700 per tonne. The industry cannot offer a higher amount for straw, because increasing the feedstock rate would make production costs unsustainable and eliminate profits for CBG producers.

The Ever Enviro PNG plant at Dhuri

Initially, the Ever Enviro plant was designed to process 100 tonne of straw a day to produce 12.84 tonne of CBG and 72 tonne of FOM with 30 per cent moisture. Due to technical reasons, the plant scaled down its processing to only 50 TPD of straw — but it now produces about 150-155 TPD of FOM with 70 per cent moisture.

Straw is chopped to below 10 mm before digestion. The chopping and digestion process along with other operations consumes about 1,600 kW as compared to 800 kW in cases where the chopping of feedstock is not required. At Rs 8.5/unit, this significantly raises the operational costs. To store the paddy straw, Ever Enviro rents 40 acre of land at Rs 80,000 per acre annually (Rs 32 lakh per year).

But one major concern for the plant is that of uncovered storage of feedstock: there is no raised platform to keep the straw, which results in the feedstock getting spoilt and the production process getting hampered during rainy season.

The plant has three digesters of 6,600 m^3 capacity each. Biogas purification includes removal of H_2S via activated carbon and CO_2 using a tower system (Minor Pressure Swing Adsorption production technology). The impure gas is recirculated, and the purified gas is dried and compressed.

Utilisation of CBG and digestates

Currently, the plant produces around six TPD of CBG — this is 40 per cent capacity utilisation. The CBG produced is sold at Rs 75 per kg, but the production cost is around Rs 95 a kg, making it economically unviable without support. About 2.5 TPD of gas is sent via cascade systems to a CNG pump 30 km away while the rest goes to Rajpura, 140 km away. Cascading requires compression of gas to 210-250 bar, which costs Rs 8-10 per kg. In contrast, pipeline systems operating at 1-2 bar would eliminate this cost. Average transport costs are to the tune of Rs 9.5 per kg. A pipeline connection could save the plant Rs 17 for every kg.

Out of the 150-155 kg of FOM generated every day, about 75-80 kg is processed into compost with some enrichment: 70 per cent of the FOM is mixed with 30 per cent moisture and 30 per cent dung and sold at Rs 3 per kg. The plant officials say that farmers willingly buy the FOM as they have analysed its impact on the yield. The plant also distributes about 75 TPD of wet FOM (72 per cent moisture) free of cost to farmers. About four acre of land is used to manage the FOM (1.5 acre inside and 2.5 acre outside the plant).

Around 15-20 farmers are currently using this compost, reporting yield gains of 200-250 kg of grain per acre. Farmers have used about 20-25 per cent of the FOM mixed with 75-80 per cent chemical fertilisers. The pricing of the FOM depends on the level of enrichment done.

The challenges

Among the current challenges faced by the plant is one of financial viability — the cost of production of CBG exceeds its selling price. In the absence of a pipeline (the nearest pipeline is 60 km away), the plant has to transport the gas through cascade, which is both costly as well as energy-intensive.

CASE STUDY 2

OPERATIONAL PLANTS SURVEYED IN THE STATE

Arc Bio Fuel CBG Plant, Barnala

Feedstock used

ANIMAL AND POULTRY WASTE

CBG production

2 TPD capacity

Arc Bio Fuel has been operational since 2016. The plant received a government subsidy that covered around 10 per cent of its initial set-up cost. It sources all its feedstock from within a 25-km radius.

Feedstock and operations

The plant uses a combination of 60 TPD of animal dung (primarily from *gaushalas*) and 40 TPD of poultry litter (from nearby poultry farms). The feedstock is semi-automatically loaded into the plant using tractors fitted with three-four tonne capacity trollies. This approach has been adopted due to limited space and equipment constraints at the site. The procurement cost is, on an average, Rs 0.35 per kg for both animal and poultry waste.

The digester at Arc Bio Fuel CBG has a total capacity of 5,200 m^3 and operates under a pressure of 210 kg. Initially, biogas produced by the plant was sold to nearby industries. However, due to inconsistent demand, gas production was irregular. Since August 2024, Indian Oil has become the primary buyer, purchasing CBG at Rs 74 a kg with a purity level of 92-93 per cent.

But despite this arrangement, there have been multiple instances in the recent past when off-take was halted for six to 12 days, leading to gas accumulation and partial shutdown of plant operations.

TABLE 7: At a glance

Parameter	Details
Year of establishment	2016
Subsidy received	~10 per cent of establishment cost
Feedstock	60 TPD animal dung, 40 TPD poultry waste
Feedstock procurement rate	Rs 0.35/kg
Feedstock radius	Within 25 km
Loading system	Manual (3-4 tonne trollies with small tractors)
Digester capacity	5,200 m^3
CBG buyer	Indian Oil (since August 2024); earlier — local industries
CBG price	Rs 74/kg (Indian Oil)
Gas purity	92-93 per cent
Off-take issues	6-12 days downtime in last 6 months
FOM/LFOM output ratio	30-40 per cent FOM, 60-70 per cent LFOM
FOM/LFOM selling price	Rs 2-2.5/kg
Organic manure land requirement	5 acre (4 external + 1 internal)

LFOM management through the lagoon process

Utilisation of CBG and digestates

Currently, the plant produces around 1.2 TPD of CBG — this points to a 60 per cent capacity utilisation using 100 tonne of feedstock. With respect to off-take, a Think Gas-City Gas Distribution (CGD) pipeline runs directly through the plant premises, offering an alternative buyer. However, Think Gas offers a slightly lower rate of Rs 70/kg and requires installation of a gas metering system, which would cost Rs 5-6 lakh. Factoring in cascade transportation cost of Rs 4 per kg, the effective earnings appear to be similar to what the current arrangement with Indian Oil is offering the plant.

To manage digestates, the plant uses a sludge-liquid separator (SPS) to extract FOM and LFOM. The FOM makes up 30-40 per cent of the output; LFOM the remaining 60-70 per cent. The LFOM is either sun-dried or stored in lagoons. Both FOM and LFOM are sold at Rs 2-2.5/kg. However, due to limited market demand, the plant manages to sell only 50 per cent of the manure.

Table 8: The economics

Category	Description	Sellable quantity (in kg)	Rate	Total (Rs/day)	Annual cost
Feedstock	Cow dung: 70-80 TPD	60,000	0.35	21,000	6,930,000
	Poultry: 30-40 TPD	40,000	0.35	14,000	4,620,000
Operations	Salaries, repairs, electricity, diesel	-	-	45,000	14,850,000
Gas off –take	30 tonne/month; sellable equivalent	900	70	63,000	20,790,000
FOM (solid fertiliser)	20 TPD, 10 per cent sellable	2,000	2	4,000	1,320,000
LFOM (liquid fertiliser)	80 TPD, 10 per cent sellable	8,000	2	16,000	5,280,000
Total FOM and LFOM revenue				0	6,600,000
Total expenses (feedstock + operations)				80,000	26,400,000
Total revenue (gas + FOM/LFOM)				83,000	27,390,000
Profit	(Total Revenue — Total Expenses)			3,000	990,000

The plant uses a total of five acre of land for manure management — four acre rented outside the plant at Rs 15,000 per month and one acre within the premises. A Point-of-Sale (POS) machine has been installed, enabling access to government subsidies under the bio-fertiliser promotion scheme.

According to feedback from farmers, the use of the FOM and LFOM produced by the plant has led to a 10-20 per cent increase in crop yields. This has helped reduce the dependence on chemical fertilisers. The use of organic manure allows for a 25 per cent reduction in chemical inputs in the first year and up to 50 per cent by the second year. Rice yields generally range from 2,200-2,400 kg per acre, and with FOM/LFOM, farmers report an increase of about 220 kg an acre. This gives them an additional income of Rs 5,500, sufficient to cover the cost of adopting organic inputs.

The challenges

The plant faces several operational and market-related challenges. Interruptions in off-take by Indian Oil cause gas accumulation and force the plant to slow down its operations, resulting in financial losses. Although a Think Gas pipeline passes through the site, the requirement of an expensive metering system makes the switch less attractive without additional support.

Manure sales are limited due to insufficient market demand, despite evident benefits in agricultural productivity. Infrastructure and awareness barriers continue to limit the potential impact of the plant's organic outputs.

CASE STUDY 3

OPERATIONAL PLANTS SURVEYED IN THE STATE

Anand Energy, Abohar, Fazilka

Feedstock used

ANIMAL DUNG AND VEGETABLE WASTE

CBG production

0.2 TPD capacity

Anand Energy holds the distinction of being one of the oldest CBG plants in the state, having been in continuous operation for the past 15 years. The plant was established with technical consultancy support from CEID Consultant and Engineering Pvt Ltd based in Punjab.

Feedstock and operations

The plant primarily uses animal dung as feedstock, which constitutes 99 per cent of the input raw material. The remaining one per cent is vegetable waste. Animal dung is procured at a cost of Rs 0.35 per kg. Seasonal variations affect feedstock consumption: during summers, approximately four TPD is processed, whereas in winters, due to the higher moisture content, consumption increases to around six TPD. Although the plant has a feedstock handling capacity of 16-20 TPD, it is currently operating at a significantly lower capacity, processing only four to six tonne a day.

A 750-m^3 digester is installed in the plant. On an average, it produces around 60 kg of CBG per day, amounting to roughly 1,800 kg per month. Additionally, the plant generates about 60 tonne of FOM and 30 of LFOM every day as by-products.

Utilisation of CBG and digestates

The compressed biogas is primarily supplied to two local industries, both of which are engaged in the manufacture of cardboard products. In the past, the gas was

Anand Energy's CBG biogas filter set-up

Table 9: The economics

S No	Category	Quantity	Sellable quantity (in kg)	Rate (Rs/unit)	Annual cost (Rs)
1	Feedstock	Cow dung: 4 TPD Rs 1,400/ trolley of 4 tonne	4,000	0.35	4,62,000
2	Operations	Electricity, labour, maintenance			8,40,000
3	Gas off-take (kg/month)	1,800	60 kg/day	55	1,188,000
4	FOM (solid fertiliser) kg/ month	60,000	60,000	3	2,160,000
5	LFOM (liquid fertiliser) kg/month	30,000	30,000	1.5	5,40,000
6	Total FOM and LFOM revenue				2,700,000
Total expenses (1+2) — feedstock + operations					1,302,000
Total revenue (3+4) gas + FOM/LFOM					3,888,000
Profit {(3+4)-(1+2)}					2,586,000

also used as fuel for public vehicles; however, the number of CBG-fuelled vehicles has declined from about 15-20 to only five-six currently. The selling price of CBG is about Rs 60 per kg.

There is presently no Point of Sale (POS) machine at the plant. Efforts are underway to procure one to facilitate easier transactions and enable record-keeping of sales data of the FOM, so that the company can claim subsidies from the government.

The digestate slurry, after drying, is marketed as organic fertiliser. It is supplied to farms growing apples, potatoes and kiwis. The use of this organic fertiliser has shown promise in enhancing soil fertility.

The challenges

Currently, the plant produces around 0.06 TPD of CBG, which is 30 per cent of the actual capacity. During the CSE team's visit, officials from the plant highlighted a critical concern in the area regarding soil health degradation due to excessive use of chemical fertilisers like urea and di-ammonium phosphate (DAP). Long-term reliance on these chemicals had led to a significant decline in the organic carbon content of soils. The officials advocated widespread use of the organic slurry from the plant, emphasising its role in restoring soil fertility, increasing production and promoting sustainable agricultural practices.

What CSE found in its survey

One of the major findings of the survey of operational plants in Punjab has been that all the plants are operating at a low capacity utilisation due to varied reasons and challenges (*see Table 10: Observations on capacity utilisation of the surveyed plants*).

Interactions with other stakeholders

Besides officials from the CBG manufacturing plants, the CSE team also interacted with other stakeholders who/which are part of the supply chain for CBG plants in the state. While the team did not come across any critical concerns regarding feedstocks such as animal dung, sewage or press mud, management of paddy straw presented some problems. Feedstocks like animal dung or sewage are available round the year; paddy straw is not. The paddy cultivation season is from mid-June to October, and harvesting happens from mid-October to a little before mid-November. This harvesting period is the window for biomass aggregation and is short — it lasts for only 15-20 days.

Table 10: Observations on capacity utilisation of the surveyed plants

Plant	Location	Feedstock	Installed capacity (TPD)	Actual output of CBG (TPD)	Capacity utilisation (per cent)	Reasons for low capacity utilisation
Ever Enviro	Dhuri	Paddy straw	12.84	6	47	1. Lack of technology support 2. Low off-take/sales of FOM/LFOM 3. High cost of production
Ever Enviro	Patran	Paddy straw	12.80	6	47	
MEPL Bio Energy LLP	Amritsar	Press mud + animal dung	5.6	0.56	10	1. The HDPE pipeline which supplies gas at 4-5 bar pressure, is only used for residential purposes; the company is now changing to a steel line 2. Supply chain problems
STP	Ludhiana	Sewage	70 MLD	1.2	NA	1. Dependent on quantity of sewage water 2. Have only two cascade vehicles, which affects the supply line
Anand Energy	Fazilka	Animal dung	0.2	0.07	35	1. High rate of feedstock 2. CBG offtake depends on the demand side because the plant does not come under the SATAT scheme, where the offtake is taken care by OMCs
TR Mega Foods	Ludhiana	Animal dung	5.0	2.5	50	Uncertain supply of organic manure
ARC CBG LTD	Barnala	Animal dung	2	1.2	60	1. Problems in transportation of gas 2. Lack of market access for selling FOM/LFOM

Of the existing operational plants in the state, 50 per cent depend on paddy straw as their feedstock. One of the key concerns is the burning of crop residues by farmers. The Central government has brought into effect a crop residue management scheme, under which it plans to support the efforts of Punjab, Haryana, Uttar Pradesh, Madhya Pradesh and Delhi in addressing the problem of crop residue burning.

Farmers

In Punjab, farmers are facing multiple challenges in managing paddy straw, especially with the shift from traditional on-farm use to its growing industrial demand. According to a *sarpanch* (Tony, of Gillamal village), while some straw continues to be used as animal fodder, a large portion is now collected by aggregators for use in industries like paper mills, distilleries and CBG plants.

However, the efficiency of current straw collection machinery is a major concern. The equipment often fails to cut the stubble close to the ground, leaving behind sharp stalks that injure labourers and make land preparation for the next crop difficult. This not only increases the manual workload, but also delays sowing and affects productivity.

Moreover, farmers are not always aware of or included in long-term agreements with CBG plants, leading to uncertainties in pricing and inconsistent off-take. Such agreements between farmers and CBG plants can ensure a win-win situation for both: farmers will be assured of their crop residue uptake by CBG plants and the plants will have a reliable supply of feedstock.

In the surveyed village in Punjab, 80-90 farmers collectively own one baler and six-seven tractors, making timely access to the baler critical for collection. Any delay forces the farmer to opt for manual collection, increasing costs by Rs 200-300 per acre. The farmer sometimes also has to pay the cost of the blade of the paddy straw-cutting machine, which is about Rs 200 per acre. The total cost, as a result, comes to Rs 400-500 per acre approximately.

Responses to the survey also highlighted the need for the state government to deploy sufficient and advanced machinery in the fields during the harvesting season; these machines should be made available by September to ensure farmers are not forced to wait and waste time. Another concern that emerged was the need for adequate storage infrastructure for the collected biomass. Biomass banks can be set up for storing biomass — this needs to be initiated at the level of the state government.

All this points to a requirement for better mechanisation, coordinated logistics and more inclusive business models that can secure farmer's participation in the evolving biomass market. Out of all the types of aggregators, engaging farmers as aggregators is being seen as the most viable and long-term option — as it will provide a sense of ownership and responsibility to farmers, and offer them a stake in the transaction process.

Punjab Energy Development Agency (PEDA)

PEDA officials, who were also involved in the interactions, were of the view that though the state has a great potential for CBG production from different feedstocks, there is resistance from communities: people complain about the smell coming from neighbouring CBG plants and fear that the emissions might be posing a health risk; this has been a hindrance in the upscaling plans of the sector.

There is no scientific basis for these apprehensions, though. There are states like Uttar Pradesh and Gujarat where a number of CBG plants are running without any resistance from local inhabitants — PEDA and the state government should work towards educating the local communities in Punjab.

Aggregators

Farmers do not bring the feedstock to the CBG manufacturing units — the aggregators do. In fact, aggregators play a vital role in the post-harvest management of crop residues, particularly paddy straw. There are three kinds of aggregators: firstly, there are those who are based locally in the villages — they purchase the machinery and provide services. The second type include companies which provide services. Thirdly, there are farmers who are stakeholders in the CBG unit as well as suppliers of biomass — Verbio India, for example, has involved nine farmers as aggregators and buys a portion of its feedstock directly from them.

In Amritsar, it was observed that approximately two to three tonne of paddy straw are collected per acre of farmland after harvesting. The aggregation process is mechanised and involves a spreader to cut the straw, a rack to line it up, and a baler to compress it into bales. These bales are then loaded and transported using tractors. The aggregator collects paddy straw free of cost from farmers and sells it to CBG industries, distilleries and ethanol plants at Rs 1,600 to Rs 2,500 per tonne — the rate varies depending on the availability of paddy straw.

Lack of local storage or decentralised collection points, delays in availability of suitable machinery, poor planning of aggregation routes, and high transportation

costs — especially for low-density feedstocks like loose straw and press mud — tend to affect profitability.

Challenges in the CBG sector in Punjab

Though Punjab has planned a number of projects, only a few have moved forward. There are several challenges that are slowing down the development of the CBG sector in the state.

Feedstock supply

- **Feedstock security:** One of the most pressing challenges which the CBG sector has been facing is consistent and affordable availability of biomass feedstock. Paddy straw, a commonly used feedstock in northern states like Punjab and Haryana, is available only during a short window of 30-40 days after the harvest. Maintaining a continuous supply to the CBG plant is a concern for other varieties of feedstock as well. In the case of press mud, annual agreements between CBG plants and the sugar industry need a relook: as per the current arrangement, the CBG plant is at a disadvantage — the renewal of its agreement is at the discretion of the sugar industry depending on the cost of press mud. Ideally, this agreement should be long-term in nature.

- **Feedstock quality**: Paddy straw contains high levels of silica and lignin, and requires expensive pre-treatment before use. Similarly, animal waste often reaches plants in a contaminated form, which reduces the biogas yield. The sector also suffers from a lack of standardised procurement practices and reliable aggregator networks, further weakening the supply chain.

- **Lack of biomass aggregation machinery:** In addition to cost and availability issues, logistical challenges hamper the efficient collection of biomass. Aggregators and contractors who are responsible for collection often face delays due to the unavailability of baling machinery, especially during peak harvest seasons. Smallholder farmers, who lack access to mechanisation, resort to manual collection, which further increases operational costs to the tune of Rs 1,200-1,400 per acre. Enforcement of crop residue management policies remains weak, with 30-40 per cent of agricultural residues still being burned in the fields.

- **Lack of biomass storage infrastructure:** The seasonality in the availability of paddy straw necessitates large-scale storage infrastructure, which is currently lacking. Punjab, in particular, faces a severe shortage of barren land, forcing

CBG plants to lease agricultural land at extremely high costs — up to Rs 80,000 per acre per year — as observed at the Ever Enviro plant.

- **Pricing of raw material:** The market price of paddy straw keeps fluctuating from about Rs 1.7 per kg to Rs 2 per kg — some plants are also paying more (Rs 2.5 per kg). This inflated pricing drastically increases the input costs and threatens the economic sustainability of CBG operations. Therefore, there is a need to rationalise the costing of the raw material for CBG manufacturers, while ensuring that farmers are also incentivised by giving them access to bio-manures.

Off-take and marketing challenges

- **Lack of pipeline infrastructure:** Punjab does not have adequate gas pipeline infrastructure. Though Gujarat Gas Limited has agreements with a few of the plants in the state, there is no significant development with regard to the other city gas distribution companies. In the absence of direct pipeline connectivity, many plants rely on costly cascade systems, which add another Rs 8-10 per kg for gas compression. As per CSE's analysis, cascade off-take gives 15-20 per cent less net earnings when compared to off-take through a pipeline grid. This problem is worse in rural or semi-urban areas.

- **Lack of off-take agreements:** There is an absence of clear and enforceable long term CBG offtake agreements. Due to this, even if the plant produces a certain quantity of CBG, the offtake remains uncertain as it is up to the CGD/OMC to take the gas. There have been instances where plants were ready to produce, but the local OMC retail outlets were not ready to offtake the gas due to a lack of specialised dispensers (cascades) at their end. The agreements rarely penalise the buyer (OMC) for failing to lift the gas, leaving the producer with perishable inventory.

Management of FOM/LFOM

- **Lack of sensitisation and awareness:** Fermented organic manure (FOM) and liquid fermented organic manure (LFOM) are nutrient-rich residues from the anaerobic digestion process in a CBG plant. Although FOM/LFOM has the potential to replace 25-50 per cent of chemical fertilisers, its adoption among farmers remains low due to lack of awareness and limited access to subsidies.

  Some plants, such as Arc CBG and Anand Energy, are able to sell only about half of their FOM production, while the rest remains dumped on the plant premises. Despite the existence of a Rs 1,500-per-tonne subsidy for FOM, the

delay in distribution of Point of Sale (POS) machines — required for subsidy claims — has affected the uptake. Without a mandatory policy requiring the blending of organic fertilisers with their chemical counterparts, FOM remains a largely untapped resource, weakening the circular economy potential of CBG projects. There is a need to create awareness among farmers regarding the application and benefits of FOM/LFOM.

- **Lack of market linkages:** There is no mechanism at the state level to ensure market linkages for FOM. Without strong market demand and farmer awareness, the potential of FOM to replace chemical fertilisers remains largely untapped.

Community resistance to CBG plants in the vicinity

Protests and resistance have been documented in some regions of the state against upcoming CBG plants, resulting in scrapping of the projects — a case in Patiala illustrates this phenomena[17]. Villagers have expressed fears over potential air and water pollution, loss of common land, and unfulfilled promises of local employment.

Regulatory and financial challenges

- **Slow mechanisms and processes:** The delay in getting approvals — including approvals for selling the gas produced — and land is a concern. Many companies have to get permissions from different government departments and agencies before they can start building, which takes a lot of time. There is no single system to make this process easy, especially for small developers and new companies.

- **Lack of financial support:** One of the most significant concerns is the absence of CBG-specific incentives such as subsidies on CAPEX-OPEX. Many companies are finding it difficult to arrange funds for their ventures. Delays in receiving government subsidies, lack of loans at low interest rates, and strict rules from banks make the going tougher. This lack of financial support hampers the economic viability of new and existing CBG projects. There are some basic incentives given under the industrial policy of the state, but considering its potential, Punjab needs a more lucrative policy for entrepreneurs in the CBG sector.

- **Lack of clarity:** There is confusion about how prices are decided and other regulations. The role of state-designated agencies is important as they are the best assessors of the requirements of the sector.

Other operational challenges

The sector struggles to cope with some other operational and maintenance concerns as well — these include delays in payments from off-takers, technical problems in plant components, shortage of skilled humanpower, and difficulties in achieving consistent plant load factors due to feedstock variability. Together, all these issues highlight the urgent need for an updated and CBG-specific policy framework in Punjab that addresses financial, infrastructural, and regulatory gaps comprehensively.

Recommendations for the sector's growth in Punjab

A comprehensive national strategy for the development of the CBG sector — which can be followed by all states — should prioritise key areas: establishing stable feedstock supply chains through farmer engagement and aggregator networks, developing shared storage and pre-processing infrastructure; implementing guaranteed off-take mechanisms with fair pricing, creating robust markets for organic fertilisers, and providing targeted financial support for project development. State governments must play an active role in adapting these frameworks to local conditions while ensuring policy stability for long-term investments.

Policy interventions

- **Develop a dedicated CBG policy for the state with significant focus on paddy straw as feedstock.** A dedicated and targeted policy at the state level, with its focus on paddy straw management and FOM/LFOM utilisation, is critically important. Paddy straw has good potential in the state, 50 per cent of the operational plants being paddy straw-based. It is, therefore, important that PEDA and other concerned agencies should include provisions on paddy straw management Paddy straw-based CBG plants should be considered for higher capital support in the form of government subsidies at the state level, and also because these plants need more capital investment. A centralised pricing mechanism, which considers regional feedstock availability, can help standardise costs. For instance, capping the price of paddy straw at Rs 0.75 per kg in Punjab could help stabilise the production economics.

- **Initiate long-term off-take agreements between CBG manufacturers and oil and gas companies.** Government-backed off-take guarantees by OGMCs should be made legally enforceable, with provisions for penalties in case of contract breaches. SATAT must evolve into a performance-based framework where OGMCs are incentivised for consistent off-take and long-term agreements.

- **Establish targets for blending of organic fertilisers to increase the uptake of FOM/LFOM by farmers.** The state government should set targets for chemical fertiliser companies for the blending of organic fertilisers. This would significantly improve the demand for FOM/LFOM and enhance soil health.

- **Develop SoPs for collection, storage and transfer of feedstock to ensure quality.** There are no guidelines on collection and storage of feedstock for CBG manufacturing plants. During monsoons, and due to inadequate collection and storage systems, the quality of feedstock gets affected, which in turn reduces the efficiency of production. Proper SoPs for the supply chain and aggregators can ensure good quality feedstock for CBG manufacturers.

- **Set up a single-window clearance system:** To reduce bureaucratic delays, a single-window clearance system should be established for CBG-related approvals. Subsidy disbursal mechanisms also need to be overhauled for greater efficiency — this would include immediate allocation of POS machines to all FOM-producing units. State governments should consider offering additional incentives such as tax exemptions, capital subsidies and interest subvention (as in the case of Gujarat) to make the sector financially attractive.

Infrastructure development

- **Deploy sufficient biomass aggregation machinery and ensure its management through an online portal.** To ensure near 100 per cent collection of paddy straw, there is a need to deploy sufficient number of biomass aggregation machines (BAM) well in time before the harvesting starts. There should be mobile baler units to ensure collection of biomass and its uniform distribution across districts and blocks.

  The state government should also think of developing a state-level online portal for farmers to ensure the utilisation of the aggregation machinery. The details of the available machinery can be uploaded on the portal; farmers can register and book the machinery as per their convenience. Through this portal, the state government can ensure that the BAM is available to farmers on the date and time required by them. At present, farmers have no clarity on availability of BAM in their neighbourhood, and have to therefore rely on private parties for collection and aggregation of biomass from the fields

- **Develop biomass banks.** The state should invest in establishing biomass banks or centralised storage depots in close proximity to CBG clusters. These facilities should be developed on government-owned barren land to avoid high

leasing costs. To support timely collection of crop residues, mobile baler units must be deployed at the panchayat or district levels, managed either by rural cooperatives or through public-private partnerships. This would help overcome the limitations faced by small farmers in accessing mechanised equipment.

- **Expand pipeline connectivity for cost-effective utilisation of the off-take model.** The government of Punjab should bring city gas distribution (CGD)/ OMC companies and CBG manufacturers together and ensure coordination among stakeholders and pipeline infrastructure development in the state — this will ensure that the benefits of Central government schemes (like DPI and CBG-CGD Synchronisation) reach the sector (Direct Pipeline Infrastructure scheme and CBG-CGD Synchronisation scheme are government schemes focused on support to ensure that CBG moves from rural production sites into urban gas grids efficiently). CBG plants should be prioritised for inclusion in CGD grids. Where pipeline access is not immediately feasible, small-scale gas liquefaction units and compressed gas corridors should be developed as interim solutions. These measures would drastically reduce transportation and compression costs for producers. There should also be a provision for financial support to CBG manufacturers in bearing the cost of CBG off-take through cascades, till a gas grid is fully developed in the region.

- **Establish demo farms for sensitisation of farmers towards utilisation of FOM/LFOM.** Demonstration farms should be established to raise awareness among farmers about the benefits of FOM in improving soil fertility and crop yield. The successful collaboration between Sampurn Agro and KVK in Fazilka can serve as a model. These demo farms can also act as sensitisation hubs for farmers on best practices in FOM management and usage.

- **Launch awareness campaigns in local languages on FOM/LFOM benefits.** It is important to reach out to farmers on the ground and instill in them a trust in the benefits of FOM/LFOM on crop yields. The Punjab Agriculture University and the Department of Agriculture could be key stakeholders for this.

- **Make farmers stakeholders in the CBG manufacturing facility.** There is a need to make farmers active stakeholders in the CBG ecosystem. By offering them equity or cooperative membership in CBG ventures, their participation and ownership can be ensured. This inclusive model can not only enhance feedstock availability, but also promote rural livelihood generation and community-based environmental stewardship.

4

STATE PROFILE

GUJARAT

Gujarat has a thriving agriculture and dairy sector which generates large quantities of biomass that can be used in producing compressed biogas. The state has the second highest number of operational CBG plants in India (after Uttar Pradesh).

There are 104 registered plants in Gujarat, with a total CBG production capacity of about 722 tonne a day (TPD). Of these, 21 were operational during the time of the CSE survey; their total capacity stood at 109 TPD. The CSE survey covered 50 per cent of these 21 operational plants.

Despite utilising multiple types of feedstock, Gujarat's plants are operating at a low capacity utilisation. The reasons range from high and increasing cost of feedstock and its uncertain quality and availability, to limited acceptability of by-products (bio-digestates).

CSE recommends measures such as introducing a pricing mechanism for different feedstocks with a cap on cost per unit of material; assessing availability of feedstock and land for setting up CBG plants; and creating awareness among farmers about the benefits of using the sector's by-products, among others.

Feedstock availability and the potential for CBG production

Gujarat, with its prominent agricultural and dairy sectors, possesses a substantial and diverse availability of biomass, presenting immense potential for sustainable bioenergy production, effective waste management and environmental conservation. The state's feedstock resources are primarily categorised into four types of waste, all of which are suitable for the production of compressed biogas (*see Table 11: CBG generation potential in Gujarat*).

Livestock waste (primarily cow dung)

Gujarat has a livestock population of about 27 million which generates a substantial amount of animal waste, particularly from cattle and buffaloes. The state has approximately 9.6 million cattle and 10.5 million buffaloes.[18] Together, they produce an estimated 240,000-300,000 tonne of dung every day — this translates into around 88-110 million tonne of dung annually. This vast quantity of animal waste plays a significant role in the rural economy and offers both challenges and opportunities in terms of management and utilisation, as it has the potential of producing about 1.76-2.2 million tonne (MT) of CBG in a year (at 2 per cent conversion efficiency) if fully utilised.

As per the GOBARdhan portal, 16 CBG plants in the state utilise cow dung as feedstock in some percentage, in which cow dung may or may not be the major component. There are 18 CBG plants under construction in which cow dung is to be used either as a primary or secondary feedstock — the combined capacity of these is about 70 tonne of CBG, with the potential for using about 3.5 MT per year of cow dung. Other than that, about 34 plants where construction is yet to start are expected to use animal dung as primary or secondary feedstock.[19]

However, despite comprehensive support and benefits that the state offers, challenges persist. These include the presence of sand and silt in cow dung feedstock, which can affect plant performance.

Table 11: CBG generation potential in Gujarat

Feedstock type	Total feedstock potential (million tonne)	CBG generation potential (MMT)
Agriculture waste (paddy)	0.1	0.01
Livestock waste	88-110	1.76-2.2
Municipal waste	3.8	0.076
Agro-industrial waste	0.35-0.47	0.014-0.018
Total CBG production potential		1.9-2.3

Note: The analysis is based on complete utilisation of available feedstocks; 70-80 per cent potential can be tapped based on mapping of availability of feedstock in different districts and the collection efficiency.

Agriculture waste

Gujarat's biomass potential is estimated at 50 MT per annum.[20] Key sources include surplus crop residues from rice. The surplus biomass potential (quantity of biomass available after all traditional uses are exhausted) of the state — as per the Kapurthala-based Sardar Swarn Singh National Institute of Bioenergy — is about 0.1 MT. The CBG production potential with the available surplus biomass is about 0.01 MT.

Municipal solid waste

According to the Central Pollution Control Board's *Annual Report on Solid Waste Management (2020-21),* Gujarat generates 10,373 tonne of solid waste every day — this is about 3.8 MT in a year. There are five MSW-based CBG plants operational in the state, with a combined capacity of about 30 tonne per day. Another three plants, with a total capacity of 35 tonne a day, are under construction.

Regarding the potential of MSW utilisation and CBG production from MSW, it is estimated that the organic waste fraction available is about 1.9 MT per year (considering the estimate that there is 50 per cent organic waste in the total MSW generated). Accordingly, Gujarat has a potential to manufacture about 76,000 tonne of CBG from MSW every year.

Agro-industrial waste

According to the Directorate of Sugar of the government of Gujarat, there are 17 sugar factories in the state. The total daily crushing capacity is 65,750 tonne a day — about 12 MT per year. The contribution of this category is the lowest in Gujarat: press mud (a by-product of sugar production) generation is to the tune of 0.35-0.47 MT per year, which translates into 14,000-18,000 tonne of annual CBG potential. Apart from press mud, rotten potatoes from cold storages, rotten vegetables, dairy plant waste, poultry litter and waste from industrial effluent treatment plants (ETPs) that treat organic refuse are also considered as feedstock for CBG manufacturing.

CBG projects: The current status

Gujarat has the second highest number of operational CBG plants in India (after Uttar Pradesh) (*see Table 12: Operational CBG plants in Gujarat*). As per the GOBARdhan portal, there are 104 registered plants in the state, and the total registered CBG production capacity is about 722 TPD. Of these 104, only 21 plants were operational as of October 2025; 29 more were under construction and about 53 plants were in the 'yet-to-start construction' category.[21]

Table 12: List of operational CBG plants in Gujarat

Project	Entity	Gas production capacity (TPD)	Solid feedstock capacity (TPD)	FOM output (TPD)	LFOM output (KLD)	Feedstock (TPD)
Bharat Biogas Energy Limited	Bharat Biogas Energy Limited	14	120	20	40	1. Cattle dung: 40 2. Press mud: 60 3. Others: 20
Greenearth Biogas Pvt Ltd	Greenearth Biogas Pvt Ltd	5	130	45	80	1. Cattle dung: 20 2. Sludge: 10 3. Press mud: 40 4. Agro/food industrial organic waste: 60
Victory Green Energies Pvt Ltd	Victory Green Energies Pvt Ltd	2.4	30	5	45	1. Cattle dung: 15 2. Press mud: 5 3. Napier grass: 10
Sayaji Bio Energies LLP	Sayaji Bio Energies LLP	6.74	240	30	270	Not available
Chem Process Systems Integrated CBG Plant Chem Process Systems Private Limited		11.822	100	16.5	0	1. Cattle dung: 55 2. Agri-waste: 35 3. Napier grass: 10
Atmos AJS Fuels BioCNG Plant	Atmos AJS Fuels Private Limited	2	50	5	50	1. Cattle dung: 10 2. Poultry waste: 3 3. Agri-waste: 7 4. Press mud: 15 5. Napier grass: 15
Agriculture Produce Market Committee	Agriculture Produce Market Committee	3.2	80	15	50	1. Cattle dung: 5 2. Agri-waste: 60 3. MSW: 10 4.Agro/food industrial organic waste: 5
Agriculture Produce Market Committee	Akshar Biotech Pvt Ltd	1.2	30	9.5	20	1. Cattle dung: 2 2. Agri-waste: 20 3. MSW (organic): 5 4. Agro/food industrial organic waste: 3
Glow Green Biotech	Glow Green Biotech	2	50	4.5	60	1. Cattle dung: 45 2. Poultry waste: 1 3. Agri-waste: 0.5 4. Press mud: 1 5. Agro/food industrial organic waste: 2.5
Govardhannathji Energies LLP	Govardhannathji Energies LLP	7.5	200	100	240	1. Cattle dung: 35 2. Sludge: 40 3. Agri-waste: 55 4. Press mud: 40 5. Agro/food industrial organic waste: 30
Plim Biotech Private Limited	Plim Biotech Private Limited	2	35	8	20	Napier grass

Continued on next page...

Project	Entity	Gas production capacity (TPD)	Solid feedstock capacity (TPD)	FOM output (TPD)	LFOM output (KLD)	Feedstock (TPD)
Banas BioCNG Plant	Banaskantha District Co-operative Milk Producers Union Ltd, Palanpur	0.8	40	8	75	Cattle dung
Biomethanation plant	Aaryan Associates & Co	0.4	15	4	18	1. Cattle dung: 6 2. MSW: 8 3. Agro/food industrial organic waste: 1
Jamnagar CBG Plant	Reliance New Solar Energy Ltd	2.4	99	30	10	1. Cattle dung: 70 2. Agri-waste: 27 3. Napier grass: 2
Vadodara CBG Plant	Reliance Chemicals and Materials Ltd	15	300	120	40	1. Agri-waste: 50 2. Press mud: 150 3. MSW: 100
Biofics Advance Multifeed BioCNG & Premium Biofertilizer Plant	Biofics Pvt Ltd	10	100	25	60	MSW
Apex Green Energy Corporation	Apex Green Energy Corporation	5.6	200	30	40	1. Cattle dung: 25 2. Poultry waste: 15 3. Press mud: 157 4. Agro/food industrial organic waste: 3
Turquoise Bio Natural Energy Pvt Ltd	Turquoise Bio Natural Energy	5.5	120	22	25	1. Cattle dung: 30 2. Agri-waste: 10 3. Press mud: 50 4. Agro/food industrial organic waste: 10 5. Napier grass: 20
Shrihari Bio CNG and Fertilizer LLP	Shrihari Bio CNG and Fertilizer LLP	5.628	180	27	25	1. Cattle dung: 30 2. Press mud: 100 3. Agro/food industrial organic waste: 30 4. Other: 20
Kakadiya Green Energy Pvt Ltd	Kakadiya Green Energy Pvt Ltd	2.4	60	12	3000	NA
Miracles Agrigreen Solutions Pvt Ltd	Miracles Agrigreen Solutions Pvt Ltd	3	200	0	200	1. Cattle dung: 100 2. Napier grass: 100

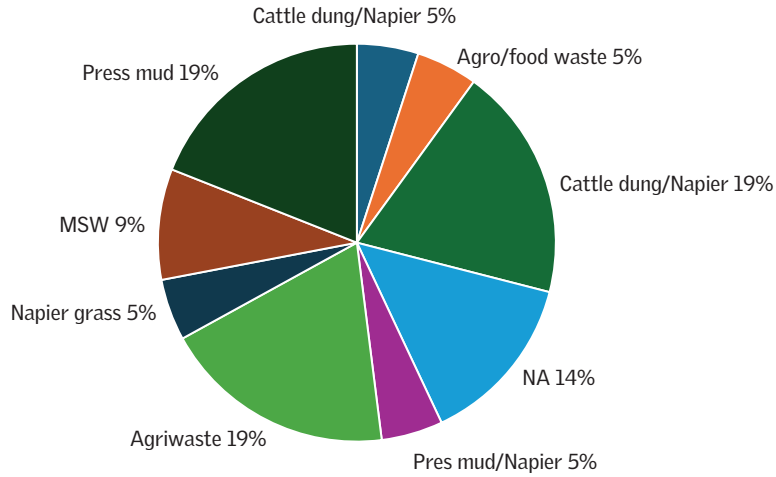
Source: GOBARdhan portal

The existing operational capacity of the state (21 plants) stands at 109 TPD. Out of the operational plants, only 21 per cent use a single type of feedstock; information regarding type of feedstock used is not available for 10 per cent of the plants; the rest use a mix of two or more different varieties of feedstock. This is important

from the feedstock security point of view — plants which base their operations on a single feedstock tend to get affected in case the feedstock supplies are low.[22]

Cattle dung, press mud and agri-waste are used as major feedstocks in about 19 per cent of the operational plants, while 9 per cent rely on municipal solid waste as their major feedstock. Almost all the plants used cattle dung in some proportion, because it helps catalyse the digestion process (*see Graph 3: Feedstock use in operational CBG plants*).

Graph 3: Feedstock use in operational CBG plants



Source: GOBARdhan portal

The CSE survey in Gujarat

As part of its primary research, CSE did extensive ground-level surveys and site visits to CBG plants in the state. The team visited functional CBG plants and interacted with stakeholders to understand the operational status as well as the issues and challenges in the sector (*see Table 13: Operational CBG plants covered under the CSE survey*).

The CSE survey covered about 50 per cent of the operational plants of the state. Of these, the Govardhannathji Energies LLP plant has been operating at 100 per cent capacity utilisation — a rare feat among operational CBG units. Two plants had closed down due to unviable cost economics, and the Shrihari Bio-CNG and Fertilizer LLP plant had been sold to another company; the plant was under maintenance when the CSE team visited. The rest of the plants (except Glow Green Biotech) were found to be operating in the range of 18-60 per cent capacity utilisation; Glow Green could manage only 1.5 per cent of its capacity.

Map 3: Location of operational CBG plants in Gujarat

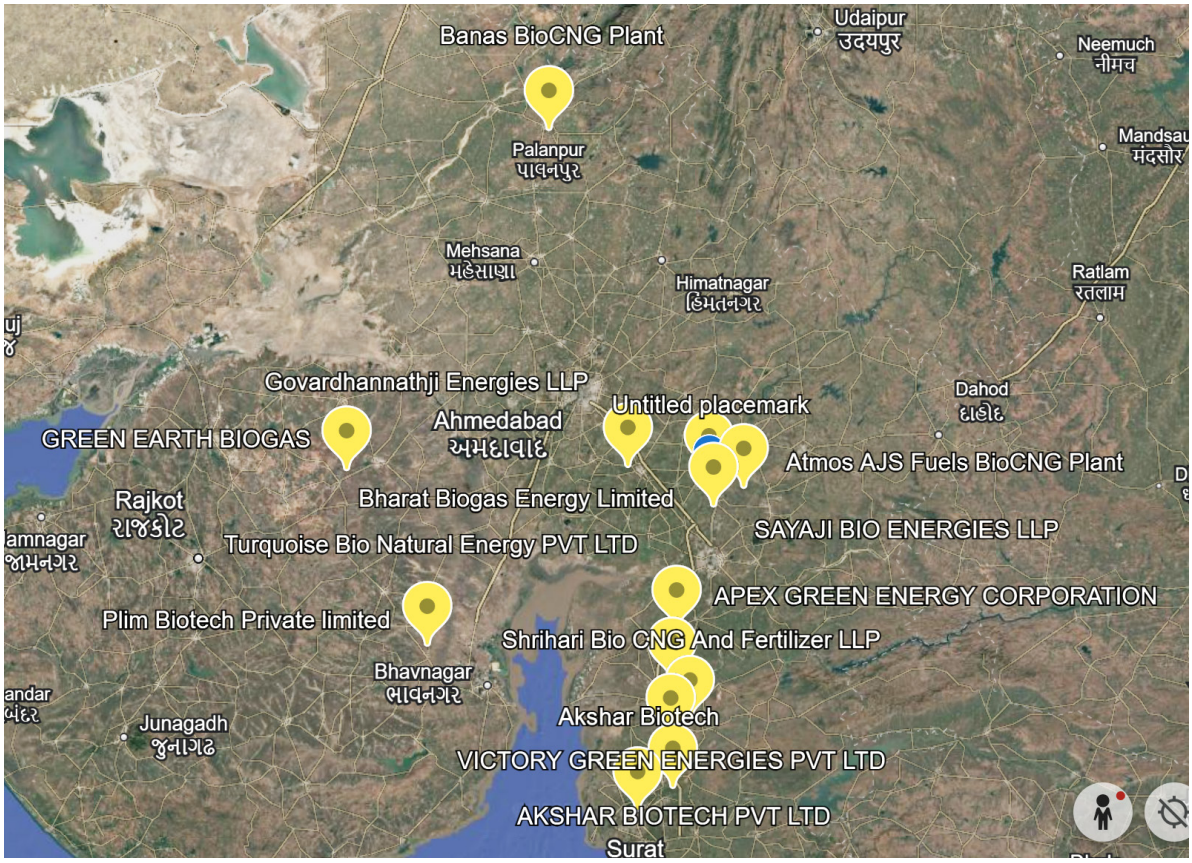


Table 13: Operational CBG plants covered under the CSE survey

S no	Name of the plant	Status of the plant	Gas production capacity (TPD)	Actual output of CBG (TPD)
1.	Bharat Biogas Energy Limited	Functional	14	3
2.	Turquoise Bio Natural Energy Pvt Ltd	Functional	5.5	1
3.	Atmos AJS Fuels BioCNG Plant	Functional	2	1
4.	Agriculture Produce Market Committee	Functional	3.2	2
5.	Glow Green Biotech	Functional	2	0.03
6.	Govardhannathji Energies LLP	Functional	7.5	7.5
7.	Vadodara CBG plant	Functional	15	5
8.	Biofics Advance Multifeed BioCNG and Premium Biofertilizer Plant	Functional	10	5
9.	Shrihari Bio CNG and Fertilizer LLP	Functional	5.628	3
10.	Apex Green Eere Corporation	Non-functional	5.6	-
11.	Victory Green Energies Pvt Ltd	Non-functional	2.4	Nil

CASE STUDY 1

OPERATIONAL PLANTS SURVEYED IN THE STATE

Banas BioCNG Plant

Feedstock used
CATTLE DUNG

CBG production
0.8 TPD capacity

The Banas BioCNG Plant located 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; the dung is then utilised to produce bio-CNG. To ensure accuracy in the collection process, tractors equipped with weighing scales are dispatched every day to collect the cow dung from these households. The beneficiaries are compensated for their contributions with Re 1 per kg credited to their accounts every 15 days, in addition to the payment for the milk.

The Banas plant produces an impressive 800 kg of bio-CNG every 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 eight kg of bio-CNG. In addition to fuel, the plant also generates solid and liquid slurry. The solid part of the slurry is transformed into vermi-compost or phosphate-rich organic manure, which is then marketed to farmers. The liquid part is recycled for treatment.

This project is a noteworthy environment-friendly initiative. By capturing methane from the dung and converting it into fuel, the Banas BioCNG Plant provides a sustainable solution to waste management while simultaneously producing fuel for transportation.

Table 14: At a glance

Parameters	Details
Operation began in...	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 off-take method	Dispensed at nearby CNG pumps using cascades
Bio-digestate production	8 TPD of solid and 32,000 l/day of liquid
CAPEX	Rs 8 crore (Rs 13,700/tonne)

What CSE found in its survey

One of the key findings of the survey has been that unlike Punjab, the majority of plants in Gujarat are utilising multiple varieties of feedstocks. In spite of that, these plants are operating at a low capacity utilisation (*see Table 15: Plants surveyed in Gujarat*).

Table 15: Plants surveyed in Gujarat

S no	Plant	Status of the plant	Gas production capacity	Actual output of CBG	Capacity utilisation	Reason for low capacity utilisation
1.	Bharat Biogas Energy Limited	Functional	14	3	21.4	Shortage of feedstock
2.	Turquoise Bio Natural Energy Pvt Ltd	Functional	5.5	1	18.18	1. Feedstock problems 2. Inability to sell FOM/ LFOM
3.	Atmos AJS Fuels BioCNG Plant	Functional	2		50	Shortage of feedstock
4.	Agriculture Produce Market Committee, Surat	Functional	3.2	2	62.5	Shortage of feedstock
5.	Agriculture Produce Market Committee, Vasna	Functional	1.2	1	83	Shortage of feedstock
6.	Glow Green Biotech	Functional	2	0.03	1.5	Focus on selling FOM/ LFOM
7.	Govardhannathji Energies LLP	Functional	7.5	7.5	100	
8.	Vadodara CBG Plant	Functional	15	5	33.33	Shortage of feedstock
9.	Biofics Advance Multifeed BioCNG & Premium Biofertilizer Plant	Functional	10	-	Yet to start operation	
10.	Shrihari Bio CNG and Fertilizer LLP	Functional	5.628	3		Under maintenance during visit
11.	Apex Green Energy Corporation	Non-functional	5.6	Nil		
12.	Victory Green Energies Pvt Ltd	Non-functional	2.4	Nil		Declared NPA by bank

Interactions with other stakeholders

Indian Oil Corporation Limited (IOCL)

Despite robust government support, there are implementation challenges, says IOCL. One of the primary hurdles, mainly for private developers, is land acquisition, which is often easier for government-backed initiatives. Another operational challenge is the lack of competent technical expertise, specifically the scarcity of reliable consultants and EPC contractors capable of delivering efficient, technologically advanced plant solutions. Securing finance support from banks remains difficult, as new entrants (which are the major entrepreneurs in the CBG sector) — that do not have an established track record — often struggle to get project approval even after submitting a detailed project report (DPR).

The regulatory pathway also contributes to delays, with the process of obtaining statutory approvals and necessary utility connections (water/electricity) taking a lengthy eight to 10 months.

The government offers substantial support to the sector through Central and state subsidies which cover approximately 35-40 per cent of the total project cost; the Gujarat state government further reduces the financial burden by offering a 7 per cent interest subvention on bank loans. This overall relaxation on investment totals around 40 per cent, backed by key frameworks like the SATAT scheme, MNRE, the Biomass Aggregation Machinery (BAM) scheme, and the Gujarat Biotechnology Mission.

In terms of initiatives related to organic manure, several companies such as Anand Fertilizer, Kribhco and GNFC are performing well. Glow Green is also making notable contributions, while RC Fertilizer and National Fertilizers Limited (NFL) remain active players in the fertilizer market.

Gujarat Energy Development Agency (GEDA)

CSE's discussions with GEDA had focused on critical supply-side challenges and forthcoming policy initiatives to support the sector. According to the Agency, the primary operational constraint remains feedstock management (raw biomass and animal waste) — specifically, the difficulty in ensuring consistent availability and segregation of waste for maximising gas production. This bottleneck directly contributes to a fundamental demand and supply gap within the sector.

In response to these issues, GEDA is currently developing a new state-level bioenergy policy. This policy aims to provide dedicated support and a strategic

framework to overcome existing challenges and ensure sustainable growth of the CBG sector in Gujarat.

Gujarat Pollution Control Board (GPCB)

The GPCB — whose regional offices have the authority to grant permissions to and monitor CBG facilities — has highlighted specific operational and regulatory hurdles impacting the CBG sector. A critical constraint on securing quality feedstock is the lack of mandatory source segregation of waste, a problem compounded by the fact that the Board cannot penalise ULBs for non-segregation. CBG plants also face an operational challenge due to inconsistency in the quality of animal waste.

Challenges for the CBG sector in Gujarat

- **Increasing cost of feedstock**: There has been a significant increase in prices of feedstock like press mud and cow dung, which forces CBG plants to operate at lower capacity utilisation. High logistics and handling costs add to the burden. In addition, land availability for storage is another limitation, restricting large-scale feedstock handling.

- **Inconsistent availability and quality of feedstock:** Most CBG manufacturers face this problem — there have been cases where the plant has had to restrict its production due to shortage of feedstock.

- **Slow progress in finalisation of off-take agreements**: The CSE team came across cases in which, due to slow progress in finalisation of off-take arrangements, the plant has had to operate at lower capacity utilisation.

- **Lack of infrastructure for gas off-take:** Gujarat's gas pipeline infrastructure is not fully developed yet, but the state fares better than Punjab in this regard. Distribution companies like Gujarat Gas Limited have developed the existing infrastructure and have played a role in many off-take agreements with CBG manufacturers not only in Gujarat, but also in Haryana, Rajasthan and Punjab.

- **Limited market for FOM/LFOM:** FOM/LFOM management is important for financial viability of any CBG plant. However, a lack of awareness among farmers regarding the benefits of using biodigestate for increasing agricultural yield, as well as their dependence on chemical fertilisers, has led to limited demand and slow uptake of these products. This, in turn, restricts revenue generation and hits a plant's operational viability.
  For farmers, the challenges are different but equally pressing. A key issue is their lack of trust in bio-fertilisers. Many farmers continue to use around 30

per cent chemical fertilisers alongside FOM/LFOM. Knowledge gaps around correct dosages, soil preparation and application methods limit the effective use of bio-fertilisers.

In the case FOM/LFOM, the enrichment is done by the plant: the costs (of enriched FOM/LFOM) increase. Prices of enriched LFOM vary between plants, from Rs 3 per kg to as high as Rs 140 per kg. This makes these products unaffordable for many; farmers prefer cheaper, ready-to-use products.

- **Regulatory approvals taking longer time:** Policy and regulatory hurdles pose another barrier to growth. There are delays in obtaining statutory approvals and necessary utility connections — many taking as long as eight-10 months. OMCs and financing institutions also contribute towards stalling any expansion initiatives. Different rules applied by OMCs, banks and other financing bodies create confusion.

- **Lack of standardisation in equipment**: Most of the equipment and machinery are imported. They are cost-intensive and may have limited availability within India. The local manufacturing industry for such equipment is not well-developed in the country. Biofics is one CBG manufacturer which has developed its own technology and has shown significant reduction in capital investments in machinery and equipment.

- **Cost of waste collection an additional burden for MSW-based plants:** MSW plants have to arrange door-to-door collection and transportation of the waste: the plant incurs additional costs on special purpose vehicles, drivers' salaries, fuel etc. The cumulative cost can be as high as Rs 4 per kg. Collection of MSW, otherwise, is the responsibility of ULBs, for which most of them hire a third party. CBG plants can also be provided a tipping fee for the quantity of MSW collected by them.

- **Land acquisition a concern for private developers:** Land is one of the major initial capital expenditures for establishing a CBG plant. Land acquisition has been one of the challenges, faced mainly by private developers. There is a need for the state government to work with the revenue department to look into this.

- **Lack of credible technical expertise to hand-hold the CBG sector:** The CBG manufacturing process is mainly based on microbiology. Purification

technologies such as PSA, membrane or amine systems require heavy investments, ranging from Rs 5 to Rs 8 crore for one tonne per day of CBG production. Technical challenges in maintaining gas purity, microbial balance and product quality add to the complexity of the operations.

There is scarcity of reliable consultants and EPC (engineering, procurement and construction) contractors capable of delivering efficient, technologically advanced plant solutions, which negatively impacts overall performance of the sector.

- **Use of alternative feedstocks in CBG manufacturing:** Due to the shortage of feedstock, manufacturers are now moving towards alternative feedstocks (other than waste) such as napier grass, also known as 'elephant' grass or 'Uganda' grass. While this practice is helping the CBG sector in coping up with feedstock shortages to some extent, it is also nullifying the advantages the sector enjoyed acting as a sink for different waste streams. There is a need for policymakers to ensure there is a policy framework that allows the sector a continuous access to waste streams as feedstock that are available — rather than growing a specific crop focusing on a business model.

Recommendations for the sector's growth in Gujarat

To unlock the full potential of the CBG sector and address the barriers hindering its expansion in Gujarat, a multi-faceted approach is essential. Sustainable growth will require deliberate policy and legal measures that encourage investment, reduce operational hurdles, and stimulate demand for both CBG and its by-products. This will involve coordinated action across short, medium, and long-term horizons, with the Gujarat Energy Development Agency (GEDA) and other stakeholders playing a central role in enabling large-scale implementation.

- **Introduce pricing mechanism for different feedstocks with a cap on cost per unit of material:** To control the increasing price of feedstock every year, there is a need to keep a check on the pricing mechanism, as it will ensure raw material availability to the CBG sector within an affordable range.

- **Conduct region-wise assessment of availability of feedstock and land for setting up CBG plants:** There is variation in the types of feedstock available in any region — thus, a feedstock assessment is needed at the district-level in the state. The information generated by the assessment can then be used as a siting criteria for setting up CBG plants.

- **Create awareness among farmers towards FOM/LFOM benefits to upscale FOM/LFOM management**: While there are examples from the state where CBG manufacturers are involved in enriching FOM/LFOM and marketing it, there is a generic lack of awareness among farmers about the impacts of using FOM/LFOM in their agricultural fields. CSE researchers suggest that the state's Agriculture Department should conduct sensitisation sessions for farmers to make them aware of how to use FOM/LFOM and understand its impacts on the yield.

- **Fast track the required regulatory approvals and gas off-take agreements and develop an online grievance portal:** State-designated agencies need to develop a mechanism to fast track the regulatory approvals for the CBG sector.

- **Develop standards/specifications for the machinery and equipment as per the technology being used and the feedstock variety:** For upscaling the sector, there is also a need for indigenous standards for the machinery and equipment — this can reduce the costs as well as down-time of the CBG process. At present, most CBG technologies are imported: this costs about Rs 5-12 crore per tonne of CBG production.

- **Work with the State Revenue Department to help it develop land banks to ensure smooth land acquisition by CBG developers:** Land availability is a key concern for CBG developers (mainly the private players); therefore, there is a need for the State Revenue Department to identify and develop district-wise pockets of land — in alignment with feedstock availability — to ensure CBG manufacturing companies are able to get the land they need.

5

STATE PROFILE

HARYANA

Haryana has 70 registered CBG and bio-CNG plants, of which 17 are functional. The state has an annual capacity to produce 1.07 million tonne of compressed biogas. Its operational plants use all varieties of feedstock, except municipal solid waste.

The sector's key challenges in the state include lack of good quality feedstock, maintaining the purity of the gas, market disadvantages, and the need for technically qualified and skilled humanpower, among other things.

The measures that CSE recommends include setting up regional feedstock collection and storage centres to ensure consistent supply of good quality feedstock; strengthening markets by introducing long-term purchase agreements that guarantee CBG procurement at fair prices; and introducing a state-level CBG development policy.

Feedstock availability and the potential for CBG production

Haryana is one of the leaders in the CBG sector in India, promoting the fuel as a clean and renewable source of energy. The state has a large agricultural base and generates huge amounts of crop residues, especially from paddy fields.

Animal dung

As per the Basic Animal Husbandry Statistics-2023, Haryana has a livestock population of about 6.3 million heads, including cattle and buffaloes. The state has approximately two million cattle and 4.3 million buffaloes,[23] which together produce an estimated 95,000 tonne of dung daily (around 34 MT annually). This vast quantity of animal waste plays a significant role in the state's rural economy and offers both challenges and opportunities in terms of management and utilisation — if fully utilised, it has the potential of generating about 0.7 MT of CBG every year.

Crop residues

Haryana generates approximately three MT of crop residues annually, primarily from rice crop. Considering a CBG yield factor of 10 per cent, this crop residue has the potential to produce around 0.3 MT of CBG per year.

Press mud

As per the Haryana State Federation of Co-operative Sugar Mills Ltd, there are about 14 sugar mills in the state with a total capacity of about 50,000 tonne of cane crushed per day. On an average, these mills crush about six-seven MT of cane per season, which generates around 0.24-0.28 MT of press mud each year. Assuming a CBG yield of 4 per cent, Haryana has the potential to produce approximately 9,000-11,000 tonne of CBG annually from the by-products of its sugar industry.

Municipal solid waste

Haryana generates approximately 8,837 tonne of municipal solid waste (MSW) a day, of which around 50 per cent is organic waste which is suitable for energy recovery. This translates to roughly 4,418 tonne of organic waste in a day which can be used as feedstock for CBG production.

Assuming a CBG yield of 4 per cent from organic waste, the state has the potential to produce approximately 177 tonne of CBG per day from its municipal solid waste. When scaled to an annual figure, this corresponds to around 64,510 tonne of CBG per year.

Table 16: CBG production potential of Haryana

Feedstock	Waste available (million tonne/year)	CBG production potential (million tonne/year)
Paddy straw	3	0.3
Animal waste	34	0.7
Press mud	0.24-0.28	0.011
MSW	1.6	0.064
Total CBG production potential		1.07

Note: The analysis is based on complete utilisation of available feedstocks — 70-80 per cent potential can be tapped based on mapping of availability of feedstocks in different districts and the collection efficiency

As per CSE's analysis, the total CBG production potential of the state from the different kinds of feedstock is estimated to be about 1.07 MT per year (*see Table 16: CBG production potential of Haryana*).

CBG projects: The current status

Haryana is actively promoting renewable energy through the GOBARdhan (Galvanizing Organic Bio-Agro Resources Dhan) initiative, focusing on the development of CBG plants across the state. According to the official GOBARdhan

Table 17: List of operational plants in Haryana

Plant	Name of the entity	Gas production capacity (TPD)	FOM production capacity (TPD)	LFOM production capacity (KLD)
Compressed Biogas and Fermented Organic Manure Plant	LR Energy Karnal Pvt Ltd	5.4	26	100
Compressed Biogas and Fermented Organic Manure Plant	LR Energy Vrindavan Pvt Ltd	5.4	26	100
Rama Green Energies	Rama Green Energies	6	100	100
Sainsons Paper Industries Pvt Ltd	Sainsons Paper Industries Pvt Ltd	3	6	0
CBG & Organic Fertilizer Plant	SPS Bio-chem Pvt Ltd	6.4	72	100
Amrit Fertilizers	Amrit Fertilizers	4.2	60	340
Demeter Ago Energies Pvt Ltd	Demeter Ago Energies Pvt Ltd	10	11.5	67.5
R2S Bio Products Pvt Ltd	R2S Bio Products Pvt Ltd	2.5	10	0
Jhajjar CBG Plant	Reliance Bio Energy Limited	20	140	30
Panipat CBG Plant	Reliance Bio Energy Limited	15	130	30
Metro Fuels	Metro Fuels	10	50	90
0.2-TPD CBG Plant	Maruti Suzuki India Limited	0.2	0.7	2
Rohtak Biogas Division, Akshay Urja Manthan Biofuel Pvt Ltd	Akshay Urja Manthan Biofuel Pvt Ltd	7	45	50
Shashi Energies	Shashi Energies	5.5	2	4.5
Devnics LLP	Devnics LLP	5	30	10
Amar Bio Energies, Panjuana	Amar Bio Energies	0.8	13	42,000

Source: GOBARdhan portal

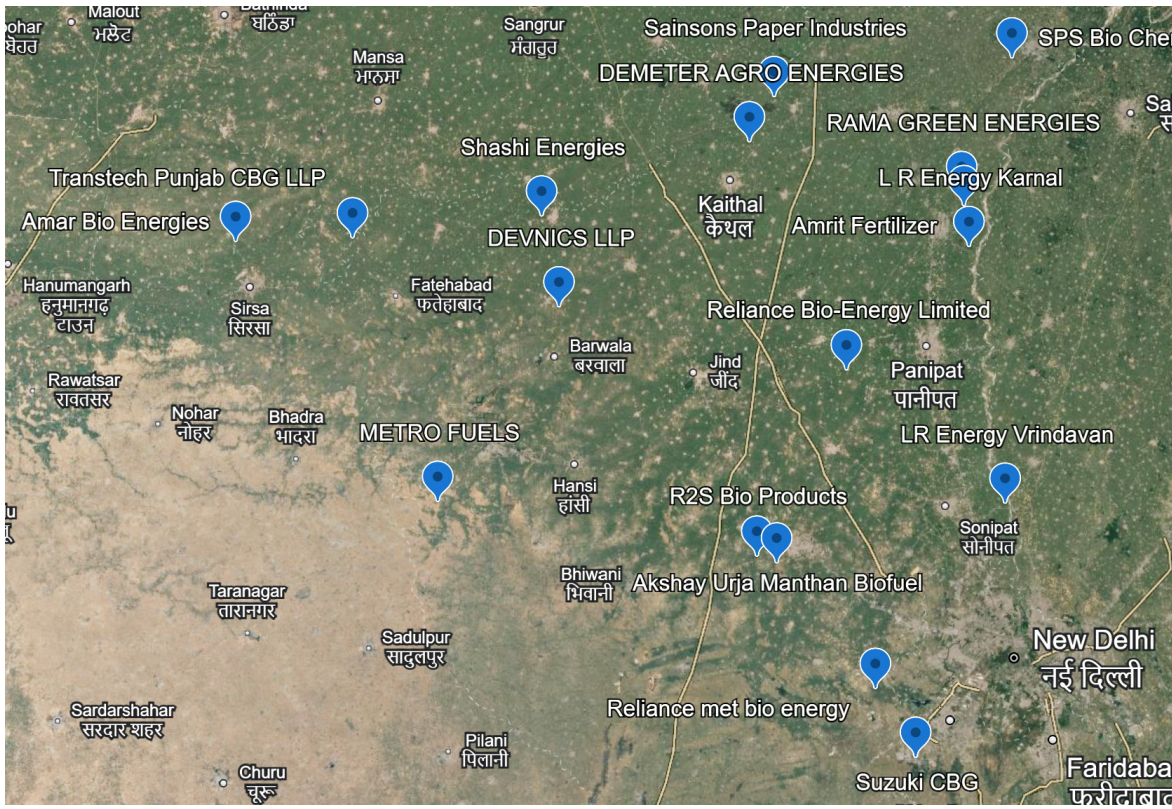
portal, Haryana currently has 70 registered CBG and bio-CNG plants. Among these, 38 plants are yet to start construction, 14 are under construction, one is completed, and 17 are functional.

The CSE survey in Haryana

CSE has done extensive ground-level surveys and site visits to CBG plants in the state. The team visited functional CBG plants (*see Map 4: CBG plants surveyed in Haryana and Table 18: Operational CBG plants covered by the CSE survey*) and interacted with all stakeholders to understand the operational status as well as issues and challenges in the sector.

Operational plants in the state are using agricultural waste (paddy straw), animal dung, press mud and poultry waste — but none of them use MSW as feedstock.

Map 4: CBG plants surveyed in Haryana



Source: Google Earth

Table 18: Operational CBG plants covered by the CSE survey

Plant	Location	Feedstock	Installed capacity (TPD)	Actual output of CBG (TPD)
Devnics LLP CBG Plant	Hisar	20% animal dung, 80% press mud, some paddy straw	5	1.8
Demeter Agro Energies Pvt Ltd	Kaithal	Animal dung, press mud	10	Not specified
Sainsons Paper Industries Pvt Ltd	–	Waste from paper mill effluent treatment plant	3	3
Reliance Bio Energy Limited	Panipat	Paddy straw	15	Not specified
Rama Green Energies	Karnal	Press mud, poultry waste, agricultural waste, animal dung	6	3
Amrit Fertilizers	–	Press mud	4	4
R2S Bio Products Pvt Ltd			2.5	Temporarily closed for 6 months
Metro Fuels CBG Plant	Hisar	20% animal dung, 80% napier grass and agro-waste	10	4-5

CASE STUDY 1

OPERATIONAL PLANTS SURVEYED IN THE STATE

Devnics LLP CBG Plant, Hisar

Feedstock used

ANIMAL DUNG, PRESS MUD AND PADDY STRAW

CBG production

5 TPD capacity

Devnics LLP is using 20 per cent animal dung (costing Rs 0.75 per kg), 80 per cent press mud (Rs 1.25 per kg), and some paddy straw (Rs 1.7 per kg). The plant produces about 1.8 TPD of CBG. The press mud has to be transported from 80-150 km away.

The plant produces high-quality gas with 98 per cent purity and generates 18 TPD of organic manure, half of which is recycled while the rest is sold or given free to farmers. The plant sells its gas to IOCL and Haryana City Gas Distribution Company at Rs 63 per kg, though the sales is limited.

The organic manure sells for Rs 0.8-1 per kg (or is given away free). The total project cost was Rs 25 crore, excluding Rs 15 crore for land. The plant produces good quality organic manure and supports local farmers, but faces low consumer demand and needs clearer regulations for organic manure sales.

What CSE found in its survey

As in the states of Punjab and Gujarat, a majority of the plants are operating at capacity utilisation in the range of about 30-50 per cent. Plants like Sainsons which are self-sufficient in terms of raw material sourcing, are able to operate at 100 per cent capacity.

Table 19: CBG plants surveyed by CSE

Plant	Location	Feedstock	Installed capacity (TPD)	Actual output of CBG (TPD)	Capacity utilisation (per cent)
Devnics LLP CBG Plant	Hisar	20% animal dung, 80% press mud, some paddy straw	5	1.8	36
Demeter Agro Energies Pvt Ltd	Kaithal	Animal dung, press mud	10	3-4	30-40
Sainsons Paper Industries Pvt Ltd	–	Waste from paper mill effluent treatment plant	3	3	100
Reliance Bio Energy Limited	Panipat	Paddy straw	15	Not specified	-
Rama Green Energies	Karnal	Press mud, agricultural waste, animal dung	6	3	50
Amrit Fertilizers	–	Press mud	4	4	100
R2S Bio Products Private Limited			2.5	Temporarily closed	-
Metro Fuels CBG Plant	Hisar	20% animal dung, 80% Napier grass & agricultural waste	10	4–5	40-50
Transtech	Fatehabad	Press mud	3	0.5	15-20

Interactions with other stakeholders

Haryana Energy Development Agency (HAREDA)

As the nodal agency, HAREDA is responsible for facilitating bioenergy projects and providing a 'single window' clearance system for various departmental approvals. Single window clearance is a system which HAREDA is looking forward to incorporate to reduce the time lost in regulatory approvals.

Farmers and Farmer Producer Organisations (FPOs)

Participation of the farming community is vital for feedstock security — this is the input CSE researchers received. However, there is a noted lack of awareness among farmers regarding the benefits of fermented organic manure (FOM) and liquid fermented organic manure (LFOM). What the stakeholder insights suggest:

- **Aggregation hubs:** There is a recommendation to empower FPOs to manage centralised aggregation hubs. This would help stabilise feedstock pricing and reduce the reliance on intermediaries.

- **Economic incentives:** Farmers in areas like Hisar (Devnics LLP) receive organic manure for free or at low costs, yet overall consumer demand remains low due to a lack of clear regulations and certification for organic manure.

Challenges in the CBG sector in Haryana

- **Lack of stable feedstock supply and quality:** Many CBG plants in Haryana face problems related to feedstock availability and quality. Plants such as Amrit Fertilizers and Devnics LLP depend on materials like press mud and agricultural residues which need to be transported from long distances, raising costs and affecting timely supply. Paddy straw-based plants, like Reliance Bio Energy, also face technical issues with pre-treatment (quality of feedstock), which slows down the production process. To solve these problems, there is a need for local feedstock collection centres, better transportation links and reliable supply.

- **Maintaining purity of the gas:** This is another key challenge. In the case of Metro Fuels, purity concerns initially led to reduced gas sales and flaring losses. The plant upgraded itself with better technology which helped improve the gas quality. With changes in the CBG standards introduced by the Bureau of Indian Standards (BIS), a consistent 95-96 per cent purity is necessary to meet buyer requirements: this demands modern purification systems and trained operators. Promoting hybrid purification methods, regular technical

training and automated monitoring can help achieve and maintain high gas quality.

- **Need for technically qualified and skilled humanpower:** Plants such as Rama Green Energies and Amrit Fertilizers have been experiencing disruptions in processing and logistics due to a shortage of well-trained personnel and operators who can handle advanced biogas technologies. Building technical training centres, encouraging research collaborations and sharing operational best practices among CBG plants would help strengthen industry's capabilities.

- **Market disadvantages and inconsistent off-take:** Most plants struggle with low demand for CBG and limited buyers: this means the revenues are unstable. Many rely only on IOCL or local city gas distributors. Plants like Sainsons Paper Industries and Metro Fuels often have to flare excess gas when the off-take is low. Expanding the buyer network by connecting directly with industries and transport sectors can improve market opportunities. State-level purchase obligations and partnerships with private distributors can also help strengthen off-take security.

- **Low organic manure utilisation:** Another persistent issue is the underutilisation of organic manure, both solid (FOM) and liquid (LFOM). Plants such as Devnics LLP and Sainsons Paper Industries struggle to sell or distribute their by-products because of low farmer awareness and lack of clear pricing. To promote usage, the government should certify bio-fertilisers, introduce mandatory use in public farming schemes, and run awareness programmes about their agricultural benefits. Incentives or subsidies for farmers using FOM/LFOM can also help create long-term demand.

- **Financial and operational constraints:** Running a CBG plant involves high expenses, including operation and maintenance costs. Plants such as Rama Green Energies report a monthly expenditure of Rs 30-35 lakh. Small-scale operators often find it difficult to sustain the initial investment and manage delays in gas payments.

Recommendations for the sector's growth in Haryana

- **Adapt a PPP model to ensure effective feedstock supply chain and related infrastructure:** To ensure steady production, Haryana's CBG plants need a stronger and more reliable feedstock management system. Many plants depend on press mud, paddy straw and animal dung, but seasonal availability

and high transport costs limit their efficiency. To overcome this, the state government and private players should establish regional feedstock collection and storage centres where residues can be pre-treated, dried and stored before use.

Additionally, feedstock aggregation hubs managed by farmer-producer organisations (FPOs) can help reduce intermediaries and stabilise feedstock pricing. Support for mechanised collection and baling of paddy straw will also help address crop residue burning issues while providing low-cost feedstock to CBG plants.

- **Introduce long-term purchase agreements that guarantee CBG procurement:** To strengthen the market, the government should introducelong term purchase agreements that guarantee CBG procurement at fair prices for at least five years. Expanding the network of potential consumers — including city vehicle fleets, industrial users and institutional buyers — can stabilise the daily gas demand. The state energy department may also consider CBG purchase obligations (CBOs) similar to renewable power obligations, which would require designated local gas distribution companies to purchase a certain percentage of CBG. Additionally, developing compressed gas bottling units and mini CNG stations under public-private partnerships can help improve local distribution.

- **Organise farmers' awareness programmes on nutrient benefits, demonstrations in agricultural fields toencourage use and marketing of organic manure:** Fertiliser management remains one of the most neglected areas in CBG operations. To resolve this, the Department of Agriculture and Horticulture should develop quality standards and certification for FOM and LFOM, so that they can compete with chemical fertilisers in the market. Government procurement of bio-manure for soil health programmes such as PM-PRANAM or PKVY can immediately improve utilisation. Awareness programmes for farmers on nutrient benefits, demonstrations in agricultural fields, and linkages with cooperatives and fertiliser agencies will encourage adoption. The state can also provide transport and marketing subsidies to reduce the cost of distribution from plants to farms.

- **Offer financial incentives and policy support:** The high cost of CBG plants makes financial planning crucial. To make CBG projects more viable, banks and government financial institutions should provide low-interest green energy loans and extended repayment periods.

A state-level CBG development policy should assure investors of price stability and consistent demand. Tax incentives on feedstock transport, electricity use and renewable energy equipment could further enhance project viability. Simplifying administrative approvals through a single-window clearance system would save time and reduce bureaucratic delays. Government departments can also collaborate to design performance-based incentives, rewarding plants that achieve higher methane yield, lower emissions, or efficient waste utilisation.

- **Invest in human resource development and capacity building:** A sustainable CBG ecosystem cannot function without skilled humanpower. Currently, most plants rely on semi-trained staff, which often leads to operational inefficiencies. Establishing training centres and certification programmes under technical institutions such as polytechnics or agricultural universities would provide specialised operators, mechanics and maintenance professionals to the sector. The government should also support exchange programmes and study visits for plant managers to observe high-performing facilities. Digital training on process control systems, troubleshooting and feedstock analysis can further improve competence and plant reliability.

  State-level skill development agencies, along with the labour department and state nodal agencies, can design and take up the training and capacity building of humanpower already employed in the industries or willing to work in CBG units.

6

THE ECONOMICS OF THE CBG BUSINESS

A plant's financial viability depends on how much of its capacity is being used. While plants are profitable at 100 per cent utilisation, nearly all feedstocks become unviable at 25 per cent capacity, resulting in losses of Rs 30-40 per unit of gas produced, regardless of government support.

The impact of MDA is most critical at 50 per cent utilisation, where feedstocks shift from losses to positive net earnings. However, at 25 per cent utilisation, none of the feedstocks remain viable even with MDA support except animal dung where with MDA support the viability remains.

While MSW feedstock is often available at no cost, plants must still account for significant operational expenses related to waste collection systems and humanpower. Despite these costs, MSW-based plants remain more financially resilient at moderate (50 per cent) capacity utilisation compared to plants based on press mud, which often turn unprofitable at that level.

Transportation is a 'margin killer'. Utilising pipeline infrastructure instead of truck cascades increases net earnings by a minimum of 14 per cent and up to 48 per cent, depending on the feedstock.

Compressed biogas production in India is emerging as a promising opportunity to enhance sustainability of industrial and business processes, as it allows management of different waste streams while reducing the dependence on imports of natural gas. At the same time, it is important that operations of CBG units are made cost-effective.

CSE has assessed the cost economics of CBG plants, taking a sample case of a five TPD- plant. The assessment is based on different feedstocks — paddy straw, animal dung, press mud and MSW — off-take mechanisms, scenarios of FOM/ LFOM management, and capacity utilisation.

Capital cost and feedstock requirement

Setting up a medium-scale five tonne per day CBG plant requires a capital investment of about Rs 6-7 crore per tonne of production capacity, with paddy straw as the feedstock (the investment typically ranges between Rs 30-35 crore); with animal dung, MSW or press mud as the feedstock, the capital cost comes to about Rs 5 crore per tonne of CBG production capacity (investment ranges from Rs 25-30 crore).[24] The cost of the plant per tonne of CBG production varies with the type of technology selected.

The average cost of the CBG produced is Rs 80 per kg average cost which plants are getting after revision in pricing in year 2025. The revenue from the sale of CBG is estimated accordingly.

The feedstock requirement varies depending on the type of waste, as different materials yield different amounts of biogas. To produce one tonne of CBG, a plant would require approximately 10 tonne of paddy straw, 25 tonne of press mud or MSW, or 50 tonne of animal dung (*see Table 20: Feedstock requirement and capital cost of a five-TPD plant*)[25]. The cost of procurement of feedstock can be calculated based on the total feedstock required at specific capacity utilisation and price per tonne of feedstock. The feedstock cost varies, depending on the cost and quantity of feedstock required.

The operational cost of a CBG plant is inclusive of humanpower costs, the costs of the feedstock, electricity, maintenance and consumables, and interest on any loans (*see Table 21: Operational cost of a CBG plant — an estimate*). A five-TPD plant generally has a humanpower requirement of about 10 employees including labourers, operator and manager; the annual humanpower cost amounts to about Rs 37 lakh. These numbers are drawn in consultation with industries and sector experts.

Table 20: Feedstock requirement and capital cost of a five-TPD plant

Major feedstock	Yield potential (feedstock/tonne of CBG)	Annual quantity of feedstock required (tonne)	Price range per tonne of feedstock (Rs)	Average capital cost (Rs)
Paddy straw	10	16500	1000-1500	325,000,000
Animal dung	50	82500	350-1000	250,000,000
MSW	25	41250	Nil	250,000,000
Press mud	25	41250	1500-2000	250,000,000
Annual operating days considered = 330 days				

Table 21: Operational cost of a CBG plant — an estimate

Feedstock	Manpower	Feedstock	Electricity	Maintenance and consumables	Interest in term on loans @10.45%	Total annual operational cost
Paddy straw	3,660,000	20,625,000	22,440,000	3,500,000	23,773,750	73,998,750
Animal dung	3,660,000	53,625,000	17,160,000	3,500,000	18,287,500	96,232,500
Press mud	3,660,000	72,187,500	17,160,000	3,500,000	18,287,500	114,795,000
MSW	3,660,000	—	17,160,000	65,375,000	18,287,500	104,482,500

Source: CSE Analysis

Electricity cost is estimated at an average consumption of 6,500-8,500 units per day (based on a benchmark of 1.3 units/kg of production) for pressmud, MSW and cowdung as feedstock and 1.7 units/kg for agro residue, with a cost per unit of Rs 8. Electricity consumption in paddy-based plants is higher compared to other feedstocks.

About 70 per cent of the project cost is considered to be a loan amount, with an interest rate of about 10.45 per cent per annum; the interest on the loan is estimated accordingly. In case of MSW-based CBG plants, though the feedstock is available free of cost, the plants are spending on humanpower and waste collection systems — these items have been considered under the operation and maintenance costs.

Revenues from sale of gas through different off-take mechanisms

The off-take mechanism also drives the economics of CBG plants. The CSE team has tried to estimate the revenues from sale of gas through pipeline off-take (without transport) and through cascades (with transport). A cost of Rs 5/kg has been considered as transportation cost for off-take distances below 50 km; transportation of CBG above a 50-km distance attracts a subsidy of Rs 1.5/kg under the Direct Pipeline Infrastructure (DPI) scheme of the Central government.

Table 22: Assessment of net earnings for CBG plant based on off-take mechanism for major feedstock

Feedstock	Quantity of CBG produced	Sale of gas revenue	Operating cost	Without transport		With transport				
	A	B= A X Rs.80/kg	C	Net earning	Net earnings/ unit gas	Cost of CBG off take<50 kms	Total operating cost	Net earning	Net earnings/ unit gas	Margin
				D= B-C	E= D/ (A*1000)	F= 5*A*1000	G= C+F	H=B-G	I= H/ (A*1000)	(E-I)/E
Paddy straw	1,650	132,000,000	73,998,750	58,001,250	35.15	8,250,000	82,248,750	49,751,250	30.15	14%
Animal dung	1,650	132,000,000	96,232,500	35,767,500	21.68	8,250,000	104,482,500	27,517,500	16.68	23%
Press mud	1,650	132,000,000	114,795,000	17,205,000	10.43	8,250,000	123,045,000	8,955,000	5.43	48%
MSW	1,650	132,000,000	104,482,500	27,517,500	16.68	8,250,000	112,732,500	19,267,500	11.68	30%

For transportation distances less than 50 km, the remuneration for the industries is already included in the cost of the gas.

The transportation cost of CBG for industries, thus, comes to an average of Rs 5 per kg (<50km) and Rs 3.5 per kg (>50 km), keeping in view the incentive from the DPI scheme (Rs 5-1.5/kg). The net earning on per unit of gas is calculated accordingly (*see Table 22: Assessment of net earnings for CBG plant based on off-take mechanism for major feedstock*).

Revenues from FOM/LFOM

Based on the different feedstocks used for CBG production, the quantity of bio-manure generated varies. The Union Ministry of Chemicals and Fertilizers of the Government of India has introduced a market development assistance scheme for promotion of organic fertilisers. Under it, market development assistance (MDA) will be provided at the rate of Rs 1,500 per tonne for the sale of FOM/LFOM at CBG plants established under the GOBARdhan initiative. The MDA is offered to authorised plants, while ensuring the organic manure is meeting the standards as specified under the Fertilizer Control Order.

In the current scenario, the management of FOM/LFOM is a major concern for most of the CBG plants. This state of affairs is mainly due to lack of sensitisation among farmers on the application and usage of this bio-manure. In line with this, for the estimation of revenues from the sale of FOM/LFOM, this assessment has considered two different scenarios:

- That the plant is able to sell about 50 per cent of its FOM/LFOM generated free of cost and get 100 per cent MDA on it.

- That the plant is not eligible for MDA and is selling the FOM/LFOM free of cost.

As per the analysis in *Table 22*, the net earnings for the plants is estimated to be Rs 10-35 per unit of CBG produced if a pipeline infrastructure is available; with plants that depend on cascades for their off-take, the effective earning is estimated at Rs 5-30 per unit of CBG produced. Net earnings, therefore, go up by 14-48 per cent where pipeline infrastructure is available for direct off-take of CBG.

Table 23 estimates revenues from FOM/LFOM under each scenario. The net earnings under different scenarios is also estimated taking into consideration the revenue from sale of gas and FOM/LFOM and the expenses incurred as operating costs, including the off-take cost of CBG through cascades. The net earnings per unit of gas vary from Rs 30-38 per unit of CBG for paddy-based plants; for animal dung-based plant, they may vary from Rs 16-54 per unit of CBG. In the case of press mud, the net earning is Rs 5-24 per unit of CBG. However, for MSW-based CBG plants, the net earning in the two scenarios is in the range of Rs 12-30 per unit of CBG.

It should be noted here that these net earnings can be realised only when a CBG plant is operating at 100 per cent capacity utilisation. The CSE survey indicates that a majority of the functional plants are operating at well below 50 per cent — keeping this fact in mind, CSE researchers have also tried to estimate the cost economics for a CBG plant at different capacity utilisation scenarios.

Table 23: Cost economics with different FOM/LFOM management scenarios (at 100 per cent capacity)

Capacity utilization	Major feedstock	Biodigestate generation		Costing of sale of FOM/LFOM under different Scenarios		Revenue under each scenario		Net earnings under different scenario		Net earnings per unit of gas	
		FOM	LFOM	sold free with MDA	Sale free of cost with no MDA	100% MDA on 50% sale free of cost	No MDA and sale free of cost	100% MDA+50% free sale	No MDA	100%MDA+ 50% free sale	No MDA+ Free sale
		A	B	C	D= Rs.0	E= CX((A+B)/2)	F= DX ((A+B)/ 2)	G= (Gas cost+E)- Optg cost	H= (Gas cost+F)- Optg cost	I=G/Gas produced	J=H/Gas produced
100%	Paddy straw	11,550,000	4,950,000	1.5	0	12,375,000	0	62,126,250	49,751,250	37.65	30.15
	Animal dung	4,125,000	78,375,000	1.5	0	61,875,000	0	89,392,500	27,517,500	54.18	16.68
	Pressmud	8,250,000	33,000,000	1.5	0	30,937,500	0	39,892,500	8,955,000	24.18	5.43
	MSW	8,250,000	33,000,000	1.5	0	30,937,500	0	50,205,000	19,267,500	30.43	11.68

Cost economics of operational CBG plants at lower capacity utilisation

Since all the surveyed plants are operating at lower capacity utilisation, CSE researchers have analysed the scenarios and worked out the cost economics with plants operating at 75, 50 and 25 per cent capacity utilisation; this has been done considering both the off-take mechanisms — through pipeline and through cascades. For lower capacity utilisation, the feedstock requirement, operating cost etc have been revised accordingly.

The analysis in *Table 24* clearly shows that plants operating at reduced capacity utilisation and using the cascade mechanism for off-take have a lower profit margin compared to scenarios where a plant has access to gas pipeline infrastructure. The margin for plants with pipeline infrastructure increases by a minimum of 13 per cent when these plants are operational at **75 per cent** capacity.

When a plant is operating at **50 per cent** capacity utilisation, the net earnings per unit of gas — either with pipeline or cascade off-take — reduces significantly. For press mud-based plants, the net earnings are negative in both the off-take mechanisms. In cases where MSW is used, the plant earns 13 per cent more with direct pipeline as compared to cascade. Paddy straw-based plants at 50 per cent capacity utilisation are estimated to earn 30 per cent more on per unit of CBG when they have access to a direct pipeline.

Table 24: Cost economics of plants at different capacity utilisation (75, 50 and 25 per cent) with or without transportation cost of CBG

Capacity uti-lization	Major feedstock	Quantity of CBG produced	Sale of gas revenue	Operating cost	Without transport		With transport				
					Net earning	Net earnings/ unit gas	Cost of CBG off take<50 kms	Total operating cost	Net earning	Net earnings/ unit gas	Margin difference
		A	B= A X Rs.80/kg	C	D= B-C	E= D/ (A*1000)	F= 5*A* 1000	G= C+F	H=B-G	I= H/ (A*1000)	(E-I)/E
75%	Paddy straw	1,238	99,000,000	63,232,500	35,767,500	28.90	6,187,500	69,420,000	29,580,000	23.90	17%
	Animal dung	1,238	99,000,000	78,536,250	20,463,750	16.54	6,187,500	84,723,750	14,276,250	11.54	30%
	Pressmud	1,238	99,000,000	92,458,125	6,541,875	5.29	6,187,500	98,645,625	354,375	0.29	95%
	MSW	1,238	99,000,000	49,906,250	49,093,750	39.67	6,187,500	56,093,750	42,906,250	34.67	13%
50%	Paddy straw	825	66,000,000	52,466,250	13,533,750	16.40	4,125,000	56,591,250	9,408,750	11.40	30%
	Animal dung	825	66,000,000	60,840,000	5,160,000	6.25	4,125,000	64,965,000	1,035,000	1.25	80%
	Pressmud	825	66,000,000	70,121,250	(4,121,250)	(5.00)	4,125,000	74,246,250	(8,246,250)	(10.00)	
	MSW	825	66,000,000	34,437,500	31,562,500	38.26	4,125,000	38,562,500	27,437,500	33.26	13%
25%	Paddy straw	412.5	33,000,000	41,700,000	(8,700,000)	(21.09)	2,062,500	43,762,500	(10,762,500)	(26.09)	
	Animal dung	412.5	33,000,000	43,143,750	(10,143,750)	(24.59)	2,062,500	45,206,250	(12,206,250)	(29.59)	
	Pressmud	412.5	33,000,000	47,784,375	(14,784,375)	(35.84)	2,062,500	49,846,875	(16,846,875)	(40.84)	
	MSW	412.5	33,000,000	45,206,250	(12,206,250)	(29.59)	2,062,500	47,268,750	(14,268,750)	(34.59)	

For CBG plants operating at about **25 per cent** capacity utilisation, the loss on net earnings per unit of gas manufactured has been pegged at Rs 20-40. This is irrespective of the off-take mechanism and feedstock being used.

Cost economics of operational CBG plants at lower capacity utilisation and FOM/LFOM management

The scenarios enumerated below have been considered for FOM/LFOM utilisation and costing. The net margin per unit of gas has been estimated in two cases — one, involving sale of 50 per cent of the FOM/LFOM free of cost and two, availing 100 per cent subsidy on sale through the MDA scheme. *Table 25* evaluates the cost economics of biogas production using different feedstocks across three capacity utilisation levels: 75, 50 and 25 per cent). For each utilisation level, the analysis compares outcomes with MDA support (100 per cent MDA + 50 per cent free sale of gas) and without MDA (only free sale of gas). This comparison highlights the role of MDA in sustaining financial viability across feedstocks.

Paddy straw

At **75 per cent** capacity utilisation, paddy straw-based plants show a clear dependence on MDA support. Under the 100 per cent MDA + 50 per cent free sale scenario, net earnings are around Rs 38.8 million, with net earnings of about Rs 31 per unit of gas. In contrast, without MDA, net earnings decline to about Rs 29.6 million; the per unit earning falls to nearly Rs 24. While the project remains viable without MDA at this utilisation level, profitability is significantly lower.

At **50 per cent** utilisation, the difference becomes more pronounced. With MDA, net earnings are approximately Rs 15.59 million, whereas without MDA, net earnings reduce to about Rs 9.4 million. Net earnings per unit drop from about Rs 18.19 (with MDA) to Rs 11.4 (without MDA). This indicates that MDA plays an important role in maintaining reasonable margins at moderate utilisation.

At **25 per cent** utilisation, paddy straw-based plants incur losses in both the scenarios — to the tune of around Rs 7.66 million with MDA and about Rs 10.76 million without MDA. This shows that MDA support alone is insufficient to offset the impact of very low utilisation.

Animal dung

At **75 per cent** capacity utilisation, animal dung-based plants perform strongly with MDA. Net earnings under the 100 per cent MDA + 50 per cent free sale scenario are approximately Rs 60.68 million, with net earnings per unit exceeding Rs 49. Without MDA, the net earnings drop sharply to about Rs 14 million,

Table 25: Cost economics with different FOM/LFOM management scenarios (at diiferent capacity utilisation)

Capacity utilization	Major feedstock	Biodigestate generation		Costing of sale of FOM/LFOM under different Scenarios		Revenue under each scenario		Net earnings under different scenario		Net earnings per unit of gas	
		FOM	LFOM	sold free with MDA	Sale free of cost with no MDA	100% MDA on 50% sale free of cost	No MDA and sale free of cost	100% MDA+50% free sale	No MDA	100%MDA + 50% free sale	No MDA+ Free sale
		A	B	C	D= Rs.0	E= CX((A+B) /2)	F= DX((A+B)/ 2)	G= (Gas cost+E)- Optg cost	H= (Gas cost+F)- Optg cost	I=G/Gas produced	J=H/Gas produced
75%	Paddy straw	8,662,500	3,712,500	1.5	0	9,281,250	0	38,861,250	29,580,000	31.40	23.90
	Animal dung	3,093,750	58,781,250	1.5	0	46,406,250	0	60,682,500	14,276,250	49.04	11.54
	Pressmud	6,187,500	24,750,000	1.5	0	23,203,125	0	23,557,500	354,375	19.04	0.29
	MSW	6,187,500	24,750,000	1.5	0	23,203,125	0	66,109,375	42,906,250	53.42	34.67
50%	Paddy straw	5,775,000	2,475,000	1.5	0	6,187,500	0	15,596,250	9,408,750	18.90	11.40
	Animal dung	2,062,500	39,187,500	1.5	0	30,937,500	0	31,972,500	1,035,000	38.75	1.25
	Pressmud	4,125,000	16,500,000	1.5	0	15,468,750	0	7,222,500	(8,246,250)	8.75	(10.00)
	MSW	4,125,000	16,500,000	1.5	0	15,468,750	0	42,906,250	27,437,500	52.01	33.26
25%	Paddy straw	2,887,500	1,237,500	1.5	0	3,093,750	0	(7,668,750)	(10,762,500)	(18.59)	(26.09)
	Animal dung	1,031,250	19,593,750	1.5	0	15,468,750	0	3,262,500	(12,206,250)	7.91	(29.59)
	Pressmud	2,062,500	8,250,000	1.5	0	7,734,375	0	(9,112,500)	(16,846,875)	(22.09)	(40.84)
	MSW	2,062,500	8,250,000	1.5	0	7,734,375	0	(6,534,375)	(14,268,750)	(15.84)	(34.59)

and per-unit earnings reduce to Rs 11.5. This shows that a significant share of profitability at high utilisation is driven by MDA support.

At **50 per cent** utilisation, with MDA, net earnings remain positive at about Rs 31.97 million, while without MDA, the project remains just profitable at around Rs 1.03 million. Net earnings per unit decline to Rs 1.25 without MDA: this indicates MDA becomes critical once utilisation falls below optimal levels.

At **25 per cent** utilisation, loss is observed without MDA around Rs 12.2 million and add before- a profit of Rs 3.2 million with MDA, showing that MDA can be a game changer at low utilisation scenarios.

Press mud

At **75 per cent** capacity utilisation, press mud-based plants show limited profitability even with MDA. Net earnings under the 100 per cent MDA + 50 per cent free sale scenario stand at about Rs 23 million, with net earnings per unit close to Rs 19. Without MDA, net earnings turn negative at around Rs 0.3 million, indicating that press mud-based projects are not viable without policy support even at relatively high utilisation.

At **50 per cent** utilisation, the project is remains positive with MDA, with net earnings of about Rs 7.2 million, but incurs substantial losses of around Rs 8.2 million without MDA. This confirms that MDA is essential for sustaining press mud-based plants at moderate utilisation.

At **25 per cent** utilisation, losses deepen further, at around Rs 9.1 million with MDA and Rs 16.8 million without MDA, reinforcing the high vulnerability of press mud projects to both utilisation levels and withdrawal of support.

Municipal solid waste (**MSW**)

At **75 per cent** capacity utilisation, MSW-based plants show strong performance under the MDA-supported scenario. Net earnings are approximately Rs 66 million, with net earnings per unit exceeding Rs 53. Without MDA, net earnings decline to about Rs 43 million, and per unit earnings reduce to about Rs 34.6 — but the project remains viable.

At **50 per cent** utilisation, an MSW-based plant continues to perform relatively well. With MDA, net earnings are around Rs 42.9 million, compared to Rs 27.4 million without MDA. Although margins reduce without MDA, the project remains profitable due to steady feedstock availability and scale benefits.

At **25 per cent** utilisation, MSW-based plants tend to become unviable. Losses are around Rs 6.5 million with MDA and worsen to approximately Rs 14.26 million without MDA. This shows that even MSW as feedstock cannot absorb the impact of very low utilisation.

What is evident across all feedstocks and capacity utilisation levels is that 100 per cent MDA combined with partial free sale of gas can consistently improve financial outcomes. The impact of MDA is most critical at 50 per cent utilisation, where several feedstocks shift from losses to positive net earnings. However, at 25 per cent utilisation, none of the feedstocks remain viable even with MDA support except cow dung with MDA. This indicates that while MDA is an important policy instrument, high and sustained capacity utilisation remains the primary determinant of project viability.

7

A NATIONAL BLUEPRINT FOR THE CBG SECTOR

The CBG sector constitutes a critical part of India's efforts towards sustainable waste management and clean energy transition. But despite supportive policies, the sector is beset by unrealistic targets, weak state-level policy implementation, unreliable feedstock supply, and expensive imported technology.

CSE suggests a blueprint for growth using an integrated approach focusing on four key areas: realistic goal-setting with emphasis on operational efficiency; state-led policy support and alignment with national targets; reliable feedstock supply chains with infrastructure and long-term contracts; and indigenous technology development to reduce capital costs.

CSE also recommends a revision of the national targets. A realistic one, it suggests, would be to have at least 1,000 waste-based operational CBG plants by 2030, achieving more than 75 per cent average capacity utilisation. This adjustment would enable better monitoring, efficient use of resources and gradual scaling-up based on proven operational performance.

The CBG sector constitutes a critical part of India's broader efforts towards sustainable waste management and clean energy transition. The sector draws feedstock from multiple sources, including municipal solid waste collected from urban areas, agricultural residues such as paddy straw that are otherwise burnt, animal dung generated from rural and dairy sectors, and industrial by-products like press mud from sugar mills. Through this integrated approach, the CBG sector addresses two major challenges simultaneously — managing waste in an environmentally sound manner and reducing reliance on fossil fuels.

CBG, when purified and compressed, has properties similar to natural gas and can be used for transportation, industrial applications, and household energy needs. This makes it a viable substitute for imported natural gas, contributing to national energy security and helping lower greenhouse gas emissions.

The sector also offers a potential for local employment generation and supports the circular economy framework by turning organic waste into valuable energy and bio-manure. With the right policy and infrastructure support, the CBG sector can become a cornerstone in India's transition towards a low-carbon, resource-efficient economy.

CBG production potential based on feedstock availability

- **Animal dung:** India has about 193.46 million cattle and 109.85 million buffaloes[26], adding up to around 303 million animals. If each animal produces about 15 kg of dung a day, the total dung generation in the country amounts to nearly 1.66 billion tonne a year. Considering that about two per cent of this dung can be converted into CBG, India has the potential to produce around 33 MT of CBG every year from cattle and buffalo dung.

- **MSW:** Urban India generates around 55 million tonne[27] of municipal solid waste (MSW) every year, of which nearly 50-55 per cent is organic or biodegradable in nature. This means that about 27-30 million tonne of organic waste is produced annually in the country. If this organic fraction is processed scientifically for bioenergy recovery, it can serve as a valuable feedstock for CBG production. Considering a four per cent CBG yield factor, India has the potential to generate approximately 1.1 to 1.2 million tonne of CBG every year from organic municipal waste alone. Utilising this resource can help reduce landfill loads, lower methane emissions, and contribute to cleaner cities and sustainable energy generation.

- **Agriculture waste (paddy straw):** India generates about 122-125 million tonne of paddy straw every year. After excluding Kerala, Tamil Nadu and Karnataka — where paddy straw contains less silica and is commonly used as animal fodder — the total paddy straw generation from the rest of the country is estimated to be around 115 million tonne per year.[28] Considering a 10 per cent CBG yield factor, India has the potential to produce nearly 11.5 million tonnes of CBG annually from paddy straw alone. Effective utilisation of this resource can significantly reduce stubble burning, improve air quality, and strengthen the country's renewable energy supply.

- **Press mud:** In the 2023-24 sugar season, around 534 sugar mills[29] across India processed nearly 356 million tonne of sugarcane, generating an estimated 10.7 million tonne of press mud as a by-product. Press mud is a nutrient-rich organic residue that can be effectively utilised for CBG production. Considering a four per cent CBG yield factor, India has the potential to produce about 0.43 million tonne of CBG annually from this feedtsock. Utilising this waste stream for bioenergy can reduce the environmental burden of sugar industries, promote circular economy practices, and contribute to the country's clean energy transition.

Table 26: Estimated CBG production potential from major feedstocks in India

Feedstock type	Annual generation (million tonne)	Estimated CBG production (million tonne/year)	Remarks
Animal dung	1,660	33.0	Derived from 303 million animals; major rural feedstock source
Agricultural waste (paddy straw)	115	11.5	Excluding Kerala, Tamil Nadu and Karnataka; helps prevent stubble burning
Municipal solid waste (MSW — organic fraction)	27-30	1.1-1.2	Based on 50-55% organic content in total MSW
Press mud (from sugar mills)	10.7	0.43	By-product of sugar industry; potential for circular bioenergy use
Total (approx)	—	46*	Represents India's overall CBG potential from major organic feedstocks

Note: The analysis is based on complete utilisation of available feedstocks — 70-80 per cent potential can be tapped based on mapping of availability of feedstocks in different districts and collection efficiency.

Current status and the way ahead

Despite its significant potential, the sector faces considerable implementation challenges. Despite several supportive Central level policies, the sector is beset by unrealistic targets, weak state-level policy implementation, unreliable feedstock supply, and expensive imported technology. These issues collectively limit the scalability and sustainability of the sector. Currently, there are only 188 operational CBG plants in the country — a small fraction (12 per cent) of the 1,550 registered projects.

A critical priority is to revisit feedstock supply chain management for CBG units. The SATAT scheme has highlighted the promise of the sector as a dual solution: an effective pathway to manage the nation's waste issues while simultaneously boosting its clean energy supply. Therefore, it is essential to ensure the sector's growth is driven by genuine waste streams such as paddy straw and MSW. The first preference should be to utilise the potential of available waste streams. The sector should be provided with sufficient feedstock to avoid any divergence towards alternative energy crops, such as napier grass.

A robust path forward requires an integrated approach focusing on four key areas:

1. **Realistic goal-setting** with emphasis on operational efficiency
2. **State-led policy support** and alignment with national targets
3. **Reliable feedstock supply chains** with infrastructure and long-term contracts
4. **Indigenous technology development** to reduce capital costs

These measures will strengthen the CBG ecosystem, ensuring that future expansion is both technically viable and economically sustainable. A national blueprint for the sector in India, thus, would need to emphasise on these aspects: CSE has developed such a blueprint which stresses on the premise that waste streams should be utilised fully as feedstocks for manufacturing CBG.

Vision and mission: A review

The SATAT scheme set an ambitious goal of establishing **5,000 CBG plants producing 15 MT per year by 2030**. But the progress remains slow. A limited number of plants have been commissioned, and most are operating at **less than 50 per cent capacity utilisation**. This gap between targets and performance reflects overestimation of implementation capacity and under-preparation in terms of infrastructure, technology and feedstock availability.

To align ambition with feasibility, the government will need to **revise its targets** to ensure quality and operational efficiency rather than only numbers. A realistic

national target would be to have **at least 1,000 waste-based operational CBG plants by 2030**, achieving **more than 75 per cent average capacity utilisation**. This adjustment would enable better monitoring, efficient use of resources and gradual scaling-up based on proven operational performance.

THE BLUEPRINT

Introduce and set up a structured feedstock and supply chain management system, specifically for agri-residues and MSW.

The biggest operational challenge for CBG plants is inconsistent feedstock availability**.** CSE's state-level studies highlight that feedstock shortages have resulted in significantly low capacity utilisation in most plants.

The supply chain for organic waste, crop residues and other biomass remains fragmented. There is no formal mechanism for collection, transport or long-term storage of feedstock. As a result, plants face interruptions in production and escalation in procurement costs.

States should establish a structured feedstock management system to ensure continuous and cost-effective supply. The recommended key actions can include:

- Introducing **long-term feedstock supply agreements** between the CBG plants and suppliers, with price escalation clauses to ensure mutual security.

- Developing **standard operating procedures** (**SOPs**) for collection, transportation and storage of feedstock.

- Creating **biomass banks or feedstock storage hubs**, accessible on a user-charge basis to aggregators and manufacturers. This approach will stabilise input supply, improve plant performance and make the sector more financially sustainable.

- In the specific case of municipal solid waste, the segregation of waste has always been the major challenge; this remains to be addressed. There is a need to **strengthen waste segregation systems**. At present, the MSW-based plants have been able to ensure at least 50-60 per cent segregation at source; the rest is done manually or mechanically at the plant. As per the Union Ministry of Housing and Urban Affairs's (MoHUA) 2025 advisory on CBG plants based on MSW, ULBs must undertake a comprehensive assessment to identify the enablers as well as challenges and the economic and technical feasibility of setting up CBG plants in their jurisdictions.

Strengthen the state-level policy and regulatory framework.

While the Central government has issued multiple policy frameworks to promote CBG, implementation at the state level is inadequate. The sector faces challenges such as high operational costs (OPEX around 60-70 per cent), dependence on land and electricity access, and lack of state incentives. In comparison, solar and wind energy projects have lower maintenance costs and clearer policy support. Further, India's national target of five per cent CBG blending by FY 2028-29 lacks corresponding state-level production targets. In the central budget FY 2026-27, the central government has exempted biogas blended CNG from Central excise duty. This will give a boost to the CBG blending as it will encourage City Gas Distribution companies to blend more and more CBG in the mixture.

State governments must strengthen their policy and regulatory ecosystems to complement Central initiatives. The actions could focus on:

- Creating **state-level capital and operational support mechanisms** The Central Government by extending excise relief on biogas blended CNG has taken an important and forward-looking step which will encourage CBG blending and infrastructure development in the country. However, building on this initiative, a complementary action by State Governments would be critical—through exemption of VAT on the CBG portion of blended CNG—would further strengthen the CBG sector

- **Identifying and allocating land parcels** through dedicated land banks for CBG units

- **Defining state-specific production and blending targets** aligned with the national five per cent blending obligation. These measures would ensure a uniform approach, encourage investment and accelerate on-ground implementation.

Initiate capacity building and awareness exercises among stakeholders.

There is a need for capacity building and awareness/sensitisation workshops for all the stakeholders of the CBG sector, targeting both upstream stakeholders (farmers, feedstock suppliers) and downstream users (industries, CGD operators, the transport sector).

- **For employable humanpower development:** The sector needs trained and skilled humanpower. There is a need to build a pool of a trained human resources for handling and operating CBG plants. The Union Ministry of Skill

Development & Entrepreneurship can develop a training module and conduct capacity building trainings for different regions in association with respective labour departments.

- **For farmers:** Trainings can be conducted through NGOs, SHGs and Krishi Vigyan Kendras (KVKs) on dosage, application and long-term soil health benefits of FOM/LFOM. These programmes should highlight the success stories of application of FOM/LFOM in agricultural fields to encourage farmers to switch over to organic fertilisers from their chemical counterparts.

- **For industries:** A more specific training for the operating industries or for potential entrepreneurs is needed to provide an understanding of all the relevant policies, technologies economics, financing and troubleshooting aspects. Sector experts, industry associations or research organisations can be roped in to conduct such trainings.

Develop infrastructure and systems for market integration.

Availability of a gas grid for off-take of CBG as well as integration of the sector with the market for upscaling FOM/LFOM utilisation are important for sustainable operations of CBG units. The following action points can be considered:

- **Expand the city gas distribution (CGD) networks and put targets of CBG blending to each CGD**: The Union Ministry of Petroleum and Natural Gas (MoPNG) already has schemes in place for development of pipeline infrastructure (DPI) and CBG-CGD Synchronisation for facilitating CBG off-take. However, there is a need to synchronise CBG plants and their operations with the CGD pipeline infrastructure. Petroleum and Natural Gas Regulatory Board (PNGRB) is the authority to grant authorization to entities to lay, build, operate and expand Natural Gas Pipelines (NGPL). With the aim to increase the availability of natural gas across the Country, PNGRB has authorized approximately 34,233 km of NGPL network which include common carrier, spur line, tie-in connectivity and dedicated pipeline across the country to various entities, out of which 25,429 km have been made operational as on June 2025. 10,459 Kms length of pipelines is under various stages of construction.[30]

  The CSE survey highlights that only a handful of plants in the surveyed states have access to a gas grid — the rest are off-taking CBG through the more cost-intensive cascade method. State-level support for grid expansion near CBG clusters can provide a secure and scalable market.

Also, there has been cases where CGD companies are not ensuring full CBG off-take to its capacity and thus results in CBG plant running at a low capacity utilisation. PNGRB needs to regulate the CGD companies with blending targets to enure upscaling of CBG sector at state level. With proposed exemption in central excise duty in Union Budget 2026-27, CGD companies are expected to get encouraged and increase CBG blending in India and development of gas infrastructure.

- **Put the onus of enriching and marketing FOM/LFOM generated in CBG industries on fertiliser companies:** The Union Ministries of Fertilizer and of Agriculture and Farmers' Welfare can introduce an Organic Fertiliser Off-take Obligation (OFO), under which fertiliser companies must procure bio-manure from CBG plants for blending and distribution. This will ensure the quality of the manure meets FCO standards and the product is marketed through retail outlets of companies like IFFCO, KRIBHCO etc.

- **Establish a Soil Health Mission at the state level to increase uptake of FOM/LFOM:** Acidic soils are a significant problem in India; a CSE study[31] says that over 70 per cent of the country's soils are either acidic or alkaline. This acidification is caused by factors like the use of ammonium-based fertilisers, intensive farming and leaching, and results in reduced crop productivity.

  States can establish a dedicated Soil Health Mission for better utilisation of FOM/LFOM to improve soil health and regulate the pH. The state departments of agriculture and forests can be the concerned authorities for implementation and monitoring of this initiative, under which degraded soil patches can be identified and procurement and application of bio-digestates done on them.

- **Sensitise farmers for adoption of FOM/LFOM**: Short-term incentives should be given to farmers for first-time adoption of FOM/LFOM to break down their psychological barriers and reduce their dependence on chemical fertilisers. This, along with mandatory procurement by fertiliser manufacturing companies, will make bio-manure a reliable revenue stream for CBG plants.

Strengthen state nodal agencies for better coordination among different approving authorities and fast-tracking of clearances.

At present, there are a number of approvals required by CBG plants which are given by different authorities. The CSE survey found that there is no synchronisation in the approval mechanism, with one department seeking approvals from another. This leads to a long waiting time and confusion. There is a need to strengthen

state nodal agencies like the HAREDA, PEDA etc for assessment and review of permissions and approvals required, and better coordination for streamlining the process.

Develop state-level resource centres for handholding and monitoring of progress.

Monitoring, coordination and stakeholder support remain weak across most states. There is no centralised platform for progress tracking, troubleshooting or dissemination of best practices. The absence of such institutional support often leaves project developers isolated once approvals are received, with limited guidance on compliance, testing or technology adoption.

A dedicated **resource centre** should be established by the MoPNG in collaboration with state nodal agencies to act as a single interface for the CBG sector. The centre should monitor project implementation, track clearances and maintain regular reporting mechanisms. It should also handle grievances from registered plants and offer technical assistance on issues related to technology, standards and testing.

Periodic **capacity-building sessions** and **stakeholder meetings** should be organised at the state level to share developments, policy changes and success stories. The resource centre should act as both a support and learning hub — facilitating coordination, ensuring transparency and maintaining the momentum of sectoral growth.

Develop indigenous technologies and standards.

CBG technology remains largely import-dependent and cost-intensive, discouraging new entrants. The sector lacks standardised technical guidelines for plant design, machinery or cost benchmarks, leading to project delays and inconsistent quality. Entrepreneurs are often uncertain about technology choices suitable for different feedstocks. Moreover, the absence of domestic technology has pushed project costs higher, reducing economic feasibility.

There is an urgent need to develop indigenous CBG technologies and create a clear technical reference framework. The government should:

- Promote **R&D for cost-effective, feedstock-specific indigenous technology**
- Publish a **CBG Technology Handbook** with a detailed guidance on plant configurations, machinery standards and benchmark costs

- Encourage pilot projects using domestic technology for real-world validation. The Biofics CBG plant, based on municipal solid waste and indigenously developed technology, demonstrates this potential. The five-TPD plant cost about Rs 25 crore — almost half of what an imported system would require. The plant is successfully operating since October 2025.

To conclude, the success of India's CBG programme depends not only on infrastructure and investment but also on the strength of institutions, stakeholder awareness and market integration. Building skilled humanpower, expanding gas grid connectivity, establishing market linkages for bio-manure, simplifying approvals, and developing state-level support structures will create the necessary foundation for sustainable growth of the sector. An integrated approach combining capacity building, policy coordination and market development will ensure that the CBG initiative achieves both environmental and economic outcomes effectively.

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The compressed biogas (CBG) sector constitutes a critical part of India's efforts towards sustainable waste management and clean energy transition. But despite supportive policies, the sector faces concerns such as unrealistic targets, weak policy implementation at the state level, unreliable feedstock supply and expensive imported technology.

This book, based on a comprehensive survey and sectoral analysis done by experts from Centre for Science and Environment's Renewable Energy Unit, presents a **blueprint for growth** for the sector, using an integrated approach; it also recommends a revision of the national targets. The book, thus, is an excellent guide and reference manual for policymakers, regulators, the entire CBG industry, and anyone else interested in this sector.

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