

Compressed Biogas in India – A Case Study

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Abstract—It is acknowledged that energy is the key input for any nation's socio-economic development. Rapid industrialization and urbanization, as well as mechanized farming, have generated a high demand for energy in all forms, including thermal, mechanical, and electrical. To meet this increasing demand, fossil fuels such as coal, oil, and natural gas have been overexploited in an unsustainable manner. The overexploitation of fossil fuels has been posing serious environmental problems, including global warming and climate change. While there is a shortage of energy and a dependence on imports in the case of petroleum, the country is fortunate to have an abundance of natural sources of energy, including solar, wind, biomass, and hydro. These sources are environmentally benign and non-depleting in nature, and are available in most parts of the country throughout the year. Biogas resources, such as cattle dung, agricultural wastes, and other organic wastes, have been one of the main energy sources for mankind since the dawn of civilization. There is a vast scope to convert this waste to energy sources like biogas. Biogas production is a clean, low-carbon technology for efficient management and conversion of organic wastes into clean, renewable biogas and organic manure/fertilizer. Biogas obtained by anaerobic digestion of cattle dung and other loose and leafy organic matters/bio degradable wastes can be used as an energy source for various applications, including cooking, heating, space cooling/refrigeration, electricity generation, and gaseous fuel for vehicular application.

Index Terms—Compressed biogas, India, Waste management, Biogas Plant

I. INTRODUCTION

The importance of energy for socio-economic development cannot be overstated. As the world grapples with the challenges of climate change, environmental degradation, and energy security, it has become imperative to explore alternative energy sources that are sustainable, renewable, and environmentally benign.

Biogas production has emerged as a promising solution. Biogas is a clean-burning fuel that can be

produced from organic waste materials such as cattle dung, agricultural waste, and other biomass resources. The production of biogas involves the anaerobic digestion of these organic materials, resulting in the release of methane gas, which can be used as a fuel for various applications.

The potential for biogas production in India is vast. With a large agricultural sector and a significant livestock population, the country generates enormous amounts of organic waste that can be converted into biogas. According to estimates, India has the potential to generate approximately 18,240 million cubic meters of biogas annually from cattle dung alone.

Based on the availability of cattle dung alone from approximately 304 million cattle, there exists an estimated potential of approximately 18,240 million cubic meters of biogas generation annually. The increasing number of poultry farms is another source, and can generate biogas of 2173 million cubic meters annually with 649 million numbers of birds. Non-edible de-oiled cake from *Jatropha* and other plants also has a significant potential.

- India is expected to experience the **greatest rise in energy demand** compared to any other country
- India's demand for oil and gas is anticipated to triple by 2050, with **gas consumption** growing **threefold by 2030**
- About **46% of the CNG** used in India is presently **imported**
- **Bioenergy** is an energy source that **derives from organic matter** present in plants or other organic waste
- According to IEA's energy analysts, **bioenergy is projected to account for 18% of the total energy supply in 2050**

In addition to gaseous fuel, biogas plants also provide high-quality organic manure with soil nutrients, which improves soil fertility required for sustainable production and improving productivity. Thus, there is a huge potential for the installation of medium-sized biogas plants in the country. The potential can be translated into an aggregated estimated capacity of 8165 MW per day power generation or 22,06,789 LPG

cylinders and 21304 lakh kg of urea equivalent or 3974 lakh tons of organic manure/fertilizer per day.

In addition to cattle dung, other organic waste materials such as agricultural waste, poultry waste, and municipal solid waste can also be used for biogas production. The use of these waste materials for biogas production can help reduce the environmental impacts associated with their disposal, such as methane emissions, water pollution, and soil degradation.

1. Biogas production also offers several benefits for rural development. Biogas plants can provide a reliable source of energy for rural households, reducing their dependence on fossil fuels and mitigating the impacts of energy poverty. Biogas can also be used for powering irrigation pumps, reducing the energy costs associated with agricultural production.
2. Biogas production can help promote sustainable agriculture practices. The slurry generated from biogas plants can be used as a natural fertilizer, reducing the need for chemical fertilizers and promoting soil health. This can help improve crop yields, reduce soil erosion, and promote biodiversity.
3. Biogas production offers a promising solution for India's energy needs, while also promoting sustainable agriculture practices, reducing waste, and mitigating the impacts of climate change. With its vast potential for biogas production, India can reduce its dependence on fossil fuels, promote rural development, and contribute to a more sustainable future.
4. Biogas production can improve public health by reducing the reliance on traditional biomass fuels, such as firewood and dung cakes, which are major sources of indoor air pollution. Biogas is a clean-burning fuel that produces minimal emissions, reducing the risk of respiratory diseases and other health problems associated with indoor air pollution.
5. Biogas production can help mitigate climate change by reducing greenhouse gas emissions. The anaerobic digestion process involved in biogas production captures methane emissions that would otherwise be released into the atmosphere, contributing to global warming. By utilizing biogas as a fuel, we can reduce our reliance on fossil fuels and lower our carbon footprint.

II. BIO GAS IN INDIA

The government's primary objectives for starting the CBG program are to reduce dependence on fossil fuels, enhance farmers' income, promote rural employment, and mitigate climate change. By promoting the use of CBG, India can decrease its reliance on imported crude oil and natural gas, providing an additional revenue source for farmers and generating employment opportunities in rural areas. The potential of biogas production in India is vast, and its benefits extend beyond the individual level to contribute to the country's sustainable development goals. Biogas production can help reduce India's dependence on imported fossil fuels, improving the country's energy security and reducing the impact of price volatility.

The Indian government's primary objectives for launching the Compressed Biogas (CBG) program are multifaceted.

1. It aims to reduce dependence on fossil fuels by promoting the use of CBG as a clean and renewable energy source. This move is expected to decrease India's reliance on imported crude oil and natural gas, thereby enhancing energy security. By diversifying the energy mix and introducing a new, renewable energy source, the CBG program helps reduce crude oil imports, saving foreign exchange.
2. Another key objective is to enhance farmers' income by providing them with an additional revenue stream. The CBG program utilizes agricultural waste and cattle dung to produce biogas, which can be sold to farmers, providing them with a new source of income. This not only helps farmers financially but also promotes sustainable waste management practices. Improved livelihoods and increased income for farmers are direct outcomes of this program.
3. The CBG program also aims to promote rural employment by generating jobs in plant operation, waste collection, and transportation. This stimulates rural economic growth by creating new industries and businesses related to biogas production. Skill development in rural areas, particularly in biogas plant operation and maintenance, is another benefit of this program.
4. CBG program also aims to mitigate climate change by reducing greenhouse gas emissions. The use of

CBG decreases carbon emissions from fossil fuels, contributing to a cleaner environment. Sustainable waste management practices are also promoted through this program, which utilizes agricultural waste and cattle dung to produce biogas. By addressing multiple challenges, including energy security, rural development, and climate change, the CBG program is a strategic initiative that can help India move towards a more sustainable and environmentally friendly future.

5. Biogas production can also help address the issue of waste management in India. The country generates enormous amounts of organic waste, including agricultural waste, food waste, and human waste. Biogas production can provide a sustainable solution for managing this waste, reducing the environmental impacts associated with its disposal.

Thus, the Government of India has recognized the potential of biogas production and has initiated various programs to promote its adoption.

1. The National Biogas and Manure Management Programme (NBMMP) is one such initiative, which aims to promote the use of biogas as a fuel and fertilizer. The program provides subsidies and technical support to farmers and rural households to set up biogas plants. The government has also set targets to increase biogas production in the country, aiming to generate 15,000 million cubic meters of biogas by 2025. The program has several objectives, including promoting biogas as a clean and renewable energy source, encouraging efficient management of manure and other organic waste.

The NBMMP consists of several components, including biogas production, manure management, and capacity building. The program promotes the production of biogas through the anaerobic digestion of organic waste, such as cattle dung, agricultural waste, and kitchen waste. It also encourages the efficient management of manure, including its collection, storage, and utilization as a fertilizer. Furthermore, the program provides training and capacity-building support to farmers, rural households, and other stakeholders on biogas production, manure management, and related technologies. The use of biogas slurry as a fertilizer

can also increase agricultural productivity and reduce the use of chemical fertilizers.

The NBMMP is implemented by the Ministry of New and Renewable Energy (MNRE) at the national level, with state nodal agencies responsible

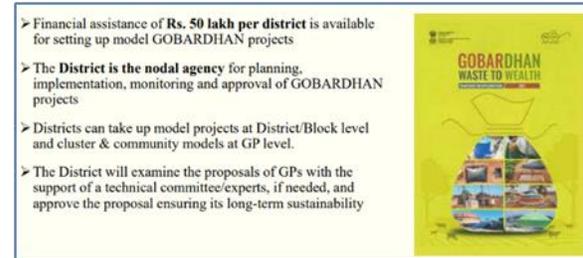


Figure 1 -- GOBARDHAN Yojana highlights for implementation at the state level. The program is also implemented at the district level through district nodal agencies and other stakeholders. The central government provides financial support to the program, with state governments and the private sector also contributing to the funding.

The NBMMP has had a significant impact on the country, with an increase in biogas production, improved waste management, and increased agricultural productivity. The program has also improved the livelihoods of rural households and farmers by providing them with a clean and reliable source of energy. Overall, the NBMMP is a crucial initiative that promotes sustainable development, reduces dependence on fossil fuels, and mitigates climate change.

2. GOBARDhan Yojana is a government initiative in India that aims to promote the use of cattle dung and other organic waste to produce biogas, bio-fertilizers, and other valuable products. The program has several objectives, including promoting the use of cattle dung and other organic waste, reducing the environmental impacts of these waste materials, improving the livelihoods of rural households and farmers, and promoting sustainable agriculture practices.

The Ministry of Animal Husbandry and Dairying is the nodal ministry for the implementation of the GOBARDhan Yojana. State governments are responsible for the implementation of the program at the state level, while district nodal agencies and other stakeholders are responsible for implementation at the district level. The program is funded by the central

government, state governments, and the private sector through public-private partnerships.

The GOBARdhan Yojana has had a significant impact on the country, with an increase in biogas production, improved livelihoods, and sustainable agriculture practices. The program has also reduced the environmental impacts of cattle dung and other organic waste. Overall, the GOBARdhan Yojana is a crucial initiative that promotes sustainable development, reduces dependence on fossil fuels, and mitigates climate change.

3. The SATAT (Sustainable Alternative Towards Affordable Transportation) scheme is a government initiative in India that aims to promote the use of Compressed Biogas (CBG) as a clean and renewable energy source for transportation. The scheme has several objectives, including promoting the use of CBG as a clean and renewable energy source, reducing dependence on fossil fuels, mitigating climate change, improving air quality, and creating new employment opportunities in the CBG sector.

The SATAT scheme plans to produce 15 million

- SATAT' scheme encourages entrepreneurs to set up CBG plants, produce & supply CBG to Oil Marketing Companies (OMCs) for sale as automotive & industrial fuels
- Provide assurance for CBG Off-take at fixed prices








Figure 3 -- SATAT scheme picks

tonnes of CBG per annum by 2023, and set up 5,000 CBG plants across India in a phased manner. The CBG plants will use agricultural waste, cattle dung, and municipal solid waste as raw materials. The scheme provides financial incentives to entrepreneurs for setting up CBG plants, and aims to create a viable alternative to fossil fuels for transportation.

The SATAT scheme offers several benefits, including the promotion of renewable energy, improved air quality, new employment opportunities, and sustainable waste management. CBG is a renewable energy source that can reduce dependence on fossil fuels and mitigate climate change. The scheme can also improve air quality by reducing greenhouse gas emissions and other pollutants. Additionally, the scheme can create new employment opportunities in the CBG sector, and help manage agricultural waste, cattle dung, and municipal solid waste in a sustainable manner.

The Ministry of Petroleum and Natural Gas is the nodal ministry for the implementation of the SATAT scheme. Oil marketing companies such as Indian Oil Corporation, Hindustan Petroleum Corporation, and Bharat Petroleum Corporation are responsible for the implementation of the scheme. State governments are also involved in the implementation of the scheme.

No	Composition	Biogas	Bio-CNG/CBG
1	Methane	55-65%	>90%
2	Carbon Dioxide	30-40%	<4%
3	Hydrogen Sulfide	0.1-4%	<16 ppm
4	Nitrogen	3%	<0.5%
5	Oxygen	0.1-2%	<0.5%
6	Moisture	1-2%	0%
7	Calorific Value	19.5 MJ/kg	47-52 MJ/kg

Figure 2 -- Composition of Biogas

The central government provides financial support to the scheme, and oil marketing companies also provide financial support. The private sector is also involved in the implementation of the scheme through public-private partnerships.

III. COMPOSITION OF BIO GAS

Biogas is comprised of 60-65% methane, 35-40% carbon dioxide, 0.5-1.0% hydrogen sulphide, and rest is made up of water vapors, etc. It has been noted that biogas is almost 20% lighter than air.

It has been observed that biogas, similar to Liquefied Petroleum Gas (LPG), cannot be converted into a liquid state under normal temperature and pressure. The removal of carbon dioxide, hydrogen sulphide, moisture, and compression into cylinders is done to

make it easily usable for transport applications and stationary applications.

CNG technology has become readily available, and therefore, bio-methane (enriched biogas), which is nearly the same as CNG, can be used for all applications for which CNG is used. It has been noted that purified/enriched biogas (bio-methane) has a high calorific value compared to raw biogas.

During the year 2008-09, a new initiative was taken for demonstration of an Integrated Technology-package, in entrepreneurial mode, for installation of medium-size mixed feed biogas fertilizer plants (BGFP) for generation, purification/enrichment, bottling, and piped distribution of biogas under the RDD&D policy of MNRE.

The installation of such plants aims at the production of CNG-quality Compressed Biogas (CBG) to be used

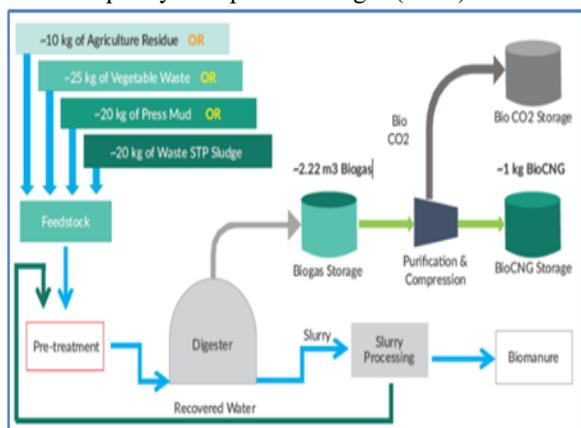


Figure 3 -- Bio gas production flow diagram

as vehicular fuel, in addition to meeting stationary and motive power and electricity generation needs in a decentralized manner through the establishment of a sustainable business model in this sector.

A huge potential for the installation of medium-size biogas-fertilizer plants in various villages and other areas and agro/food processing industries of the country has been identified. Under the demonstration phase, central financial assistance has been provided by the Ministry for a limited number of such projects for implementation following an entrepreneurial mode.

The main components of Compressed Biogas (CBG) Bottling Projects (BGFP) are identified as follows:

1. Pre-treatment system
2. Biogas generation system

3. Biogas storage system
4. Biogas purification system
5. Biogas bottling system
6. Slurry handling system

The first Biogas Bottling Project, with a capacity of 500 m³/day, was sanctioned to Ashoka Biogreen Pvt. Ltd. and commissioned on 16.03.2011 at Vill. - Talwade, Dist.-Nashik (Maharashtra). A license for filling and storage of compressed biogas in CNG cylinders was obtained from the Petroleum & Explosives Safety Organization (PESO).

The second Biogas Bottling Project, with a capacity of 600 m³/day, was sanctioned by the Ministry of New and Renewable Energy (MNRE) to Anand Energy at Vill. - Kalatibba, Teh.- Abohar, Dist.- Ferozepur (Punjab) during the year 2009-10, with a Central Financial Assistance (CFA) of Rs. 45.50 lakh. The project was commissioned on 17.11.2011 after obtaining the necessary license from PESO.

It is noted that both projects have been successfully

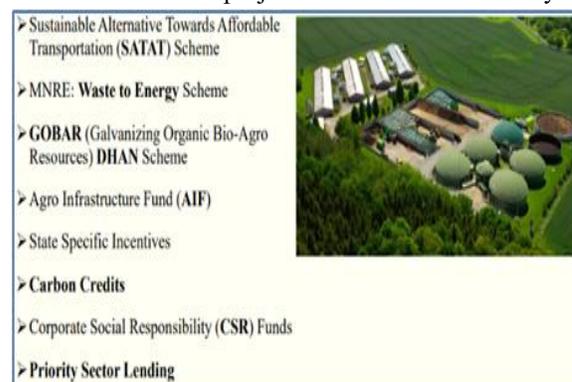


Figure 4 -- Policies & Financial Assistance Related to CBG

commissioned and are operating efficiently. The implementation of these projects has demonstrated the feasibility of biogas bottling technology in India and has paved the way for further development and deployment of this technology in the country.

The success of these projects is attributed to the support provided by the MNRE and the efforts of the project developers, Ashoka Biogreen Pvt. Ltd. and Anand Energy. The commissioning of these projects marks a significant milestone in the development of biogas bottling technology in India and is expected to contribute to the growth of the renewable energy sector in the country.

IV. CHALLENGES IN BIOCNG INDUSTRY

The Bio-CNG industry in India faces several challenges that hinder its growth and development.

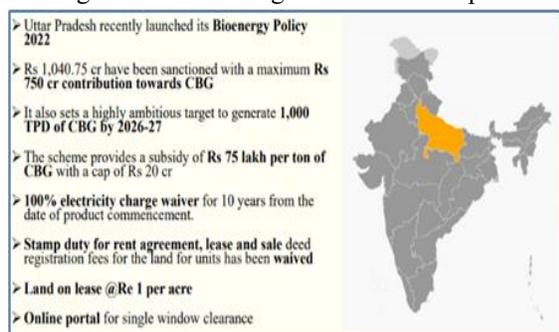


Figure 5-- State specific initiative

One of the major challenges is the uncertainty of long-term regular supply of feedstock. Bio-CNG projects require a consistent supply of organic waste, such as agricultural waste, municipal solid waste, or sewage sludge. However, feedstock availability can vary significantly depending on the season, weather conditions, and agricultural practices. This uncertainty can affect the viability of Bio-CNG projects.

Another challenge is the importance of source segregation, which is crucial for Bio-CNG production. Effective source segregation of organic waste from non-organic waste is essential to produce high-quality biogas. However, receiving non-segregated waste can lead to contamination risks, which can affect the quality of the biogas produced and the overall efficiency of the project.

Financing is another major challenge facing Bio-CNG projects. Private sector banks are hesitant to finance Bio-CNG projects due to limited understanding of the technology and perceived risks. Even when financing is available, the cost of debt is often high, making it challenging for project developers to achieve viable returns on investment.

Industrial Sector	Category	Pollution Index Score
CBG plants based on municipal solid waste	Orange	41-59
CBG plants based on process waste (industrial waste, press mud, molasses, organic sludge)	Orange	41-59
CBG plants based on crop residue (paddy straw, wheat straw, corn sweet sorghum, nappier grass)	Green	21-40
CBG plants based on animal waste (dairy farms, poultry farms, other animal waste)	Green	21-40
CBG plants (irrespective of the type of feed) producing FOM and LFOM and not discharging any wastewater	White	<20

Projects under the category of "WHITE", which is practically non-polluting, will not require either Environmental Clearance under Environment (Protection) Act, 1986 or Consent under Air (Prevention and Control of Pollution) Act, 1981 and Water (Prevention and Control of Pollution) Act, 1974.

Figure 6 --Pollution category of CBG Plant

The lack of access to infrastructure is another significant challenge. Bio-CNG projects require access to a reliable road network for feedstock transportation and a compressed natural gas (CNG) distribution network for biogas off-take. However, in many areas, especially rural regions, the road network and CNG distribution infrastructure may be limited or non-existent.

The year-on-year variation in feedstock price is another challenge that affects the viability of Bio-CNG projects. The price of feedstock can vary significantly from year to year, affecting the project's revenue streams. The absence of an established feedstock pricing mechanism makes it challenging for project developers to negotiate fair prices with feedstock suppliers.

Furthermore, the poor marketability and lack of fixed price for off-take of biogas fertilizer are significant challenges. The biogas fertilizer produced as a by-product of Bio-CNG production may have limited marketability due to lack of awareness, limited demand, or competition from other fertilizers. The absence of a fixed price for biogas fertilizer makes it challenging for project developers to negotiate fair prices with off-takers.

Finally, the lack of a single window for a large set of approvals is a regulatory challenge that affects the development of Bio-CNG projects. Bio-CNG projects require multiple approvals from various regulatory agencies, which can be time-consuming and challenging to navigate. The absence of a single window for approvals can lead to delays and increased costs for project developers.

V. CONCLUSION

India's growing energy demand necessitates the exploration of alternative energy sources to reduce dependence on imported fossil fuels. Bio-gas/CBG emerges as a promising solution, offering a cleaner, sustainable, and domestically produced fuel option. By promoting CBG as a substitute fuel for various applications, India can decrease its reliance on imported LPG, mitigate climate change, and promote sustainable energy development. The government can support this transition through tax incentives, subsidies, infrastructure development, and awareness campaigns. Ultimately, adopting CBG as a substitute fuel will contribute to India's energy security,

economic growth, and environmental sustainability, paving the way for a cleaner and greener future.

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