India

Neutral *(no change)*

Agribusiness

Biogas: Energy freedom, social development

- Efficient utilization of biogas potential can offset national emissions.
- Biogas can help raise rural incomes by at least 4.5% and eliminate the need to import natural gas.
- Napier grass-biogas is a better automotive fuel than ethanol.

Biogas is a proven technology which is now being pushed by govt

Biogas plants have been around since the 19th century. India's Ministry of Petroleum and Natural gas has set an aggressive target of setting up 5,000 compressed biogas plants and annual production of 15mmt by FY23F-24F. Currently, there are only 180 biogas projects operational in India. Of these, only 12 produce compressed biogas.

Biogas, a versatile material, can also be used for hydrogen output

Biogas can be used to replace natural gas; produce electricity and hydrogen. The byproducts from natural gas production can also be used as fertilizers. According to our calculations, on a national scale, the efficient use of ready biogas feedstock can replace entire natural gas consumption and generate **27% more electricity**. The hydrogen production potential is approximately 36mmt (National Hydrogen Mission's target is 5mmt by 2030F). Fertilizer from byproducts can replace approximately 20% of national chemical fertilizer consumption.

Production cost of biogas largely driven by feedstock cost

Analyzing the cost breakup of biogas plants, we observed that the cost of biogas production is largely driven by the cost of feedstock.

Carbon credit generation

The dung-to-biogas plants can generate 7.15 carbon credits annually per animal. This means a considerable amount of revenue can be obtained through the sale of carbon credits. On a national scale, it is possible to offset **82% of carbon emissions** through dung-to-biogas plants.

Great scope for sustainable development in rural areas

As biogas plants can use agricultural waste, there is a great scope for the sale of fresh waste products at the village level because the use of aggregators as middlemen would raise feedstock cost too much. Thus, the livestock and farm-owners can benefit much more. Biogas plants also achieve a profitable scale very early; thus, a very large investment-plant would generate worst returns when compared with small-scale plants

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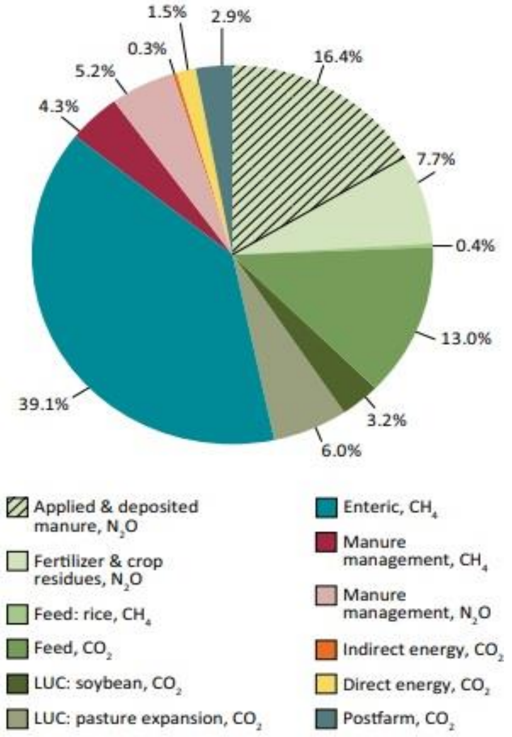
Introduction to biogas and why it's important for the environment

Climate impact of livestock industry necessitates the use of biogas

Cows and other farm animals produce around 14% of human-induced climate emissions. In fact, cattle are the largest source of greenhouse gas emissions globally. Most human-induced methane emissions globally come from cattle. While methane has a shorter life in the atmosphere as compared to carbon dioxide, it is 28 times more potent. Thus, abatement of methane emissions is an important priority for agricultural industries.

Figure 1: Breakup of farm emissions



THIS GRAPHIC FROM FAO.ORG SHOWS THE BREAKUP OF GREENHOUSE GAS EMISSIONS FROM THE LIVESTOCK INDUSTRY

SOURCE: FAO.ORG, INCRED RESEARCH, COMPANY REPORTS

As we can see from the chart above, methane emissions from the cattle's digestive tract account for 40% of the livestock industry's carbon emissions.

It is precisely due to this climate impact that it's necessary for us to ensure that all methane is turned into carbon dioxide before being released into the atmosphere.

How long have we been using biogas?

The first digestion plant was built at a leper colony in Mumbai (erstwhile Bombay) in 1859. In 1895, biogas was recovered from a "carefully designed" sewage treatment facility and used to fuel street lamps in Exeter.

How the system works

When organic matter from plants and animals in the form of food waste or faeces is left to decompose in the open air, it makes carbon dioxide and a small quantity of methane.

However, when there is no fresh air and hence, no oxygen, the gas produced is a combination of methane, carbon dioxide, water vapour and hydrogen sulfide with methane being produced in the largest amount. In a biogas plant, to maximize the amount of gas produced in a shorter time, the feedstock is often processed into smaller pieces if its dry and mixed with an equal quantity of water to aid digestion and biogas production.

Figure 2: Biogas production and methane content from various feedstocks

Average maximum biogas production from different feed stocks

Sl. No.	Feed Stock	Litre /kg of dry matter	% Methane content
1.	Dung	350*	60
2.	Night-soil	400	65
3.	Poultry manure	440	65
4.	Dry leaf	450	44
5.	Sugar cane Trash	750	45
6.	Maize straw	800	46
7.	Straw Powder	930	46

SOURCE: VIKASPEDIA.IN, INCRED RESEARCH, COMPANY REPORTS

As we can see, depending on the feedstock used, the quantity of biogas produced and its methane content varies by a significant margin.

Figure 3: Nutrient status of biogas slurry

Nutrient status of Biogas slurry

	N	P_2O_5	K_2O
Bio-gas slurry	1.4	1.0	0.8
Farm Yard Manure (FYM)	0.5	0.2	0.5
Town Compost	1.5	1.0	1.5

SOURCE: VIKASPEDIA.IN, INCRED RESEARCH, COMPANY REPORTS

The leftover slurry is often rich in nutrients and can be used as a fertilizer as well.

Indian government is pushing biogas production

Current biogas production ➤

Currently, most biogas projects focus on electricity generation.

Figure 4: Current biogas projects

S.No.	Type of Project	Aggregated Capacity	Number of Projects
1	MSW power plants	65.7 MW	6 projects
2	Grid power projects in industries	71.8 MW	18 projects
3	Captive off-grid projects	111.4 MW	70 projects
4	Biogas for captive thermal	About 6 lakh m3/day	74 projects
5	BioCNG projects	46 tonnes/day	12 projects

SOURCE: GOOGLE, INCRED RESEARCH, COMPANY REPORTS

Government has started pushing biogas production ➤

Earlier, the government only provided subsidy for small biogas plants at the household level. Now, it is also pushing bio-CNG production as an automotive fuel through the following schemes:

- The Ministry of New and Renewable Energy is implementing the Waste to Energy (WTE) Programme under the umbrella of the National Bioenergy Programme. The WTE Programme has a budget outlay of Rs6bn for the period FY 2021-22 to FY 2025-26. This programme, inter alia, supports the setting up of plants for generation of bio-CNG from urban, industrial and agricultural waste by providing central financial assistance (CFA).
- The Ministry of Petroleum and Natural Gas, under the Sustainable Alternative Towards Affordable Transportation (SATAT) initiative, envisages setting up of 5,000 bio-CNG plants with a production target of 15mmt of bio-CNG by 2023F-

24F. The SATAT initiative encourages entrepreneurs to set up bio-CNG plants and produce & supply bio-CNG to oil marketing companies (OMCs) for sale as automotive fuels.

- The Department of Drinking Water and Sanitation (DDWS) launched the Galvanizing Organic Bio-Agro Resources Dhan (GOBAR-DHAN) scheme in 2018. Gobardhan is an integral part of the Swachh Bharat Mission Phase-II or SBM (G) under Solid Waste Management. The operational guidelines of Phase-II of SBM(G) provide for financial assistance up to Rs5m per district for the period 2020-21 to 2024-25 for setting up of cluster/community-level biogas plants.
- Concession is available on customs duty for the import of machinery and components required for initial setting up of projects for generation of power and bio-CNG from non-conventional materials.
- Bio-CNG/compressed biogas has been included under priority sector lending.
- Eight Biogas Development and Training Centres (BDTCs) have been established at India's premier Institutions to provide technical assistance, R & D, testing and validation of new biogas models/designs, field inspections of biogas plants, and training and skill development.
- The Ministry of Road Transport and Highways amended the Central Motor Vehicles Rules, 1989 in Jun 2015 and included the provisions for usage in motor vehicles bio-CNG produced from waste (including Municipal Solid Waste, MSW).
- The National Policy on Biofuels-2018 promotes the production of bio-CNG and other biofuels.

National potential

Biogas generation

For the purposes of our analysis, we assume that all sewage, such as dung from farm animals and food & farm waste is used to produce biogas.

Figure 5: National water consumption

		Annual waste material generation		water needed (in tonne or t)
Sewage	Human population	20,44,00,00,000.00	kg	2,04,40,000.00
Livestock	Crossbred/exotic cattle	3,68,06,60,00,000.00	kg	36,80,66,000.00
	Indigenous cattle	7,78,05,22,50,000.00	kg	77,80,52,250.00
	Buffalo	8,01,90,50,00,000.00	kg	80,19,05,000.00
	Pigs	16,53,45,00,000.00	kg	1,65,34,500.00
Waste	Farm waste	5,00,00,00,00,000.00	kg	50,00,00,000.00
	Food waste	7,00,00,00,000.00	kg	70,00,000.00
			Total	2,49,19,97,750.00
			India's estimated water demand	8,13,50,00,00,000.00
			Biogas plant water demand as %age of national water demand	0.31%

SOURCE: GOOGLE, VIKASPEDIA.IN, INCRED RESEARCH, COMPANY REPORTS

Thus, we see that the amount of water needed to run biogas plants is only another 0.31% of national water demand and hence, there wouldn't be a water shortage due to biogas plants.

Electricity generation and natural gas substitution potential

Figure 6: National biogas to electricity potential

		daily production of biogas (in cubic meter)	Methane content	Annual methane production (in bcm)
Sewage	Human population	25,59,200.00	65%	0.61
Livestock	Crossbred/exotic Cattle	4,03,36,000.00	60%	8.83
	Indigenous cattle	8,52,66,000.00	60%	18.67
	Buffalo	8,78,80,000.00	60%	19.25
	Pigs	18,12,000.00	60%	0.40
Waste	Farm waste	82,19,17,808.22	45%	135.00
	Food waste	76,71,232.88	70%	1.96
		1,04,74,42,241.10		184.72
			2020 natural gas import	33.9
			Approx. India's natural gas consumption	67.8
			Methane leftover available for electricity	116.92
			Electricity from biogas methane @38% efficiency in TWh	441.94
			India's 2019 electricity production	1,598.00
			%age rise in electricity production	27.66%

SOURCE: GOOGLE, VIKASPEDIA.IN, INCRED RESEARCH, COMPANY REPORTS

Please note that we have assumed a relatively low electricity efficiency of 38%. This is because biogas is being turned into electricity at small-scale plants and not gas-fired thermal power plants. Thus, the generators used would be of an inferior quality. But, despite that, 27.66% extra electricity is generated. It's also noteworthy that this would be baseload power as we can generate biogas and burn it in a generator 24 hours a day. Another important point is that India's entire natural gas consumption has been replaced by biogas.

Fertilizer production potential

In the biogas production process, we generate by-products too. The first is biogas and the second is leftover slurry, which is also called digestate. This material comprises around 80% water and the rest may be used as an organic fertilizer.

Figure 7: Fertilizer production potential

		Daily production of biogas in cubic metre	Methane content	Annual fertilizer production in mt
Sewage	Human population	25,59,200.00	65%	3.84
Livestock	Crossbred/exotic cattle	4,03,36,000.00	60%	69.09
	Indigenous cattle	8,52,66,000.00	60%	146.04
	Buffaloes	8,78,80,000.00	60%	150.52
	Pigs	18,12,000.00	60%	3.10
Waste	Farm waste	82,19,17,808.22	45%	93.85
	Food waste	76,71,232.88	70%	1.31
	total	1,04,74,42,241.10		467.75
			Arable land area (in m ha)	155.369
			Organic fertilizer production/arable land	3.010.561809
			2020 fertilizer consumption/arable land	209.4

SOURCE: GOOGLE, VIKASPEDIA, INCRED RESEARCH, COMPANY REPORTS

As we can see, the organic fertilizer produced is 14 times the amount of fertilizer the country consumes. This organic fertilizer not only boosts the fertility of the soil but also helps ensure its longevity.

Figure 8: Nutrient status

		Daily production of biogas (in cubic metre)	Slurry production (in mt)		Nutrients (in mt) N content	P content	K content
Sewage	Human population	25,59,200.00	18.16		0.032	0.010	0.015
Livestock	Crossbred/exotic cattle	4,03,36,000.00	345.50		0.617	0.194	0.292
	Indigenous cattle	8,52,66,000.00	730.35		1.303	0.410	0.618
	Buffaloes	8,78,80,000.00	752.74		1.343	0.422	0.637
	Pigs	18,12,000.00	14.69		0.026	0.008	0.012
Waste	Farm waste	82,19,17,808.22	444.11		0.793	0.249	0.376
	Food waste	76,71,232.88	6.22		0.011	0.003	0.005
	Total	1,04,74,42,241.10	2,311.76	Total	4.125	1.297	1.957
		Arable land area in m ha	155.37				
		Fertilizer production/arable land	14,879.15				
		2020 fertilizer consumption/arable land in kg/ha	209.40	Nutrients needed (in mt)	18.591	9.296	4.648
				Ideal needed	4	2	1
				%age consumption substitution	22.19%	13.95%	42.10%

SOURCE: INCRED RESEARCH, COMPANY REPORTS

The above table shows that biogas-based fertilizers can substitute a considerable portion of chemical fertilizer consumption. So, the usage of biogas-based fertilizers can help reduce the import bill and hence, the fiscal burden of the fertilizer subsidy.

Hydrogen production potential

Another possibility is the production of hydrogen from methane in biogas.

This can be done in two ways. The first is to substitute natural gas for purified biogas in the steam methane reforming process. The second is to use the electricity generated from burning biogas in a generator to electrolyze water and thereby generate hydrogen.

Among these two processes, the steam methane reforming process is much more efficient and can be done in a relatively small scale of 50Nm3/hr hydrogen production.

Figure 9: Hydrogen production potential

		Daily production of biogas (in cubic metre)	Methane production (in mt)	Hydrogen production (in mt)
Sewage	Human population	25,59,200.00	0.33	0.10
Livestock	Crossbred/exotic cattle	4,03,36,000.00	5.41	1.71
	Indigenous cattle	8,52,66,000.00	11.43	3.62
	Buffaloes	8,78,80,000.00	11.78	3.73
	Pigs	18,12,000.00	0.24	0.08
Waste	Farm waste	82,19,17,808.22	82.62	26.15
	Food waste	76,71,232.88	1.20	0.38
	Total	1,04,74,42,241.10	113.00	35.76

SOURCE: INCRED RESEARCH, COMPANY REPORTS

Through steam methane reforming of methane from biogas, we can produce 35.76mt of hydrogen annually. This is seven times the National Hydrogen Mission's target of 5mmt of annual hydrogen production by 2030F.

Production cost

Biogas

The cost of production of biogas primarily depends on the cost of the feedstock used. Cattle dung is the most common feedstock used for this process.

Figure 10: Biogas production cost

Cost head			Units
Capacity		1,000	m3/day
Cattle dung needed		16.67	t/day
Working days		330	
Total production		3,30,000.00	m3/day
Dung price	₹	1,000.00	Rs/t
Capex			
Capex cost	₹	25,00,000.00	
Interest rate		10%	
Debt:asset ratio		70%	
Loan tenure		20.00	years
Annual interest payment	₹	2,05,554.34	
Opex			
Raw material cost	₹	55,00,000.00	
Labour	₹	2,40,000.00	
Total opex	₹	57,40,000.00	
Production			
Biogas-annual		3,30,000.00	m3
Methane production		2,14,500.00	m3
Fertilizer		5,161.75	t
Manure price	₹	200.00	Rs/t
Manure by-product credit	₹	10,32,350.00	
Biogas production cost	₹	49,13,204.34	
Biogas cost per m3	₹	14.89	Rs/m3

SOURCE: INCRED RESEARCH, COMPANY REPORTS

Here, we see the cost of biogas after a moderate purification level is around Rs 15/m3.

Figure 11: Biogas cost breakup

Feedstock cost	₹	16.67	Rs/m3 biogas
Labour cost	₹	0.73	Rs/m3 biogas
Capex cost	₹	0.62	Rs/m3 biogas
Manure by-product credit	₹	-3.13	Rs/m3 biogas
Biogas production cost	₹	14.89	Rs/m3 biogas

SOURCE: INCRED RESEARCH, COMPANY REPORTS

The cost breakup above shows that the price of biogas is driven largely by the price of feedstock. Hence, it's extremely important to maintain a low cost of feedstock.

Hydrogen

Figure 12: Hydrogen production cost

Cost head			Units
Capex	US$	0.15	$/kg H2
Opex ex-feedstock	US$	0.18	$/kg H2
Biomethane cost for H2	US$	0.45	$/kg H2
H2 production cost	US$	0.78	$/kg H2

SOURCE: INCRED RESEARCH, COMPANY REPORTS

Based on a USD-INR exchange rate of US$1=Rs81, we arrive at the cost of production for hydrogen from biogas at US$0.78.

Electricity

Figure 13: Electricity generation cost

Capacity		**1,000**	**m3/day**
Dung needed		25	t/day
Number of cattle		2,000	
Working days		330	
Total production		3,30,000.00	m3/year
Dung price	₹	1,000.00	Rs/t
methane content		65%	
Power production		274.81	KW
Capex			
Digester	₹	15,00,000.00	
H2S scrubber	₹	5,00,000.00	
Transmission sub-station	₹	5,00,000.00	
Genset cost	₹	25,00,000.00	
Total	₹	50,00,000.00	
Interest rate		10%	
Debt:asset ratio		70%	
Shareholder equity	₹	15,00,000.00	
Loan tenure		10.00	years
Annual interest payment	₹	5,69,608.88	
Opex			
Raw material cost	₹	82,50,000.00	
Labour	₹	7,68,000.00	
Total opex	₹	90,18,000.00	
Production			
Biogas-annual		3,30,000.00	m3
Methane production		2,14,500.00	m3
Electricity from methane @45%		7,26,000.00	kwh
Fertilizer		7,742.63	t
Manure price	₹	200.00	Rs/t
Manure by-product credit	₹	15,48,525.00	
Carbon credits generated		14280.00	
Price of a carbon credit in 2023	$	5.90	
USD-INR rate	₹	81.00	
Net revenue from carbon credits	₹	68,24,412.00	
Electricity cost	₹	12,14,671.88	
Electricity production cost per kwh	₹	1.67	Rs/kwh

SOURCE: INCRED RESEARCH, COMPANY REPORTS

This is a simple model for a biogas-to-electricity plant. It should be noted that this is a relatively unoptimized plant as it only generates 40m3 of gas/t of dung. Under optimal circumstances, such as temperature control of the biogas digester, it is possible to generate up to 60m3 of gas/t of dung.

Viability

There are several factors which affect the viability of a biogas plant. A key factor is adequate groundwater. This is an important operational requirement as the feedstock is mixed with water before being put into the biogas digester.

The cost of feedstock is the primary factor, as seen in the previous table. So, the biogas plant ought to be situated at a location close to the raw material site so as not to incur very heavy transportation costs.

For the above calculation, we assume the USD-INR exchange rate at US $1=Rs81. We can see that this is a cost-effective method of producing hydrogen and it can even be relatively decentralized because the steam methane reforming process is very well commercialized.

Carbon credit

A biogas-to-electricity project in Maharashtra, which has been running since 2014, found that each cattle added to the project generated approximately 7.14 carbon credits.

Figure 14: National carbon offset revenue

Number of cattle	Carbon credits	Notes
1.00	7.15	
30,23,80,000.00	2,16,06,36,044.93	This is based on the total cattle population of India
India 2019 carbon emissions (in t)	2,63,00,00,000.00	
Cattle dung carbon offsets as %age of carbon emissions	82%	
Price of biogas carbon offset	$ 5.90	
Carbon offset revenue	$ 12,74,77,52,665.09	
India FY23 trade deficit	$ 1,22,00,00,00,000.00	
Carbon offset as a proportion of trade deficit	10%	

SOURCE: INCRED RESEARCH, COMPANY REPORTS

Extrapolating these results to the national scale, as shown in the table above, we can expect a net carbon emission reduction of 82%.

Carbon credits also generate a large revenue stream which will keep rising as the prices of carbon offset keep rising. But, even at current prices, the national potential revenue from carbon offset is enough to reduce the trade deficit by 10%.

Thus, we see that biogas is both economically and ecologically very beneficial and can generate a considerable revenue stream from carbon credits too.

Farming biogas

Current biogas plants

Traditionally, biogas plants have been using cattle dung as their primary feedstock. Some new commercial biogas plants use press mud (waste from sugar mills) as a feedstock. In the case of the latter, these plants must be situated near sugar mills. This is to keep operational expenses low. As we have seen in the table detailing the breakup of biogas cost, these plants must manage feedstock cost in order to maintain viability.

A new type of feedstock

Hybrid strains of napier grass seem to be a very good feedstock for biogas production. Currently, napier grass is used as a cattle feed. Hence, it is more energy dense than cattle dung, as cattle dung contains waste energy which is leftover after the animal has digested the fodder.

Napier-based biogas is a much better fuel than ethanol

Figure 15: Napier, super napier compared with ethanol

	Napier	Super Napier	Rice (India)	Rice (Vietnam)	Units
Farm yield	180.00	360.00	1.13	2.36	t/acre/year
Biogas/ethanol generated per t	100.00	150.00	0.45	0.45	m3/t
Net fuel yield/acre/year	18,000.00	54,000.00	0.51	1.06	m3/acre/year
Energy density of fuel	6.00	6.00	5.89	5.89	kwh/L
Tank-to-wheel efficiency	16%	16%	16%	16%	
Net usable energy	17,280.00	51,840.00	0.48	1.00	kwh/acre/year

SOURCE: INCRED RESEARCH, COMPANY REPORTS

Super napier is a hybrid variety of napier with a higher farming yield and more biogas output too. In the above table, we assume that Vietnam's rice farming yield is the highest national rice farming yield achievable in India.

As we can clearly see, even normal napier grass-based biogas is a much higher-yielding automotive fuel production process than the rice-to-ethanol process for cars. Notably, the production cost, as a fraction of the sale price, is also lower, allowing for much better margins.

Challenges could be a blessing in disguise

Conventional production happens at a household scale

In India, we colloquially call biogas as gobar gas. This is because we generally make biogas from cattle dung (gobar) in villages. Most of these biogas plants are at the scale of a single farm and this gas is generally consumed by the farmers' own family to meet his fuel needs.

Government has started providing incentives to scale up biogas production

Recently, the government has been providing incentives to increase biogas production. This has empowered several rural entrepreneurs. In turn, this drives social development by allowing the setting up of multiple relatively large biogas plants, which provide livelihood and income to more people.

Positive social impact through biogas feedstock sales

Figure 16: Boosting rural income through dung sales

Rural income		
Average annual rural income	₹	40,925.00
India rural population		89,80,24,100.00
India cattle, buffalo population		30,23,80,000.00
Rural cattle, buffalo ownership per capita		0.34
Income per cattle from biogas @Rs1/kg dung price	₹	5,475.00
Rise in per capita rural income from dung sales		4.50%

SOURCE: INCRED RESEARCH, COMPANY REPORTS

The above table shows the potential for a rise in per capita rural income if all cattle owners sell/utilize the dung from their animals at a price of Re1/kg. We see that per capita rural income rises by an impressive 4.5%. This lends further credence to the fact that the mass adoption of biogas can not only generate considerable financial benefit, but also meet several social goals by empowering the rural population and contributing to their development.

Industry is unlikely to get centralized

A biogas plant achieves profitability at a relatively low scale. Thus, there are likely to be diseconomies of scale for a large investment of around Rs1bn. Given this facet of the industry, it will be difficult for large players to move in and push the smaller ones out. Hence, the social benefits of the biogas industry would persist well into its maturity.

Investment ideas

Several companies can benefit from the popularization of biogas in India. They range from gas cylinder manufacturers to OMCs to automobile manufacturers who build gas-fueled vehicles.

Gas cylinder manufacturers

There is only one listed entity in the compressed gas cylinder space - Supreme Industries. However, it's recommended to do one's own due diligence in the case of this company.

OMCs

There are a number of oil marketing companies or OMCs with CNG businesses which can easily pivot to using CBG too. They include:

- Indraprastha Gas: 75% of its revenue from CNG sales.
- Indian Oil Corporation: 2% of its revenue from CNG sales.
- Bharat Petroleum Corporation: 1% of its revenue from CNG sales.
- Hindustan Petroleum Corporation: 3% of its revenue from CNG sales.

Automobile manufacturers

In this industry, companies who manufacture CNG-fueled vehicles and those who have exposure to rural sales can benefit. This is because CNG vehicles can easily use automobile grade CBG as fuel. As far as rural sales are concerned, as biogas production will take place mainly in rural areas, we expect the wealth generation and investment to occur in that sector.

- Bajaj Auto: The company has a sizeable exposure to CNG automobiles.
- Escorts Kubota: Manufactures tractors and other related machinery.

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