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Institutional Biogas Plants- Present Scenario, Available Capacity and Future Possibilities: A Case Study of Sonepat District in Haryana

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ABSTRACT

Biomass resources are found in abundance in our country. In this study, attempt has been made to investigate institutional biogas plants for use of biomass waste in one district (Sonepat) in Haryana state. In Haryana, HAREDA is trying to utilise all viable forms of non-conventional sources of energy to improve access of rechargeable energy and for maintaining the ecological balance with the help of institutional biogas plants. However, the question is: Do all the institutions maintain institutional biogas plants that function adequately and are these plants installed according to their capacity? The case study of Sonepat district presents biomass as a resource and the institutions as a source of ample biomass resource. It also shows government efforts and policies towards institutional biogas plants for use of biomass waste, enumerate the institutional biomass waste resources in Sonepat district with the help of secondary and primary data collection, presents empirical research on the installed institutional biogas plants in the district and enumerate the potential production as well as unutilized potential of biogas generation for fulfilling the use of cooking, electricity and manure needs.

Keywords: Biogas, biomass waste, institutional biogas plants, potential, resource, sustainable development

INTRODUCTION

"India's plan to add 175 GW of capacity from renewable by 2022 can succeed only if the relevant stakeholders act in ways that encourage investment in the segment...." (1). India has a lot of biomass whose sane use can speed-up the level of development. As per Ministry of New and Renewable Energy (MNRE) biomass resource assessment conducted between 2002 and 2004, biomass availability was about 500 Million Metric Tonnes (MMT) per annum along with surplus biomass of about 120-150 MMT per year in agrarian and forestry residues (2).

Biomass as a resource: As per MNRE, the above biomass has potential of about 18,000 MW which can be enhanced with other opportunities in high yield varieties and wastelands. Other than that, country's 550 sugar mills could produce about 5,000 MW additional power with bagasse by optimum techniques (2). Biomass waste can be used for making bio-fuel, specifically biogas, which is a green source of energy. Though ethanol and biodiesel are other forms of biomass fuel; but in a scenario, where food security is one of the major problems; to shift the use of our limited land to fuel crops will not be suitable. So, use of biomass through biogas can provide us huge benefits. Institutional biogas plants can provide benefit at many fronts. In the process of making biogas from biomass, we get two main products; i) Methane (55-70 %) and ii) Slurry i.e. organic fertilizer (3). These can be used for different purposes. Methane can be used to light the houses and as a fuel for vehicles. The organic fertilizer is considered far more productive than the traditionally made fertilizer and is used extensively in the fields. As per the MNRE reports- the slurry obtained from biogas plant contains 80% carbon, 1.8% nitrogen, 1% phosphorus and 0.9% potash, making it an excellent source of not only humus but also micronutrients for crops (4). Since petroleum and coal are exhaustible reserves, it is obligatory to consider alternative sources of energy. Sustainability approach suggests avoiding the use of our durable but limited resources, when perishable resources are already available to serve the needs. Use of biomass, to get biogas and fertilizer, will help overcoming the BOP problem as significant import payments are done because of our energy and chemical fertiliser requirements. It's unused, misused or underutilized status creates and aggravates the problem of sanitation and health. Biomass as a source of energy is not similar to other sources of green energy. It can be generated and supplied round the clock in contrast

to solar and wind, which is intermittent in nature. Bio-methanation process of converting biomass into gaseous fuel, is superior and a sustainable process that needs to be preferred for such biomass materials that can be processed in biogas plants. In contrast, when biomass is subjected to combustion/gasification process, it ends up in the destruction of biomass and only ash is left after extraction of energy (5). On one hand, the digested slurry can replace chemical fertilizers which can help in organic agriculture, and hence would be further beneficial for health, soil and groundwater quality as well as in the reduction of the emission of Green House Gases (GHGs); on the other hand GHG release will also be bunged because of open exposure of biomass, left openly. In comparison to traditionally made fertiliser, the digested fertiliser is helpful in reducing the germination of weeds and pests and can benefit the economy in many ways. It is also useful for the problem of termites in the fields (6, 7).

For proper use of biomass, Ministry of New and Renewable Energy is implementing the National Biogas and Manure Management Programme (NBMMP) in the country. About 47.5 lakh family biogas plants were already been installed up to 2014. During the year 2014-15, a target of setting up of 1,10,000 biogas plants had been set (8) and for the year 2015-16, the target was set at 1,11,000 (9). It is an intensely subsidized program of the government, with the purpose to use the biomass resources for the economy; however despite the expected immense benefits to the society and the myriad efforts by the government, biogas plants are being shut down. In a research survey done in Uttar Pradesh**,** out of the 16 biogas plants **on** the list, 13 were found to be not functioning. Most of the plants lasted for about four years and were discarded for a variety of reasons (10). Evaluation Study on National Project on Biogas Development finds it problematic to own and operate Family Type Biogas Plants for most rural households. The study also raises questions about credibility of MNES/State Governments secondary data as primary data don't support the impressive secondary data (11).

Institutions as a producer of biomass resources: There are regular waste disposal problems in almost all institutions like hostels, hospitals, convents, old age-homes, etc. where a large number of people stay together. Then there are institutions like *goshalas*, dairies and hatchery farms where number of people living and their need of cooking fuels is significantly less than the potential of generating fuel with available biomass of the institutions. All these institutions are valuable source of biomass resources, especially because of the bulk availability of biomass resources.

Government's efforts to use the institutional biomass resources through Institutional Biogas Plants in Haryana: Government is trying to use the resources of the institutions through Institutional Biogas Plants**.** Haryana Renewable Energy Development Agency (HAREDA) is implementing the scheme 'Institutional Biogas Programme' to promote installation of biogas plants in *goshalas,* dairies etc. to meet their energy requirement. HAREDA documents about 'Biogas Utilisation Programmes in Haryana' and presents that "Haryana, with cattle population of about 7.6 million, (which was 8.81 Million in 19th Livestock Census 2012), has the potential of generation of about 3.8 million cubic meters of biogas which can be used to generate about 300 MW power or can be purified, compressed and bottled for production of about 1.2 million Kg of compressed biogas (12). So far, 112 institutional biogas plants have been installed in Haryana out of which 98 (87.5%) plants are installed in *gaushalas* and 14 (12.5%) plants are installed in other institutions; including a dairy farm, few *deras* and *gurdwaras,* a poultry farm, an agro farm and a few educational institutions (13). Out of 408 *gaushalas* (registered and unregistered) in Haryana, comprising 3,06,490 animals (14); 319 (78.19%) have never installed while only 89 (21.81%) have installed the plants till now (13). Here installation doesn't clarify its present state of commissioning. If India succeeds in its proposed plan to create 175 gigawatts of renewable energy by 2022, it will meet its emissions intensity target even in the absence of significant efficiency improvements. Combined with efficiency improvements, an aggressive renewable energy push can reduce the emission intensity of GDP far more than 35 per cent (15).

METHODOLOGY

Methodology: To understand the qualitative and quantitative aspects of the gap between the available and the desired patterns of utilizing biomass resources and problems of the Institutional Biogas Plants, an in depth study of the plants was required. By using the primary and the secondary data and with ethnographic field visit and personal interactions, a mix approach dominated by case study method was chosen to study the issues. Sonepat district was chosen as it has all the characteristics of a good sample because of the availability of biomass resources, institutions containing biomass and set up of institutional biogas plants. Field exposure period was between January to June 2016.

RESULTS AND DISCUSSION

A. *Enumeration of institutional livestock and biomass resources in Sonepat district in Haryana:*

Table I indicates the importance of different institutions for the availability of biomass resources. *Gaushalas* are the biggest stable institutions since independence, with a high amount of biomass. Poultry farms are also a big source of litter and waste. As per the veterinary doctors of the area, most of the poultry is in broilers type farms, which are less stable and work for short term (often for only 6 months), while parent stock and layers type of farms works generally for long term and are stable are generally less in numbers. It so happens because broilers in general keep birds for the sale of meat but not for production or hatchery purpose.

Table I: Enumeration of Institutions, their livestock and biomass waste in Sonepat district[1]

Sr. No.	**Name of the institutions[2]**	**Number of institutions**	**Animals in institutions**	**Average number of animals /birds per institution**	**Biomass waste of animals (approximate)**
1.	Gaushalas[3]	23	50,000	2173.9	5, 00,000 kg. (10 kg/animal/day)
2.	Dairy Farms[4]	11	1080	98.2	16,200 kg. (15 kg/animal/day)
3.	Poultry Farms[5]	108	1512300	14002.8	2, 72,214 kg. (0.18 kg/bird/day)
4.	Piggery Farms[6]	3	500	166.7	1125 kg. (2.25 kg/animal/day)
5.	Slaughter Houses[7]	0	-	-	-

Notes:

1. Though there are other institutions having producing biomass like hostels, hospitals etc. which can be taken further but here only Institutions[#] regarding livestock are taken, because of much more availability of biomass waste resources in these institutions. I

also tried to get the list of educational institutions with hostels, from the office of education department but it was found that they also don't have any list till now.

2. *Gaushalas* are charitable while others are non-charitable institutions.
3. 34889 animals are in the list of *gaushalas* according to the website of animal husbandry department of Haryana (11) But 50,000 animals are taken on the estimation based on field visit which presents approximately 40-45% increase in animals.
4. Taken on the basis of interviews of the veterinary doctors and concerned authorities of the district for dairies having more than 50 animals.
5. Data received from the interviewees, animal husbandry department of the district for total poultry in the poultry farms of the district according to census held by animal husbandry department, due to bird flu, in 2013-14
6. As the data is not available on formal sector so it is estimated on the basis of interviews and individual interactions from vet-nary doctors and employees of animal husbandry department and a pig farm owner.
7. Registered slaughter houses in 2005-06 = 0 (zero)[source: planning department; govt of Haryana] (16)
8. Calculated on the basis of Biogas: A Fit Option for Rural Energy (3).

Published data is found only for *Gaushalas*, which is also modified as per field visit findings and observations. Diary farms[5], Poultry Farms[6] and Piggery Farms[7] are in informal sector and the concerned data has been collected with the help of personal interviews of various concerned people, authorities and veterinary doctors.

B. Empirical research of institutional biogas plants in the district:

In Sonepat district, six IBP (Institutional Biogas Plants) have been installed in five locations.

As per the officials; in the last five years, the authorities have received about 10-12 applications per year. However despite the approval for subsidy to all the applications, only one plant was installed (during 2013-14). It is noticed that the institutions do not apply to their full capacity as maximum capacity availed till now is 85 cu. m. while biomass available is much more than the capacity in all the institutions. Their demand for the capacity depends upon many factors, like--their requirements of gas or slurry, their budget, space available and consensus of the management. Because of all these factors, most of the applicants are applying for a small plant, comparative to the amount of

biomass available. The reasons behind no installation or less number of installation of plants are Space, budget and consensus among the management. For some *gaushalas,* only 1-1.5 acre is available and substantial space is used for dumping raw dung. Even after subsidy, it costs about Rs. 6-8 lakhs for installation of the plant. Opinions are mostly divided whether to spend Rs. 6-8 lakhs on the installation of a plant or construct a few sheds instead. The reasons described for discontinuity, according to the related authorities, are carelessness and damage of the plant. Reestablishment depends initially upon the efforts of the management to start it again and finally upon government's approval for aid to reinstallation. A few years back, based on the surveys done on the instructions of the government, approximately 10 estimates have been sent to the government, to install the plants on *gaushalas.* Non-charitable institutions like dairies, hatcheries etc. are also willing to install the plants but are unable to do so because of the absence of subsidy.

C. Case study of all the installed institutional biogas plants of district Sonepat:

Tables II, III and IV present the case study of 5 places, where plants have been installed till now, based on secondary data and ethnographic research methods. Through these case studies institutional actions and behaviours regarding plant installations, problems faced by them, their future expectations and strategies and hindrances in the way along with finding out the mechanism to solve the problems is understood.

Table II shows the details of the plants. Out of total 6 installations of IBPs in Sonepat district, only one plant was found to be functioning. Though all the installation were up to the capacity of 85 cu.m, yet it was significantly less than the biomass available in the institutions, according to the 'Biogas Utilisation Programmes in Haryana', where only 250-270 animals are required for this capacity. Not only the capacity of installed plants was less than the available potential biomass, the installed ones were also not used to their optimum capacity. None of the plant on *gaushalas* was found to be working. Though records showed 34,889 animals to be present in the *gaushalas* of the district but as per the data shown by the concerned authorities, and on field visits, approximately more than 50,000 animals were found to be in the *gaushalas* of the district. The only commissioning plant is an Ashram. Out of six plants only one was functional, and only at about one third of its capacity. So, Coefficient of utilisation for Institutional biogas plants ($CoU_{IBP)}$ in Sonepat district was about 1/18.

Table II: Details of institutional biogas plants of district Sonepat. (Source: Interviews, focused group discussions and field visits of the plants).

Institutions where Plants were installed	**Year of installation of IBP with capacity**	**Feeding material used for digester**	**Present situation (Commissioning/ Non-commissioning)**	**Time period of the functioning of biogas plants**	**Dung used to feed the plant**	**Present use of dung**
1. Plant A (6000 + animals)	1998-99 (85 Cu.m)	Dung	Non-commissioning	2.5-3 years	Approximately 10% of the available dung	Discarded as heaps of dung and sold to the peasants for their demand as fertiliser
2. Plant B (4000 + animals)	2003-04 (85 Cu.m)	Dung	Non-commissioning	9 years	Very meagre amount (dung of approximately 7-8 animals per day)	Discarded
3. Plant C (1500+ animals)	1994-95 (85 Cu.m)	Dung	Non-commissioning	10-15 days	Small amount	Discarded
4. Plant D (approx. 1400 animals)	2003-04 (45 Cu.m)	Dung at initial stage but later connected to latrines	Non-commissioning	2-3 months	10-15 animals	Discarded
5. Plant E (150 animals)	2013-14 2nd plant* (85 Cu.m)	Dung	Commissioning	Working	Approximately half of the available	Discarded
Note : Names of plants have been given as alphabets due to privacy and research ethical concerns						

Table III: Use of the products in different IBPs at commissioning state

Institution's name	**Possible uses of biogas and their use in particular plants**				**Reasons for using (or not using the biogas)**	**Use of the slurry**
	For cooking or for anything as a flammable gas	For lighting	For engine	For grinding or to fulfil the other requirements of electricity		Sale or self-use
1. Plant A	Yes	Yes; partially	Yes	Yes	Required Knowledge	Sale
2. Plant B	Yes	No	No	No	Lack of knowledge and technical problem	Nothing extracted in the past 9 years due to low feeding
3. Plant C	Yes	No	No	No	Discontinuing at the initial stage of commissioning, due to malfunctioning	Nothing, because of shutting down during the initial stage itself
4. Plant D	Yes but only till time when feeding material was dung	Yes; partially	No	No	Due to availability of other substitutes	Nothing because of shutting down
5. Plant E	Yes	Yes; partially	Yes	Yes	Knowledge	Very little amount is used as fertiliser for their personal requirements
Source: Interviews, focused group discussions and field visits of the plants.						

Table III shows the Use of the products in different IBPs at its commissioning stage.

Plant A worked on full capacity and was being used for cooking and grinding wheat. In **plant B,** due to lack of knowledge, only a small amount of dung was fed and slurry was never extracted in past nine years. They were doing so for the purpose of fuel requirement

for food but not for other purposes like electricity. Another technical problem which they faced at the time of functioning and which affected their supply of gas was width of pipeline, which was left smaller than the required width. **Plant C** discontinued within 20-25 days of its commissioning. They got gas only for these many days but in unsatisfactory amounts. Though they were given engine by the government to produce electricity but it didn't work. Initially, **Plant D** was being used for making food and lighting to some extent, by the migrant workers residing in the *gaushala.* **Plant E** was also using biogas for several purposes but not to its full capacity.

Table IV presents the reasons for discontinuation and willingness to restart. In **Plant A**, malfunctioning was the main reason for discontinuation. Plant B discontinued as the dung container got cracked and got jammed. However people were interested to restart. **Plant C** discontinued in its initial stage of commissioning due to leakage in the lid. Owners did not contact the concerned authorities. Though they were also aware about their electricity generating capacity but because of multilevel problems- as time, management, lack of expert knowledge; they were not willing to do extra efforts for its maintenance. In **Plant D,** main reason for its discontinuity was its connection to the latrines and the workers denied to use it for food purpose. The people responsible for this plant are willing to restart it and are also willing to supply gas to the villagers if some help is provided from the government. Money is the main problem behind lack of installations. . In the words of a person from one of the management teams-*"Gaushalas don't have money".*

Table IV: Discontinuing of the IBPs; their willingness to start them again and the challenges

Institution's name	**Reasons of discontinuing**	**Willingness to start the IBP again**	**Problems to start the IBP again**	
	Main Reasons		**Major constraints**	**Other possible problems**
1. Plant A	Malfunctioning	Yes	Funds	Consensus among management, time, technical knowledge, workers for the plant needs

2. Plant B	Jammed IBP due to crack in inlet.	Yes	Funds	Technical knowledge, workers for the plant needs
3. Plant C	Malfunctioning (leakage in the lid) at the very initial stage of commissioning and indifferent behaviour of the management.	No, as lack of time to manage the installation and functioning of the plant and doubt for its functioning was told the main concern	Funds and time	Technical knowledge, workers for the plant needs
4. Plant D	Altered attitude towards gas when it got connected with latrines.	Yes	Funds	Consensus, time, technical knowledge, workers for the plant needs
Source: Interviews, focused group discussions and field visits of the plants.				

D. *Potential production and utilised capacity of institutional biogas for the use of cooking, electricity and manure in the district:*

Table V to VIII presents potential and utilised capacity of institutional biomass through IBPs in district sonepat. Table VII, using Tables V and VI, enumerates the institutional capacities for different possible uses of their biomass waste by getting different products in terms of biogas and fertiliser. Table VIII and IX present the utilized capacity in the areas and per day average capacity of the institution respectively.

Table V: Potential biogas yield from different feed stock

Animal dung	**Average biogas yield [m^3/animal/day]**
Cattle	0.36
Buffalo	0.54
poultry	0.011
pig	0.18
Source: Biogas: A Fit Option for Rural Energy (3).	

Table VI: Possible applications of biogas

Cooking [1m^3gas/day]	**4 persons**
Electricity[1m^3gas /day]	5/4 units
Digested slurry / day	.7-.8 Kg digested slurry in 1kg dung
Source: Biogas: A Fit Option for Rural Energy (3).	

Table VII: Per-day overall capacity of the institutions for different uses in Sonepat district.

Source: compiled from table I, V and VI.

Uses of biogas (per day)	**Overall capacity of all the 23 *gaushalas* with 50,000 cattle population (18,000 cubic gas per day)**	**Overall capacity of 11 dairy farms with 1080 buffalo population (583.2 cubic gas per day)**	**Overall capacity of 108 poultry farms with bird population 15,12,300 (16635.3 cubic gas per day)***	**Overall capacity of 3 pig farms with pig population of 500 (90 cubic gas per day)#**	**Overall capacity of all the institutions 35308.5 cubic gas per day**
Cooking	72,000 persons	2,332.8 persons	66,541.2 persons	360 persons	1,41,234 persons
Electricity	22, 500 units	729 units	20794.125 units	112.5 units	44,135.625 units
Slurry (digested manure)	3,50 ,000-4,00,000 kg	11,340- 12,960 Kg	190549- 217771.2 Kg	787.5- 900 Kg	5,52,676.5 - 631631.2 Kg

Table VIII: Per-day utilized capacity of the operating plant for different uses

Approximate number of animals whose dung is used for Biogas generation	**Total dung [10 kg per animal]**	**Biogas generation capacity [0.36 m^3/animal/day]**	**Cooking capacity [1m^3 biogas / 4 persons / day]**	**Electricity generating capacity [1m^3 biogas / 4/5 units / day]**	**Digested fertiliser [.7-.8 Kg digested slurry in 1kg dung]**
100	1000 kg	36 m^3	144 persons	43.75 units	700-800 kg

Table IX: Per-day average capacity per institution for different uses in Sonepat district (compiled from table VII)

Uses of biogas (per day)	**Average capacity per *gaushala***	**Average capacity per dairy farm**	**Average capacity per poultry farm**	**Average capacity per pig farm**
Cooking	3130.435 persons	212.072 persons	616.122 persons	120 persons
Electricity	978.261 units	66.273 units	192.538 units	37.5 units
Slurry (digested manure)	15217.39 - 17391.30 kg	1030.91 -1178.18 kg	1764.34 – 2016.4 kg	262.5 - 300 kg

There are strong possibilities that overall gas generation capacity can be much more than this as in the case of poultry. According to the veterinary authorities, 5 new farms (3 research and breeding farms and 2 of layers) consisting 1,42,000 birds and 9 farms regarding parent stock consisting 88,000 birds exist at present, implying that 2,30,000 additional birds are also there (and since they are not in the list and hence are not included here while making the calculations).

Major findings from the study:

One out of 5 institutions are at the operating stage (Table II). Overall biogas generation capacity of the institutions is 35308.5 m^3 gas per day while only 36 m^3 gas is being produced presently which is only 0.10 % of the available capacity ((Table VII and VIII). Per day potential production capacity, with institutional biogas plants system, for the use of cooking, electricity and digested manure in the district is 1, 41,234 persons, 44,135.625 units and 5, 52,676.5- 631631.2 Kg respectively (Table VII). Per-day utilized capacity of the operating plant for the uses of cooking, electricity and digested manure in the district is merely 144 persons, 43.75 units and 700-800 kg, respectively (Table VIII). *Gaushalas* and poultry farms are identified as the biggest source of unexplored institutional biomass resources (Table VII). In the present policy, full utilization of resources (installation-wise or capacity-wise) has not been targeted yet. Though a large percentage of beneficiaries are *gaushalas* but still most of them have never installed plant till now. Malfunctioning has been the main reason for discontinuations (Table IV). The non-operating plants are all *gaushalas* and at present no *goshala* is having any operating plant in the district (Table II). Approximately more than 50,000 animals are there at present. Presently, biomass waste (dung) of these animals is used crucial sub-optimally (Table II). Capacity of none of the plant is installed according to the availability of the biomass resources i.e. input but are installed according to the decision taking by the management; mainly depending upon their funds, their requirements and consensus of the management and many other problems regarding use of the product, in the case of extra production. 3 out of 4 discontinued institutions are keen on starting the plant again (Table IV).

CONCLUSIONS

Sonepat district has institutions with large amounts of unexplored biomass and are having enormous potential of biogas to contribute for sustainable development. Gaushalas and

poultry farms are the big source of institutional biomass waste. Biogas can be used for cooking and power generation while digested slurry (DS) can be used as manure for agriculture and aquaculture as its nitrogen, potash, phosphorus (NPK) content is comparatively better than farmyard manure (FYM). With right policies and constructive steps in the direction can yield positive results.

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