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Existing Household Biogas Technology and Its Ground Realities in Rural India

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ABSTRACT: Sustainable economic and industrial growth of nation requires safe, sustainable resources of energy. This paper reviews household biogas technology ground realities in rural India and investigates challenges facing in operation of existing household biogas plants. It further captures the current status and functions of biogas plants as well as the impact of these plants on the people who use them. The study was done by surveying fifty (50) household biogas installations from hilly rural border area of pune and satara districts of Maharashtra state, India, and conducting interviews with plant users. From the survey, it was observed that 20 % installations were Fixed-dome and 80 % were floating dome. It was revealed that subsidy was the main motivational reason for construction of biogas plant, whereas subsidy was the motivational reason for using biogas plant. Out of 50 plants, 26 (52%) were functioning satisfactorily, 5(10%) functioning but defective where as 19 (38 %) were not functioning. Reasons for non-functioning include non-availability of cow dung for feed, breakdown of structure, leakage of gas holder due to corrosion, absence of maintenance services, lack of operational knowledge.

KEYWORDS: Biogas, Biogas technology, Household biogas plant, Sustainable development, Bio-energy.

I. INTRODUCTION

"Super challenges" of 21st century is to provide clean and healthy environment as well as fulfilment of energy demand, a renewable energy supply because of depletion of Earth's fossil fuel resources. The current way to produce, convert and consume energy through out the world is not sustainable. Majority of existing practices of energy production consume non-renewable raw material for energy production such as coal, petroleum products which leads to release of pollutants in the environment.

Renewable energy sources that meet domestic energy requirements play an important role in the energy and have the potential to provide energy with zero or almost zero emission of greenhouse gases [1]. Renewable energy technologies directly help to mitigate the climate change by reducing greenhouse gases emission in the global and a long term process. Harvesting the renewable energy in decentralized manner is one of the options to meet the rural and small scale energy needs in a reliable, affordable and environmentally sustainable way [2].

Biogas is a renewable energy used for cooking and lighting as well as heating purposes. It is a mixture of gases that is composed mainly of CH_4 40- 70 %, CO_2 30-60 % and other gases 1-5 %. The calorific value of biogas is about 16-20 MJm^{-3} [3]. This is produced by bacteria that decompose organic matter under anaerobic conditions. For the biogas production different substrates can be used such as waste water, organic waste from household, animal manure, human excreta, agriculture waste etc. Energy production from biogas has dual benefits, renewable and clean energy production for household purpose in one hand and in another hand management of organic waste.

Approximately 72.2% of the total population in India belongs to rural areas having less access to resources and awareness [4]. Biogas is an alternative and renewable source of energy, derived from organic wastes. The feed materials for production of biogas such as animal and agricultural wastes are abundantly available in rural and semi-urban areas of India. Biogas, primarily a mix of CH4 (methane) and CO2 (carbon dioxide) is generated in the process of biodegradation of organic materials under anaerobic conditions. Biogas technology is not new to India and Ministry of New and Renewable Energy (MNRE) has over the years through various programs facilitated the availability of standardized models of biogas plants which are suitable for individual households and communities. At the household

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level, the cumulative number of biogas plants built from 1982 to 2006 is estimated to be 3.83 million [5], against a potential of12–17 million [6].

II. RELATED WORK

Biogas technology has brought benefits to the environment, economy and energy conservation. The development of sustainable biogas energy relies on the availability of local resources as a feed, environmental concern, and the local societal and economic conditions [7]. The national project on biogas development was set up in1981 for the promotion of biogas plants using cattle dung and other biomass waste to generate methane for house hold cooking and lighting [7]. For the development of biogas technology subsidies and financial assistance were provided centrally to each state based on economic profile [8]. In spite effort taken by government, NGO's and other private organisations this technology is not delivering the promise. This study was aimed to investigate the performance of existing household biogas plants in rural India, with the structured questionnaires and open-ended unstructured interviews with the respective plant user. The main objective of study was to understand ground realities of biogas technology in rural India and investigate the factor which affects penetration of technology as promising renewable energy source.

III. METHODOLOGY

The study was conducted in close accordance with the objectives. The data was collected with the structured questionnaires and open-ended unstructured interviews with the respective plant user. Additional investigation tools for data collection included observations, especially of different components of biogas plants, household kitchen, biogas plant type, toilet attachment to plant and slurry pits in the sampled households and informal discussions with people in the survey clusters. During the field survey, the study team adopted an interactive approach rather than a 'question and answer session' with the biogas plant users to enhance the quality of data and information collected. The numbers of plants to be surveyed were decided to be 50 in total. Samples were selected randomly from hilly rural area border area of pune and satara districts of Maharashtra state, India. Details of sample are shown in table. 1.

Table 1:-Biogas Plants Sampled for the Study

Sr. No	District	Tahsil	Village	No. Household Biogas Plant
1	Pune	Bhor	Kenjal	05
2	Pune	Bhor	Khanapur	12
3	Pune	Bhor	Bajarwadi	08
4	Pune	Daund	Nangaon	07
5	Pune	Daund	Kadethan	04
6	Satara	Khandala	Hartali	09
7	Satara	Khandala	Wadwadi	03

The whole study was divided into three major parts based upon the activities carried out:

1. Preparation of questionnaires:

Questionnaire was prepared considering various aspects of biogas technology such as motivation, physical status and functioning, feed material availability, technical soundness, operation and maintenance, perception on technology etc.

2. Investigation and Data Collection:

Data were collected with structured questionnaires, field visit observation by study team and unstructured interview of plant users.

3. Data Analysis:

Data were analyzed by considering various realities of technology in rural India such as physical status and functioning of biogas plant, feed material and operation, operational activities and maintenance by users and user's perception on technology and efficiency.

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IV. RESULTS AND DISCUSSION

Physical Status and Functioning Of Biogas Plant:

The existing physical condition of different components of household biogas plants were observed in detail during the field investigation to assess the quality of construction, effectiveness of maintenance activities carried out and the operational status prior to categorizing them. The physical status of different components of household biogas plant have been categorized in three different headings viz. good (functioning without defects), fair (defective but functioning) and poor (defective and not functioning) in qualitative manner, dependent on the physical observation of the plant made by the members of the study team during field investigation. The following table shows the categorization of general condition of biogas plant and its Components.

Table 2: Physical status of different component of biogas plants

Sr. No.	Plant Component	Plant under study different category					
		Good (functioning without defects)		Fair (defective but functioning)		Poor (defective and not functioning)	
		Nos.	%	Nos.	%	Nos.	%
1	Biogas Plant as a whole	26	52	05	10	19	38
2	Inlet tank	41	82	05	10	04	08
3	Digester and dome (gas holder)	36	72	-	-	04	08
4	Outlet (displacement chamber)	13	26	37	74	-	-
5	Pipeline	43	86			07	14
6	Main gas valve	39	78	06	12	05	10
7	Gas lamp	-	-	-	-	-	-
8	Gas stove	31	62	-	-	19	38
9	Slurry pit	37	74	04	08	09	18

Functional status of biogas plants were analyzed considering biogas plant as a hole, and different components such as inlet tank, digester and dome, outlet, pipeline, main gas valve, gas lamp, gas stove and slurry pit . From the study it was observed that despite number of defects and weaknesses, the functional status of household biogas plants on an average was satisfactory. Out of the 50 plants under analysis, 26 (52%) plants were functioning satisfactorily without defects, 05 (10%) plants were functioning partly with defects and the remaining 19 (38%) plants were not functioning at all during the time of field investigation (Table 2). Reasons for failure of biogas plants were poor quality of construction and construction materials, non availability of repair and maintenance services.

Fig. 1 Present physical status of biogas plans due to faulty construction and poor workmanship

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It was observed that the 10 household biogas plants which closed can restart with nominal repair, where as 9 biogas plants are not in the state of repair due to structural failure. From the analysis it is observed that most of fixed dome household biogas plants were constructed by unskilled mason. Out of 50 plants 20 biogas plants not utilized 180 principles. Failure of biogas plant structure as a hole might be due to poor quality of workmanship, poor quality of construction materials and settlement of soil, whereas plants which are not working satisfactorily can improve their performance with nominal repair (figure 1). For trouble free operation of plant need training, but not a single user had received basic training. That indicates high need of training to educate the users on basic operation and maintenance of the installed plants. Existing physical status and functioning of majority of the plants under study also suggested that the users were not fully aware of the importance of effective operational activities and timely repair works for trouble-free performance of biogas plants.

Feed Material and Operation

The amount biogas production in household biogas plants depends upon the quantity and quality of feeding added to it daily provided plant is functioning technically all right. The following table shows the composition of feeding materials being used in biogas plants.

Table-3:-Composition of feeding materials

Sr. No	Type of Feed	No of Plants
1	Cattle dung only	08
2	Cattle dung and human excreta	22
3	Cattle dung , human excreta and kitchen waste	-
4	Cattle dung and kitchen waste	-
5	Human excreta and kitchen waste	01
6	Nil	19
	Total	50

Cattle dung was the major feeding material used. Besides these, kitchen and household wastes, human excreta and urine of animals were also used to feed biogas plants. It was observed that 22 biogas plants were feeding on Cattle dung and human excreta, 8 biogas plants were feeding on cattle dung only and 1 biogas plant was feeding on human excreta and kitchen waste, where as 19 household biogas plants were closed due to lack of cow dung, leakage and poor construction (table 3). It was also observed that whole quantity of dung produced in the stable was not utilized for biogas production; part of it is utilized as a fuel after drying. The present study revealed that out of the 50 biogas households under study, all of them have constructed latrines in their premises and only 22 of these households have attached latrines with the biogas digesters. 18 of them were motivated by the service providers and the remaining two decided by their own. The concept of connecting household latrines to biogas digester is unacceptable in much of rural India for a variety of socio-cultural and religious reasons. The thought of using gas from such a source for cooking purpose remains very much taboo.

Operational Activities and Maintenance by Users

Table-4:-Frequency of different operational activities by plant users

Operation Activities	Operation Frequency										
	Daily	Once In two days	Once in three days	Once in four days	Once in a week	Once in a 15 days	Monthly	Half yearly	Never	As and When needed	Not applicable
Feeding	26	2	2	1	-	-	-	-	-	-	19
Checking leakages	-	-	-	-	-	1	1	-	29	-	19
Cleaning of outlet	-	-	-	-	-	1	-	-	30	-	19
Composting	-	-	-	-	-	-	-	-	18	13	19
Cleaning of gas stove	-	-	-	-	-	-	-	-	29	2	19

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Besides feeding of plant, frequency of other activities carried out by users for smooth working of plant were reported and analyzed. It was observed that out of 50 plant users 29 plant users never checks leakages, 30 plant users never checks outlet and 29 plant users never clean gas stove (table 4). From analysis it was revealed that operational activities were reported to be carried out on as and when needed basis. Majority of the plant owners lack knowledge on different operational activities needed to be carried out regularly for the trouble-free and smooth functioning of biogas plant and its components. This was due to ignorance and negligence of the plant users, as they have not been provided with training on operation and maintenance of biogas plants.

Motivation and Users Perception on Technology

Effort was taken to understand the most important motivating factors for the installation of biogas plants. It was observed that, most popular motivating factors were the Subsidy (29 users), Economic benefits (12 users), motivation from service Provider (4 users), Motivation from existing plant owners (2 users), Saves time and energy (1 user). It was observed that 58 % plant users were motivated due to subsidy, where as 24 % plant users motivated by economic benefits associated with technology. This indicates that the potential of subsidy by the various agencies and economic benefits of technology to become tool for promotion and extension of the technology.

V. CONCLUSION

Biogas technology is promising technology for sustainable development. To meet 'lifeline energy' requirement for cooking needs to penetrate biogas technology in rural India as a sustainable energy source. Technology has various problems which not delivered enough, in spite of the deployment efforts by various agencies. In spite of efforts by government, this technology is not delivering the promise due to the various reasons such as non-availability of cow dung for feed, breakdown of structure, leakage of gas holder due to corrosion, absence of maintenance services, lack of operational knowledge. It was observed that, motivation for construction of biogas plants were subsidy provided by the various agencies and economic benefits of technology. This indicates that subsidy and literacy of technology can become tool for promotion and extension. This study suggested that the existing biogas plants are functioning at a satisfactory level though there are lots of rooms for further improvement.

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REFERENCES

1. N.L. Panwar, S.C. Kaushik and Surendra Kothari., "Role of renewable energy sources in environmental protection: A review, Renewable and Sustainable Energy" Reviews vol. 15, pp. 1513–1524, 2011.
2. Ravindranath NH and Hall DO., "Biomass energy and environment a developing country perspective from India" oxford, United Kingdom: Oxford University Press. Renewable Energy Association ,2009.
3. Kurchania A.K., Panwar N. I., Savita P. D., "Design and Performance evaluation of biogas stove for community cooking application" International journal of sustainable energy 29(2): 116-23. 2010.
4. Census of India, 2001. http://www.censusindia.gov.in
5. Ministry of New and Renewable Energy (MNRE). New Delhi: Government of India; 2007 /http://mnes.nic.in/S
6. Ravindranath N.H. and Balachandra P. "Sustainable bio-energy for India: Technical, economic and policy analysis". Energy(2009),doi:10.1016/j.energy.2008.12.012
7. Yanfei Deng, Jiuping Xu, Ying Liu and Karen Mancl. "Biogas as a sustainable energy source in China: Regional development strategy application and decision making" Renewable and Sustainable Energy Reviews 35 pp. 294–303, 2014.
8. Debadayita Raha, Pinakeswar Mahanta and M. L. Clarke. "The implementation of decentralized biogas plants in Assam, NE India: The impact and effectiveness of the National Biogas and Manure Management Programme" Energy Policy vol. 68, pp. 80-91, 2014.