CHAPTER - I

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HISTORY AND GROWTH OF BIO-GAS PLANTS

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HISTORY AND GROWTH OF BIOGAS PLANTS IN INDIA :

1.1 INTRODUCTION :

In this chapter we explain the meaning of biogas and biogas plant. Then we present the brief history of biogas plants, pattern of subsidy provided by Central government as well as brief history and growth of biogas plants in Maharashtra, Sangli District and Miraj Taluka. Lastly we have made an attempt to review the available literature on biogas plants.

1.2 What is biogas and biogas plant ?

Biogas is biological energy which can be synthesised. Biogas is a flamable gas generated by anaerobic fermentation of various organic materials like cow dung, leaves, waste agricultural residues, grass and garbage.[1] Biogas produced by microbes when organic materials like above are fermented in a airtight place at specified range of temperature. Biogas contains methane, carbon dioxide, very small amount of hydrogen sulphide and nitrogen. It gives blue flame which can reach the temperature of 1400 Oc and release 8562 to 9500 Kilo-calories heat.

Biogas plant is a intrument which is prepared to obtain biogas and manure. It may be considered as a mini fertilizer factory of farmers which provides readymade good quality of plant nutrition to farmes.[2]

The slurry that comes out of biogas plant is high quality organic manure which increases crop yield by 10 to 25% more than farm yard manure. It is like a old adage. " Eat the cake and have it too."[3]

1.3 Brief History and growth of biogas plants in India :

The presence of methane (biogas) in farm yard manure was detected by Mr. Humphrey Davey in the early 1800's.[4] The first plant obtaining biogas was designed at London (U.K.) in 1851.[5] But in India the first plant was set up in 1900 at Matunga (Bombay).[6] After the first world war, production of methane was received in Great Britain and later on it spread. After second world war due to acute shortage of fuel caused by blockage of Nazi occupied areas, the process was satisfactoy as deviced by French scientists in North Africa in 1940 and it evoked good response in Austria, Italy, Russia, Kenya and South Africa.[7]

In the year 1939 Mr. S. V. Desai of Indian Agricultural Research Institute (IARI) designed and built a first cattle dung and studied the nature of the cattle dung degester process.[8] Later in 1946, Mr. N. V. Joshi designed, built and made available to the public a small plant.[9] The first break through in the manufactoring of practical plant was made available by Shri J. J. Patel, who patented his plant " Gramlaxmi " in 1951.[10] The research work was continued by the scientists of Indian Agricultural Research Institute and some individuals notably ' Swami Vishwa Karma of Bulurmath and Shri. S. G. Das Gupta of Khadi Pratisthan of Culcutta.' In 1959 the improved design of ' Gramlaxmi ' was adopted by Khadi and Village industries commission (KVIC). The KVIC since then has been popularising the use of Gobar Gas Plant through nation-wide programme. Gujarat state has been pioneer in the country by setting up of about 100 biogas plants in 1955-56. Till the end of 1974 Gujarat has maintained the lead by establishing 3000 plants out of total 7000 plants in the country. Then Haryana state has taken lead by setting up of 12,000 plants in next two years. U. P. Punjab and Maharashtra these states are accelerating the progress.[11]

Since after 1962 KVIC has been taking interest in promoting the development of biogas programme but upto 1974 it could not achieve satisfactory progress. After 1974 Government of India started to give subsidy for construction of biogas plants through KVIC.[12] This gave further boost to the biogas programme in India.

During the fifth five year plan KVIC constructed 0.66 lakh plants. During the 1981-82 Central Government launched National Project on Biogas Development (NPBD) and a separate department was also set up by the government of India under the Ministery of Energy i.e. Department of Non-Conventional Energy Sources (D N E S). During the sixth plan period KVIC constructed a little over 0.61 lakh plants. During the first two years of seventh five year plan KVIC could install 40,249 plants. Upto 1986-87 KVIC installed 1.82 lakh biogas plants.[13]

After 1981 Gobar Gas Research Planning and Action Department Lecknow has been popularising ' Janata ' biogas plants and Zilla Parishads, Panchayat Samitis and Panchayats are involved in it also.[14] After 1981-82 the scheme is transfered to Zilla Parishad.[15] In sixth five year plan there was a target of 4 lakh biogas plants which is achieved during this plan. First two years of Seventh Plan i.e. 1985-86 and 1986-87 additional 3,92,391 plants were set up by bringing the total number of plants in the country to 8,44,000. This achievement was mostly due to subsidy assistance provided for the project.[16] In addition to this 134 community biogas plants and institutional biogas plants were set up upto December 1985. These community biogas plants act as focal points fo socio-economic uplift of the community providing sanitation toilet facilities.[17]

The programme was being implemented by the department of co-operation, dairy development co-operatives, milk producing co-ooperatives, Khadi and Village Industries Boards, KVIC and voluntary agencies registered under 1860 act.

1.4 Pattern of subsidy by Central Government :

Central government gives subsidy for family based biogas plants under national project for biogas development as shown in the following table.

Table No. 1.1

1.4:1 Pattern of government subsidy for biogas plants for 1985-86.

Capacity of plants (in cubic) metre	Amount of Central Government subsidy (in Rupeees)		
	For North-Eastern Region States, Sikkim and notified hilly areas and desert districts	S.C. S.T. Small and Marginal farmers including Landless labourers	For all others
1.	1500	1250	830
2.	2940	2350	1560
3.	3600	2860	1900
4.	4300	3220	2140
6.	5350	3920	2610
8.	6400	3100	3100
10.	8080	3700	3700
15.	11440	5430	5430
20.	15200	7300	7300
25.	17640	8190	8190

1.4.2 Funding pattern for community and institutional bio-gas plants for 1985-86 :

Community biogas plants : Capital cost - 100 % by Government of India including cost on controlled operation upto a maximum for one year (Normally for Six months).

In the World Energy Conference held in Sept. 1983, late Prime Minister Indir Gandhi underlined the importance of decentralised system of alternative sources of energy. She said, " All known strategies of development and rising living standards of poor are dependent on centralised system.[18] It is necesary to promote regional self relience and help further utilization of material as the animal and plant wastes which are available in the villages. Such processes could be managed and maintained even by those who do not have such education.

1.5 Potentialities in India :

According to the estimates, the total availability of wet cattle dung is about 575 million tonnes per annum assuming the average wet dung available per animal per day to be 10 Kg. at collection rate of 66 %. If the total quantity of dung is put to use by bio-gas plant

22,425 million litres of kerosene can be saved per year. Nearly 206 million tons of organic manure would be produced annually by the bio gas plants saving about 1.4 million tons of Nitrogen, 1.3 million tons of phosphate and 0.9 million tons of potash.[19]

1.6 Various models of bio-gas plants developed by Governmental and non-governmental R and D Agencies in India :

A typical bio-gas plant consists of a digester where the anaerobic fermentation takes place. A Gas holder for collecting the bio-gas, the inlet and outlet units for feeding the influent and removal of the effuent respectively. The basic design of bio-gas plants can be classified according to two characteristics.

i) Arrangement of the gas holder in the plant.

ii) Mode of flow of slurrry.

According to these two characteristics, the plant designs are of the following three cattegories.[20]

1.6:1 Floating gas holder design :

The gas holder design is flexible unit attached to the digester. It may be a drum floating on slurry supported by a central guide pipe as in te K.V.I.C. Model. The movable gas holder maintains fairly costant gas pressur in the whole gas distribution system.

1.6:2 Integrated design :

In this design both digester and gas holder can be built below the ground. Therefore it saves space and facilitating temperature regulation inside the plant. In this design the upward extension of the digester serves as gas holder. This design is cheaper than floating gas holder design because it saves the expenditure on mild steel gas holder.

1.6:3 Separate gas holder design :

In this design plant is separated from the gas holder. The gas outlet pipe is set into the gas tank cover which opens at the bottom of tank. In this system more than one digesters are usually connected to a separate the gas holder.

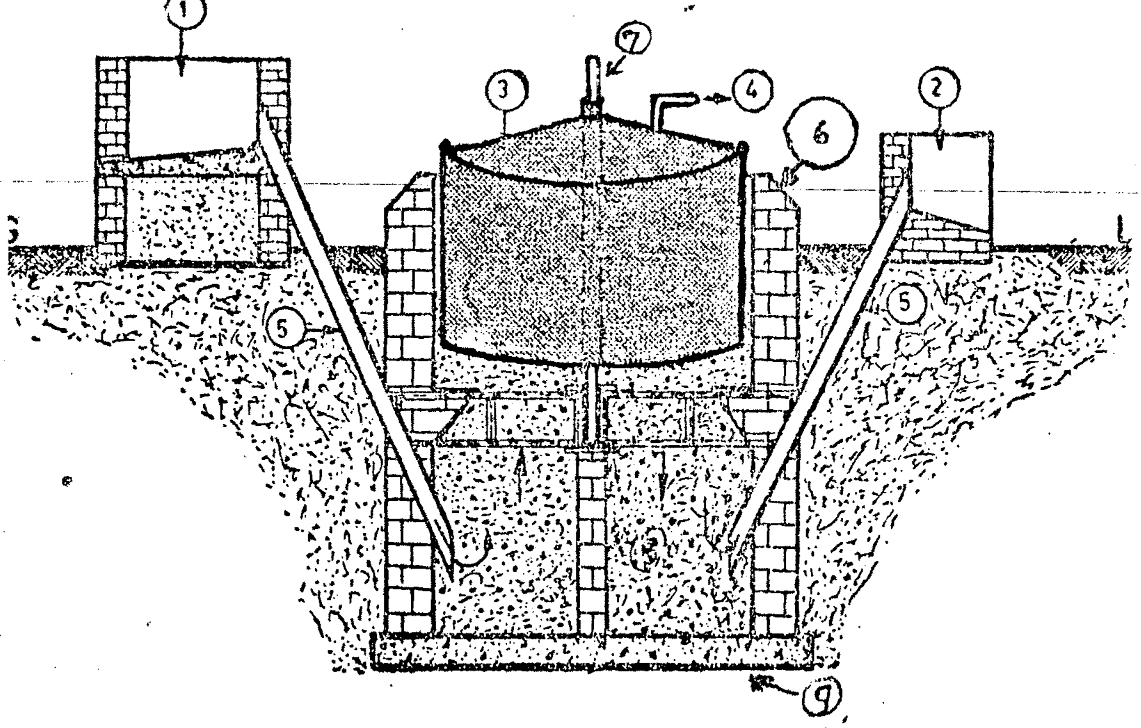
1.7 Different Models :

In India there are different models of bio-gas plants. In the light of the policy guideline regarding multi-model and multi agency approach, many agencies (governmental and non-governmental) have taken keen interest and developed so many models in view of the basic principles of construction of bio-gas plants. They have reduced the scarce materials and consequently the cost of plants. Different models of bio-gas plants which are developed by various R and D agenciesas follows :

1.7:1 KVIC Model :

This model was popularised by the K.V.I.C. based on a model designed by Shr. J. J. Patel in 1951. This model is the pioneer of floating drum gas holder **design.** The digester is an underground masonarry tank, the depth which varies according to size of plant The gas holder acts as a cover of digester. The drum rises as gas is collected and accumulatedand vice versa. The advantage of this model is its capability to maintain steady pressure of biogas by the movement of the gas holder. Periodical maintenance of the gas holder for preventing corrosion, difficulties in maintaining optimum fermentation conditions when the digeter is exposed to automoshperic temperature and wind. Expensive construction materials, steel gas holder, transportation and on the site fabrication of the mild steel gas holder are major onstraints in popularising this plant.

KVIC MODEL



1) Feed Chamber

2) Discharge Chamber

3) Gas Holder

4) Outlet Pipe for Gas

5) Feed Pipe

6) Digester Wall

7) Guide Pipe

8) Dividing Wall

9) Foundation Layer

1.7:2 Janata Model :

The Janata Model is a modification of the Chinese fixed model. It is a continuous fixed dome model. It has a underground cylindrical digester and hemispherical dome without manhole cover The gas holder is through a small piece of G I pipe fitted at the top of the dome. The digester and the gas holder dome are made of bricks and cement masonary. The floor of the digester is of cement concrete and brick ballast. The dome is constructed with frame work prepared from localy available shuttering materials such as bamboo, wooden planks etc., This model requires great care and skill in construction of the dome.[22]

Generally it is accepted that a closed type bio-gas plant or fixed dome plnt is cheaper than that of the KVIC plant which has a mild steel gas holder. This plant is not a constant pressure plant permitting the efficient use of gas. This type of plant was installed on a very large scale in China, numbering about 7 million bio-gas plants. It is stated from reliable source that about 50 % of them are not in working conditions in China.[23] It is, therefore, recommended that field trials in clusters be carried out using this design in various temperature zones and its performance carefully assessed.

1.7:3 MCRC Design :

This plant is different from the Janata model. It is a closed type variable pressure plant with a divider wall, similar to the one used by the KVIC model. In this model offtake of gas is possible only when a positive pressure develops after the dome rises to its full extent.[24]

1.7:4 TNAU & ASTRA Designs :

Tamil Nadu Agricultural University, Coimbatore produced four closed type plnt designs. Two of them are mobile metal plant designs. One of them is cylindrical in shape and other in the form of cube. Out of the other two, one design closely resembles Janata Model and other is akin to the Nepalese varsion of Chinese plant using a concave bottom and ferocement dome. The special merit of this design is the small retention period of only 15 days.

The ASTRA design is a modification of the KVIC design with lower retenton period of 35 days. The dimension of the digester and the gas holder are optimised for minimum cost. Two experimental plants with capacity of 2 Cu. m. and 6 Cu. m. are istalled and there performance over a period of one year is reported to be marginally superior to the KVIC design of same capacity with 40 % less cost.

1.7:5 Gayatri model :[25]

This model is developed by Government Implement factory, Bhubaneswar. It eliminates the use of the bricks dome and brings down the use of cement to the minimum. Instead of brick dome, a pre-fabricated fibre glass reinforced plastic (F R P) dome of the same dimension is used for collecting the gas. Mud slurry is used for construction of digester.[27] Hence this model is claimed to be less expensive than the Janata model. Moreover pre-fabrication of dome and its transportation are quite easy. A pilot scale Gayatri model plant of 2 Cu.m. capacity had been functioning satisfactorily at the Government Implements factory, Bhubaneswar.

1.7:6 Ganesh Model :

This model is an improved version of the KVIC model. In this model there is no use of cement. The digester is made of bamboo strips, mild steel rods and low density polythylene sheets. The gas holder is made of high density Polyethylene sheet. The structure of gas holder is as lik KVIC model. Plant construction is easier since locally available raw materials like bamboo splits. The

HDPE shits are found to check water seepage better than cement or bricks. However, the life expectancy of the HDPE gas holder tends to be short due to its exposure of ultra violet rays. A small size pilot model was commissioned at the Government Implements factory, Bhubaneswar.

1.7:7 Manipal Model :[28]

This model is blend of the Indian and Chinese modes. The digester is in the form of a rectangular tank built of masonary, with a flat but sloping RCC roof. The gas holder is integrated with the digester and the sloping roof permits a larger capacity for holding biogas over the slurry with small increase in the depth of the tank. This model is economical because it replaces the mild steel gas holder with small ferro-cement gas holder.

1.7:8 Jyoti Top Loaded Digester :

This model is designed by Jyoti Solar Energy institute, Baroda. in this model fresh bio-mass is fed through the top of the gas holder to surface of the slurry by means of a plunger arrangement. This model solvesthe problem of scum formation which is acute in case of agricultural wastes digestion.

1.7:9 Belur Math Model :[30]

This model was designed by Swami Vimukhanand at the Ramkrishna Mission Belur math. This model consists of the digester which is simple pit dung in the earth. It can also built with bricks or sheets. It has an inlet outlet and a gas proof metalic cover. This gas holder consists of two cylindrical tanks, one inverted over the other. The lower tank is filled with water. The gas pipe runs through its bottom to above the water level. The lower end of the pipe is connected with the heating or lighting devices. The slurry is fed into the digester.

1.7:10 The NEERI Model :

This model is developed by National Enviromental Engineering Research Institute, Nagpur. In this model the digester is partly above and partly below the ground level with a floating drum at the top to collect gas. It is intended to run on night soil. Night soil and water in the ratio of $1:\frac{1}{2}$ are fed into the digester. There is a provision in the digester for intake of night soil slurry and removal of sludge. Ten lbs of lime can be added initially for acceleration of gas production.

1.7:11 IARI Model :

This is the first biogas model designed in the country.[31] It consists of a floating drum gas holder introduced upside into the digester. The digester is constructed with bricks and masonary, while the gas holder is made of mild steel.

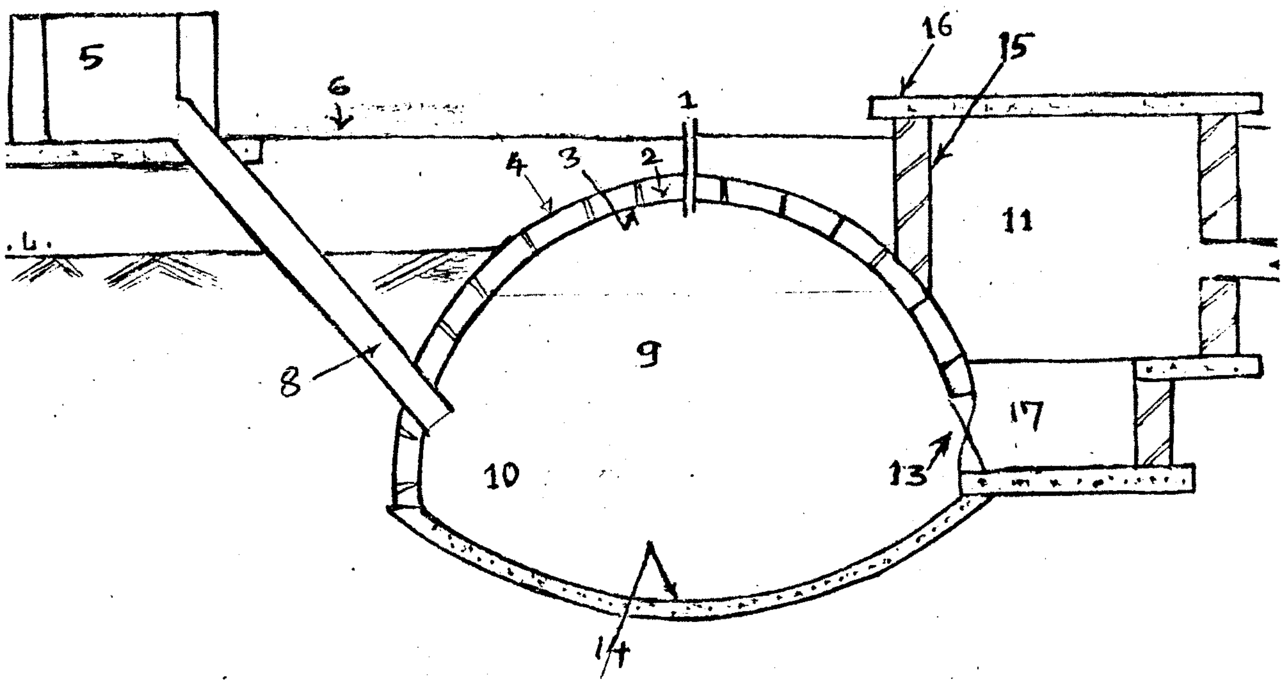
1.7:12 Dinbandhu Model :

This model is designed and constructed by Action for Food Production, New Delhi. This design consists of two segment of sphere of different diameter joined at their basis. The structure thus formed acts as a digester and the gas storage chamber respectively. The retention period of this plant is 40 days.

1.7:13 The Keragiri Horizontal Plants :[32]

This model was developed by the department of Agriculture, Government of Kerala, exclusively for high water table areas, water logged locations and areas even below sea level. This model requires lesser depth. It can also use other biomass material such as water hyacinth.

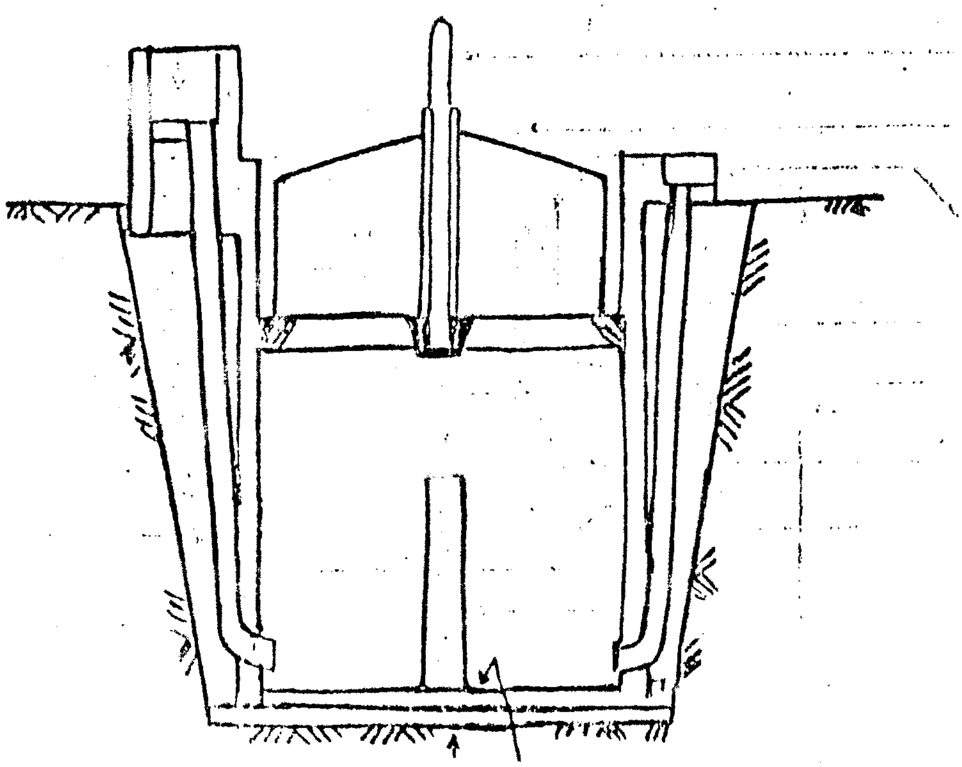
DINBANDHU MODEL



1) Gas outlet pipe
2) Brick Masonary
3) Plaster
4) Plaster
5) Mixing Tank
6) Plinth Level
7) Ground Level
8) Inlet Pipe
9) Gas storage
10) Digester
11) Displacement Chamber
12) Slurry discharge hole
13) Outlet opening
14) Foundation Cement Concrete
15) Brick Masonery
16) Cover R.C.C. Slab
17) Outlet Tank

SHIVASADAN BIOGAS PLANT

(Improved Model of KVIC)



1) Feed Chamber.

2) Discharge Chamber.

3) Gas Holder.

4) Outlet Pipe for Gas

5) Feed Pipe

6) Readymade Digester Wall

7) Guide Pipe

8) Dividing Wall

9) Foundation Layer.

1.7:14 ' Shivasadan ' Biogas Plant :

This model is an improved model of the KVIC model which is constucted by Shivasadan Co-operativ Housing Society Ltd., Sangli, in August 1988. This is a readymade biogas plant available in the factory.[33]

1.8 History and growth of biogas plants in Maharashtra State

Maharashtra state is a developed state in all respect compared to the development of other states especially the sectors like agriculture and industry are developed rapidly. The co-operative movement in Maharashtra is also developed one. New techniques and new methods of cultivation have been adopted in agricultural sector. Development of biogas plant programme in Maharashtra is acepted as a tool of rural development and especially agricultural development.

1.8:1 History and Growth :

The first plant for obtaining methane from waste materials was set up in 1900 at Matunga (Bombay).[34] The first biogas plant was constructed by Late social worker Shri. Appasaheb Patwardhan in 1955 at ' Gopuri ' in Ratanagiri district (now it is in Shindhudurg district).[35] This is the pioneer plant in Maharashtra. Many social workers like Shri. Appasaheb Patwardhan have tried to popularise this scheme after 1955.

The biogas scheme is being implemented by the Government of India through the state governments (i.e. Zilla Parishads and Khadi and Village Industries Commission). Khadi and Village Industries Commission has been popularisin and implementing through nation wise programme since 1962 in the Maharashtra state. The biogas development scheme is transfered to Zilla Parishads, Panchayat Samitis and Khadi and Village Industries Commission by the Maharashtra Zilla Parishads and Panchayat Samitis Act 1961.[36]

The total biogas plants constructed in Maharashtra by Maharashtra State Khadi and Village Industries Commission is 30,463 from 1962 to July 1989. The above figure shows poor performance in implementing the biogas programme because they could not reach to the rural people.

Since 1981 Govt. of Maharashtra is implenting this scheme by Zilla Parishad too on a large scale. Zilla parishad have reached to the grass root level i.e. village level. They are getting full response from the rural masses. Following table shows Divisionwise biogas plants in Maharashtra State(by Zilla Parishads) during 1982-83 to 1987-88.

Table No. 1.2

Divisionwise Biogas Plants in the Maharashtra State.

Division	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
	A	A	A	A	A	T	T
Bombay	1341	1991	8381	9525	10722	6000	5300
Pune	1643	5838	14495	20044	17112	13700	8400
Aurangabad	2756	13581	27050	28623	59639	25000	18400
Total :	5740	21410	49926	58192	87473	44700	32100

(A = Achievement. T = Target)

Source Govt. of Maharashtra - Maharashtra Legislative Secretariate Library -

Performancc Budgct:

1983-84, 1984-85, 1985-86, 1986-87, 1987-88 & 1988-89.

Rural Development Department, Government Press Nagpur. 1982, 83, 84, 85, 86, 87, and 1988., p.p. 464,465, 477, 478, 489, 490, 448,449 & 369,370.

In Maharashtra actually 2,22,741 biogas plants are constructed by all Zilla Parishads during the year 1982-83 to 1986-87, and 30,463 plants are constructed by Khadi and Village Industries Boards during 1962 to 1989.

1.9 History and growth of bio-gas plants in Sangli District and Miraj Taluka :

1.9:1 Sangli District :

Sangli district is one of the progressive districts of Maharashtra state particularly in agriculture, industry and trade. There are 8 Co-operative Sugar factories. These factories are the indicators of agricultural developments. Western part of this district is developed and eastern part remain backward due to recurring drought conditions.

New techniques and new methods have been implemented in the agricultural sector. Bio-gas plants as a new tool of agricultural and rural development have been adopted on a large scale since 1981. Khadi and Village Industries Board has been popularising bio-gas plants through nationwide programme since 1962. Zilla parishad Sangli and Panchayat Samitis trying to increase the bio-gas plants by providing credit subsidies from government and technical know how to plant holders. Co-operative Sugar factories are also giving incentives to their members by providing special assistance of Rs. 1,500/- for construction of Lantrines.

The first bio-gas plant was set up in 1963 at Daphalapur village of Jat Taluka. This is the pioneer plant in the Sangli District.[38]

Khadi and Village Industries Board, Sangli has set up 1300 bio-gas plants of K.V.I.C. model during the period between 1963 to Sept. 1988.

Since 1981 Zilla Parishad Singli has been implementing the bio-gas programme on a very large scale. Zilla parishad have been popularising " Janata Model " bio-gas plant which is popularised by Gobar Gas Research Planning and Action Department, Lucknow. During the period between March 1982 to Sept. 1988, 13,652 bio-gas plants were set up by Zilla Parishad Sangli which are actually in operation.[39]

Block wise or Taluka wise bio-gas plants which are constructed during March 1982 to Sept. 1988 are shown in Table No. 1.3.

Table No. 1.3

Blockwise bio-gas plants in Sangli District implemented by Zilla Parishad.

Name of Taluka	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	March 1988 to Sept. 1988	Total
Tasgaon Taluka	29	305	413	650	600	1006	235	3238 (23.71)
Miraj Taluka	49	208	328	607	500	400	150	2142 (15.69)
Walva Taluka	125	332	531	752	625	1405	424	4194 (30.72)
Shirala Taluka	125	95	144	171	254	401	185	1261 (9.23)
Vita Taluka	43	205	75	341	201	300	81	1246 (9.12)
Jat Taluka	05	22	34	160	125	125	57	528 (3.86)
Atpadi Taluka	07	22	65	151	65	100	27	426 (3.12)
Kawathe Mahankal	32	51	80	177	155	151	51	697 (5.10)
Total :	301	1229	1670	3009	2525	3888	1030	13652

(Figures in the brackets show percentage to the total biogas plants in Sangli District)
(Source- Zilla Parishad Sangli Office record book)

Table No. 1.3 explains the blockwise situation about construction of biogas plants.

1) Walva Taluka is a leading taluka in Sangli district by setting up 4,194 biogas plants during 1982 to 1988 i.e. out of total bio-gas plants in Sangli district 30.72 % plants are in Walva Taluka.

2) Tasgaon and Miraj Talukas are very backward than Walva taluka by setting 3238 and 2142 biogas plants respectively.

3) There after Shirala, Vita, Kawathe-Mahankal, Jat and Atpadi these talukas have set up 1261, 1246, 697, 528 and 426 respectively during the period 1982 to Sept. 1988.

4) Comparatively Kawathemahankal, Jat and Atpati these three talukas have poor performance because these three talukas are economically backward due to scanty rain fall.

1.9:2 **Miraj Taluka :**

First biogas plant in Miraj Taluka was set up in July 1967 at Padmale by Shri Shamrao Vishvanath Patil. Upto 1980 Biogas programme was not so popular. After 1981 Panchayat Samiti Miraj has been popularising this programme very effectively. Upto 1980 the number of biogas plants was very negligible but after 1980 implementation of Biogas programme came under Zilla Parishads and it took the speed.

In 1982-83 target for Miraj taluka was only 60 bio-gas plants and achievement was only 49. In 1983-84 target was 150 biogs plants and achivement was 208. After 1982-83 Miraj Taluka has exceeded the target of bio-gas plants upto Sept. 1988, 2142 biogas plants were set up i.e. out of total plants in Sangli District 15.69 % plants were set up in Miraj Taluka.

1.10 Review of Literature on biogas plants :

Here we have made an attempt to review the available literature on biogas plants.

We collected the information from khadigaramodyog a journal of rural economy - " Economics of Gobar Gas Plants in Ahamadnagar District of Maharashtra by Patil S.J. and Dhongade M.P."[40]

In this study the main advantages of gobar gas plants, though are accepted as the best alternatives in the present predicament of fuel shortage and expensive nature of Chemical fertilizers, face some criticism in certain cases. It is, therefore necessary to workout their suitability according to the requirements and then install the plant of a size best suited in a given situation.

In view to workout the economics of gobar gas plants, a study was undertaken in Rahuri and Shrirampur tahsils of Ahamadnagar district of Maharashtra. Following were the main objectives of their study.

1) To estimate the establishment cost of gobar gas plant of different capacities.
2) To find out the economic returns of goabr gas plants of different capacities and
3) To estimate benefit cost ratio in plants of different capacities.

This study was based on a sample of 30 gobar gas plants selected purposively. For economic evaluation of different plants, the plants were divided according to their capacity. They have explained the composition of fixed cost and variable cost (operational cost). They have calculated the depreciation cost and interest on fixed cost. The value of dung was estimated in terms of Nitrogen, Phospate and Potash (NPK) obtainable from given guantity of dung. In estimationg this, it was assumed that the given quantity of dung produces 73 % of manure and NKP content of manure is 0.5,0.65 and 0.8 percent respectively. The estimated quantity of NPK was valued at prevailing market prices viz. Rs.3.49, Rs.3.87 and Rs. 1.37 per Kg. for NPK respectively.

Then they have calculated the total annual cost of gobar gas plant. Likewise they have calculated the total revenue which is obtainable from gobar gas and manure. The value of gas has been measured in terms of fuel, firwood, kerosene and cow dung cakes. The value of manure has been evaluated at the market price of NPK contents of the manur i.e. 1.6, 1.4 and 1.0 percent respectively. By using this percentage of manure content, they have calculated the total value of manure.

Lastly they have calculated the benefit cost ratio dividing by total annual cost to total revenue. Obtainable from gas and manure and found out that, the medium size plants are more profitable than the others.

We have also collected the information from " Biogas Energy in India " Socio-economic evaluation of biogas energy in India.[41]

In this study they have collected the data from the four states (M.P.,U.P., A.P. and Haryana) Eighty four villages and 173 plants were selected at random from four states.

In this study, they have worked out the level of education land ownership, size of land, land irrigated, total live stock and size of family of biogas plant holders. They have also worked out the purpose of installed plant, problems faced in maintaining the plants and suggestions to improve the plant technology. They have assumed that the economic life of biogas plant is 40 years. They have calculated the average fixed cost, average variable cost and average revenue of different size of biogas plants and estimated the benefit cost ratio. The total quantity of gas produced has been converted into firewood equivalent using the conversion factors worked out. On the basis of this manure **production** valued at the sample average price of manure per cart. The benefit cost ratio also varies with the increase in size of the plant. They have also found out that the community biogas plants are more economical than the others.

REFERENCEs

1) Khadi and Village Industries Commission - Khadigramodyog - The Journal of Rural Economy - Vol. XXXIV No. 4, June 1988, p. 408 Biogas Programme in India - I by Ramarao A.

2) Ibid., p. 399.

3) Ibid., p. 400

4) H. S. Dwivedi for Adarsh Seva Sangh - Rural India - January 1987, p. 13. A Community Biogas Plants - An experience of community project in villages of Gujarat - by Subuddi Karunamay.

5) Ravishankar - Kahani Biogas Kee - Agricol Publishing Akadami New Delhi, 4, 1984. p. 25.

6) Op., Cit., Rural India. p. 13

7) op., Cit., Rural india, p. 13

8) op., Cit., Rural India, p. 13

9) Moulik T. K. - Biogas Energy in India - Academic Book Centre Ahmadabad - July 1982, p. 2.

10) Op, Cit., Rural India p. 13

11) Op., Cit., Rural India p. 13 .

12) Yojana - july 1988 p. 8 - Biogas Yojaneche Mulyamapan by Dr. Jayant Welankar.

13) Khadi and Village Industries Commission - Khadigramodyog - The Journal of Rural Economy Vol. XXXIV No. 3, December 1987, p. 166 - March of Biogas Programme by Appanna C. H.

14) Op., Cit., Yojana, p. 8.

15) Government of Maharashtra - Performance Budget 1984-85, Rural Development Department, Government Press, Nagpur 1984, p.461.

16) Op., Cit - Khadigarmodyog p. 400.

17) Op., Cit - Khadigramodyog p. 402.

18) Op., Cit - Khadigramodyog p.399.

19) Op., Cit Khadigramodyog p..400

20) Op., Cit Khadigramodyog p. 402.

21) Op., Cit Khadigramodyog p. 404.

22) Op., Cit Khadigramodyog p. 405.

23) Op., Cit., Khadigramodyog p. 405.

24) Op., Cit., Khadigramodyog p. 406.

25) Op., Cit., Khadigramodyog p. 406.

26) Op., Cit., Khadigramodyog p. 406.

27) Op., Cit., Khadigramodyog p. 406.

28) Op., Cit., Khadigramodyog p. 407.

29) Op., Cit., Khadigramodyog p. 407.

30) Op., Cit., Khadigramodyog p. 407.

31) Op., Cit., Khadigramodyog p. 408.

32) Khadi and Village Industries Commission - Khadigramodyog - The Journal of Rural Economy - Vol. XXXIV July 1988, p.443 - Biogas Programme in India II by Ramarao A.

33) Shivasadan Grahnirman Sahakari sanstha Ltd. Sangli p.p. 1 to 4.

34) Op., Cit., Rural India, p. 13

35) Discussion with Nikam M.N. - Khadigramodyog Board, Sangli.

36) Op., Cit., Performance Budget 1984, p. 461.

37) KVIC Bombay (Office Record)

38) Khadi and Village Industries Board.(Informations Collected from Office Records)

39) Zilla Parishad Sangli - Agricultural Department (Office Record)

40) Op., Cit., Khadi and Village Industries Board Sangli (Office Record)

41) Khadi and Village Industries Commission - Khadigramodyog - The Journal of Rural Economy Vol. XXX No.4, January 1984 p.p. 195 to 198. Economics of gobargas plants in Ahamadnagar District of Maharashtra by Shri. Patil s. J. and Dhongade M. P.