ECONOMIC FEASIBILITY OF BIOGAS PLANTS IN HARYANA

By

SUNIL SURI

Thesis submitted to the Haryana Agricultural University in partial fulfilment of the requirements for the degree of :

MASTER OF SCIENCE

in

AGRICULTURAL ECONOMICS

College of Agriculture
ıryana Agricultural University

Hisar

1985

DEDICATED TO

My

RESPECTED DADIJI

and

PARENTS

CERTIFICATE I

This is to certify that this thesis entitled "Economic feasibility of biogas plants in Haryana" submitted for the degree of M.Sc. in the subject of Agricultural Economics, is a bonafide research work carried out by Shri Sunil Suri under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

DDGupta 15.12.85

(D.D.Gupta)
Major Advisor
Extension Specialist
(Farm Management)
H.A.U., Hisar.

CERTIFICATE II

This is to certify that the thesis entitled, "Economic feasibility of biogas plants in Haryana" submitted by Shri Sunil Suri to the Haryana Agricultural University in partial fulfilment of the requirements for the degree of M.Sc., in the subject of Agricultural Economics, has been approved by the Student's Advisory Committee after an oral examination on the same, in collaboration with an External Examiner.

Major Advisor

External Examiner

Head of the Department

Dean, Postgraduate Studies

ACKNOWLEDGEMENTS

I have great pleasure and profound privilege in expressing my deepest sense of gratitude to my major advisor, Dr.D.D.Gupta, Extension Specialist (Farm Management), for his continued interest, judicious guidance and valuable suggestions throughout the course of this investigation.

I would like to record my deepest thanks to the members of my advisory committee: Dr.Himmat Singh, Associate Professor, Department of Agricultural Economics; Dr.L.S.Kaushik, Associate Professor, Department of Mathematics & Statistics; Dr.A.R.Rao, Associate Professor, Department of Veterinary Physiology; Dr.B.S.Panghal, Associate Professor, Department of Agricultural Economics and Dr.Rajender Singh, Assistant Professor, Department of Microbiology for their valuable suggestions from time to time.

I am also highly thankful to Dr.A.C.Gangwar, Associate Professor and former Head of the Department and Dr.D.S.Nandal, Head, Department of Agricultural Economics for their suggestions and providing necessary help for conducting the present study.

I feel obliged to staff members Sh.Deepak Grover, Assistant Statistician; Sh.K.L.Banga, Assistant Professor (Agricultural Engineering), Kaul; Sh.Anil Rathee, District Extension Specialist (Farm Management), Kurukshetra and Sh.K.K.Sharma, Assistant Scientist, Department of Agricultural Economics and friends Sarvshri: Jagbir Singh, Pratap Singh, Randhir S.Kairon, Sushil Sharma, Balbir Singh for extending all sort of help when and where I needed.

Last but not the least, I owe sincere thanks to my parents and Dadiji for their blessings which enabled me to complete this work.

Sunil Suri

Hisar

December 17, 1985

(SUNIL SURI)

CONTENTS

INTRODUCTION

Presently, Indian agriculture is facing the problem of not only the shortage of fertilizers but also of organic manure due to a large scale burning of animal dung as fuel. Another problem which is faced by the farmers is the inadequacy of fuel. Firewood is becoming scarce and expensive. Cattle dung cakes are the main source of fuel in rural India. In Haryana too, dung cakes, firewood and plant stalks fulfil the major part of the fuel demands of rural households. However, burning of dung cakes is a national waste of valuable organic manure which can improve soil fertility.

Biogas plants can provide both fuel and manure. Biogas is obtained through the anaerobic fermentation of cattle dung. It contains 55 per cent of methane and 45 per cent of carbondioxide. It is an excellent fuel and burns without smoke. Biogas can be used for cooking, heating, lighting and running of engines. This gives more than 60 per cent of thermal efficiency for gas as against only 11 per cent by burning dung cakes. The manure so obtained contains more nutrients than farm-yard manure which is odourless and easy to apply on the fields. Thus, a biogas plant provides gas as fuel and enriched manure from the same quantity of dung.

It was known for centuries that a gas which can burn can be evolved from waste organic material. It was called 'marsh gas'. This phenomena was firstly used in the last quarter of the nineteenth century for the disposal of city effluents. In 1937, at Bombay, a sewage purification station was commissioned which inspired Dr.S.V.Desai of the Division of Soil Chemistry of the I.A.R.I. in 1939, to study the anaerobic digestion of cattle dung. Further work was carried out by Prof.N.V.Joshi of the same institution who developed a biogas plant in 1946. But, this design could not became popular. In 1954, Sh.Jashbhai J.Patel developed a commercially successful plant known as Gramlaxmi II. The Indian Agricultural Research Institute, New Delhi, Planning, Research and Action Institute, Lucknow and Swami Vishwakarmanand of the Ramakrishna Mission, Belur Math suggested several improvements in Patel's gas plant. In 1962, Patel's design was adopted by the Khadi and Village Industries Commission (K.V.I.C.) and this is the main organisation working for the promotion of biogas programme. The K.V.I.C. is providing technical guidance and financial assistance for the installation of biogas plants.

India has the largest livestock population in the world, with about one-sixth of cattle, half of buffaloes and one-fifth of goat population of the world. India possesses the capacity of installing more than 25 million biogas plants of 210 c.ft size and thus has a vast potentiality for the use of dung as a fuel and enriched manure.

Presently, in rural India, non-commercial sources of energy are animal dung (30 %), agricultural wastes (17%) and firewood (53%). Agricultural wastes and dung can easily be used in biogas plants which generate methane gas for fuel purposes and manure for raising of crops. By using dung and agricultural wastes through biogas plants, not only the quantity fed is put to a better use, it will also prevent the felling of trees for firewood.

We have 4,57,100 biogas plants in India by 1984-85 and the Government of India has a target of establishing 1.5 million family size biogas plants during the Seventh Five Year Plan with an annual subsidy of Rs.168 crores. Therefore, it becomes essential to study the economics of family-size biogas plants on individual farms.

In Haryana, there are six intensive biogas development districts, though the scheme of encouraging biogas plant is operating in all districts of the State. As per the plants installed upto 1979-80, the percentage of capacity utilization was maximum in Haryana, which was 1.69 per cent as compared to the all India average of 0.32 per cent. Upto 1984-85, 18,114 family-size biogas plants were installed in Haryana.

Whereas a great emphasis is being laid on the importance of biogas plants, there is a great need to evaluate the family size biogas plants from the economic point of view. In this study, only the fixed dome type (Janta Model) biogas plants have been studied, because at present this model is being mainly promoted by the Government and so far no attempt has been made to evaluate its economics. This study is intended to evaluate the economic feasibility of different sizes of biogas plants at the farm level through the benefit-cost analysis technique which is an important tool for the justification of an investment.

Installation of biogas plants results savings in the consumption of other fuels. In this study, savings in fuel consumption on the farms having biogas plants was also studied. Government departments and financial institutions are providing financial assistance as loan and subsidy, for the installation of biogas plants. There is need to study the utilization pattern of the financial assistance.

Specific objectives of the study are :

1. To study the economics of different sizes of biogas plants on various sizes of holdings.

2. To study the savings in the consumption of other sources of energy on the farms having biogas plants.

3. To study the utilization pattern of financial assistance on different sizes of farm holdings.

REVIEW OF LITERATURE

Rakib et al. (1968) reported that burning of cow-dung not only resulted in wastage of manurial value of dung but also led to extensive prevalence of trachoma amongst housewives due to abnoxious smoke of burning dung-cakes in kitchen. Gobar-gas being non-poisonous, provided an ideal sanitation because the digested slurry does not attract flies and insects.

Chawla et al. (1969) carried out laboratory experiments for increasing biogas production during winters. They estimated that on an average about 27 per cent of dry matter of dung is converted into combustible gas, leaving a spent resistant fraction of about 73 per cent to be utilized as manure. The yield of gas could be increased by addition of sugar, cellulose and leaves. Gas production could also be increased by addition of urine.

Mann et al. (1972) carried out chemical analysis of dung and slurry. They observed that nitrogen availability is increased by microbial degradation of gobar in biogas plants. It was also found that there was no significant change in the availability of P and K. Biogas plants also yields bio-manure with lower C/N ratio which controls soil-productivity. Their analysis has proved that bio-manure obtained through biogas plant is better than the farm-yard manure.

Chawla (1972) explained the benefits of gobar-gas plants. The major benefit is the gas used for fuel purpose. It provides a highly sanitary method of disposal of dung and other waste materials, as slurry produced by gobar-gas plants is odourless and free of flies and other insects. The spent slurry is a superior manure in three major plant nutrients i.e. N, P and K. It was reported that dung cake has a utilization efficiency of 11 per cent whereas gobar gas has 60 per cent. It was further reported that dung, considered the cheapest fuel to buy, was found to be most expensive due to its low utilization efficiency.

Misra (1974) conducted studies in the Ratlam district of Madhya Pradesh and assessed the benefits of 150 c.ft plant through (a) use of gobar gas as fuel and (b) rise in level of production due to rich quality manure of slurry. He found an increase in cropping intensity from 140 to 150 per cent due to more availability of manure after the installation of plant.

Bio-manure was double in humus than F.Y.M. and had 2.5 per cent nitrogen against 0.75 per cent in F.Y.M. There was 20-33 per cent increase in the level of production of various crops and on sample farms (average 10 acre farm), there was an additional income of Rs.3274.6 from the use of bio-manure. He calculated annual expenditure as Rs.1012.50 and annual income as Rs.1600, leaving a surplus of Rs.587.50 to repay the loan.

Patel (1974) conducted benefit-cost analysis for four different sizes plants of 100, 150, 200 and 250 c.ft. The study revealed that plants were underutilized as farmers used only 29, 37 and 54.7 kg gobar/day against recommended quantity of 65, 100 and 165 kg/day for 100, 150 and 250 c.ft plants respectively which formed only 41 per cent of the recommended dose. Plant owners did not have the requisite number of animals. The size of the plant increased with the increase in land holding size, number of cattle and size of family. He also found that in the total benefits of Rs.372, 358 and 600 per year for 100, 150 and 250 c.ft plants respectively, share of fuel, better manure, dung saved and lighting was 66.7, 26.6, 5.8 and 0.9 per cent respectively. The owners used other fuels along with gobar-gas to meet their 42.57 per cent fuel requirements. The general belief of saving of large quantities of dung through bio-gas proved to be wrong because bio-gas replaced crop-stalks and firewood and not dung-cakes. Biogas replaced only 7.32 per cent petroleum products. The main advantage was reported for cooking gas and better manure.

Biswas (1974) studied 100 c.ft capacity gas plant for a family of five or six members and having 5 to 6 heads of cattle. The calorific value of gas was found to be 550 B.Th.U./c.ft (1491 K cal/cu.m.). It was estimated that such a biogas plant in a year could produce 40,000 c.ft of combustible gas and residual slurry with manurial value equivalent to 100 kg of urea, 250 kg of single superphosphate and 50 kg of potassium sulphate. He also found that large sized biogas plants can be used for industrial purpose and running of engines.

Nahar (1975) compared benefits from 45 kg gobar/day for a year by composting it in manure pit (Rs.105), converting it into dung-cakes for fuel (Rs.197) or processing it through gobar gas plant (Rs.303). He also pointed out some short-comings such as gobar-gas had 40-45 per cent CO_2 which reduced the efficiency of gobar gas and caused deposition of CO_2 in the engines and burners. Production of gas was low in winter and a lot of ammonia gas (nitrogen source) was lost when slurry was made to dry.

Bhavani (1976) did the economic evaluation of a community bio-gas plant along with that of family size plant. It was estimated that if entire dung available from 237 million cattle population of India was used in biogas plants, it would give 28 million tonnes of N, P_2O_5 and K_2O nutrients and

23425 million cubic meter of gas. Assuming distribution cost to be zero and one-third dung used as fuel previously, net present value (NPV) of a community biogas plant at 10 and 20 per cent discount rates was calculated to be Rs.75491.77 and Rs.33193.92 respectively.

Net present value (NPV) and benefit-cost (B/K) ratio for 2 cubic meter plant was calculated under different assumptions. Assuming that two-third dung was used as manure previously, NPV was calculated to be Rs.1366.33 and Rs.63.98 and B/K ratio as 1.4556 and 0.9751 at 10 and 18 per cent discount rates respectively.

With the assumption that entire dung was used as manure previously, NPV was Rs.792.98 and Rs.453.19 and B/K ratio 1.2344 and 0.8266 at 10 and 18 per cent respectively.

Under third set of assumptions, that whole dung was burnt previously, NPV came to Rs.2692.93 and 829.38 and B/K ratio 1.898 and 1.3173 for 10 and 18 per cent discount rates, respectively. If additional value of manure was not considered, NPV even at 10 per cent discount rate was negative.

Bhatia (1977) presented a framework for a detailed social benefit cost analysis of investments in biogas plants. He estimated Net prevent values (NPV) and benefit-cost ratios (B/C Ratios) for 70 c.ft plant at 10 per cent social rate of discount under two cases. For first case, where only value of gas is considered, NPV is negative at different levels of gas use and B/C ratio varies from 0.37 to 0.69. For second case, with additional value for manure, NPV is again negative and B/C ratio varies from 0.62 to 0.97. This indicates that the investment in biogas units is unprofitable. Under another situation when investment cost was reduced by 30 per cent, biogasplant was found to be economical only in case when gas is used for lighting purpose and additional value of manure is considered. He also mentioned that investment in biogas plant to run irrigation pumps is not economic from the view point of society.

His studies indicated that investment in biogas units was not economical from the view point of society.

Jain and Mishra (1978) explained that 12-15 c.ft of gas is required for cooking meals per person per day and 10 c.ft of gas for lighting 40 candle power lamp per hour. It was found that optimum temperature for gas production is 30^{o}-$35^{o}C$. It was further found that fresh slurry contains 3 per cent nitrogen which on drying drops to less than 2 per cent. On oven dry basis the cow dung slurry contains 1.6-1.8 per cent N, 1.1-2.0 per cent P_2O_5 and 0.8-1.2 per cent K_2O.

Sirohi and Singh (1981) conducted study on biogas plants for three categories of farm households for the North as well as South India. The three categories were (i) farmers using the gas for fuel, (ii) peasants working on non-farming jobs, and (iii) farmers using gas for running the engine of the pumping sets. The cost of KVIC biogas plant was considered and benefit-cost ratio and present worth was calculated under different situations.

It was reported that the KVIC family size biogas plants ranging from 2-8 cubic meter size were not financially feasible in North India as well as in South India if the gas was not used for productive purposes. Only bigger sized community plants were found to be financially feasible for cooking purpose to the farmers who purchased about 50 per cent of fuel used for cooking.

I.F.F.C.O. (1982) reported in their bulletin 'Biogas plant' that the total biogas generation potential of total quantity of available dung in India is 22,57,526 million c.ft, sufficient to meet the cooking fuel needs of 400 million persons. Assuming a 60 per cent exploitation, a production of 13,54,000 million c.ft of biogas per annum was estimated which could meet the cooking fuel need of 264 million people. It was estimated that the slurry thus produced will have a nutrient content of 2.70 million tonnes. It was also reported that direct composing of fresh dung results in 50 per cent of manure and there will be loss of nitrogen, whereas manure through biogas plants is 73 per cent of the quantity of dung fed and this manure is rich in nitrogen and other nutrients.

Rao and Malik (1982) had made a study of four alternative modes of utilization of dung. These four alternatives were (i) dung as a source of manure, (ii) dung used as dung cakes in the common chulah, (iii) dung used in biogas plant and gas is used for cooking, and (iv) biogas as a diesel replacer for running diesel engines. The assessment of the diverse uses of dung confirmed that biogas is a superior option and that the gas has greater utility as a replacer of diesel for stationary engines than as a cooking fuel.

Prasad and Sharma (1982) did the economic evaluation of different sized plants. Benefit-cost ratio was computed by considering (i) cash and non-cash expenses and (ii) cash expenses only. In both conditions, the benefit-cost ratios were calculated for the situations with and without subsidy. The B/K ratios were minimum (1.86) in case of 150 cubic ft plant and maximum (2.25) in case of 250 cu.ft plant with subsidy for the first condition. It was found that the 250 cu.ft plants were more profitable followed by 300 cu.ft plants whereas 150 cu.ft plant had the least economic feasibility. The B/K ratio declined in case of those without subsidy.

For the second condition, the B/K ratios varied from 1.13 to 1.73 and 1.06 to 1.59 in case of with and without subsidy for 150 and 300 cu.ft plants respectively.

Varma (1983) made a broad study at the national level. According to his assumption if 55 per cent of total dung is collected it will give 39.85 million cubic metre gas. This amount of gobar gas in terms of petroleum product is equivalent to Rs.2794.26 crores, which is 51 per cent of total oil importing bill. If this oil import is reduced, the oil import bill as percentage of entire export earnings will come down from 79 to 35 per cent. He made comparison of biogas energy with electricity and diesel alternatives and found the use of biogas energy highly economical. By utilizing biogas energy potential to the maximum extent there would be a saving of Rs.770 crores every year, the burden on subsidies and loans will be Rs.168 crores every year whereas there would be a net saving of Rs.502 crores. The energy crisis and balance of payments can improve to a large extent by using biogas technology.

K.V.I.C. (1983) in its booklet "Gobar-Gas, Why and How" reported that by passing gobar through the gobar gas plant, there was 20 per cent more heat than that by burning entire amount of gobar owing to 60 per cent thermal efficiency of gobar-gas against only 11 per cent thermal efficiency of dung cakes. The amount of manure obtained through the gas plant is 43 per cent more than the pit manure.

Patil and Dhangade (1984) studied the economics of gobar-gas plants in Ahmednagar district of Maharashtra. The study was based on a sample of 30 plants of different sizes for which benefit-cost ratios were estimated. In the annual costs, the share of fixed and operational costs was 23 and 77 per cent respectively. The benefit-cost ratio was highest (2.61) in case of 250 c.ft plants followed by 150 c.ft (2.24) and 350 c.ft (2.05) sized plants. The study revealed that medium sized biogas plants (250 c.ft) were relatively more profitable.

In most of the studies, the major emphasis has been laid on the availability of manures from biogas plants. The manure produced from these plants is rich in NPK and has low C/N ratio which improves the soil fertility. Beside this, the bio-gas has thermal efficiency of 60 per cent as against 11 per cent that of dung cakes. According to the estimates of different research workers total bio-gas generation potential of India is 22,57,526 million cft which is sufficient to meet the cooking fuel needs of 400 million persons.

Economic feasibility of bio-gas plant has been worked out in many studies. In most of the studies practical field data had not been collected and results are based on the KVIC data, with minor changes in the values. Biogas had been valued in coal or kerosene equivalents, this is not in realistic because practically farmers uses either dung cake or firewood. The benefit cost analysis had been used for working out economic feasibility and in most of the studies this ratio was found more than unity, which proves the economic feasibility of biogas plants. It had been found in most of the studies that biogas plants were economical to the farmers keeping in view the opportunity cost of biogas and additional manure provided by these plants.

METHODOLOGY

This chapter deals with the methodology adopted to examine the economic feasibility of biogas plants in Haryana, saving in consumption of other sources of fuel and utilization pattern of financial assistance. A brief description of sampling design, source and method of collection of data and methods of analysis is given below:

Sampling

Multistage sampling technique was used. At the first stage, a district-wise list of biogas plants in Haryana was prepared which is given in Table 3.1.

Table 3.1: District-wise list of Biogas Plants in Haryana (upto March, 1984)

S.No.	District	Number of biogas plants
1.	Ambala	1259
2.	Kurukshetra	2099
3.	Karnala	2008
4.	Sonepat	603
5.	Rohtak	801
6.	Hisar	2063
7.	Bhiwani	1408
8.	Sirsa	1410
9.	Gurgaon	1182
10.	Faridabad	388
11.	Jind	722
12.	Mohindergarh	1172
	Total	15168

Source: Division of Agricultural Engineering, Department of Agriculture, Haryana.

Among these districts, Kurukshetra having the maximum number of biogas plants in the State was selected purposively. In district Kurukshetra, Thanesar block was randomly selected for the study.

At the third stage of sampling, 10 villages having biogas plants of Thanesar block were selected randomly for the purpose of data collection. Only the working biogas plants of Janta Model were selected for the study of economics of the plants and savings in fuel cost. Information regarding the non-working biogas plants of those villages was also collected. A list of villages along with number of working biogas plants is given below in Table 3.2.

Table 3.2: List of sampled villages and village-wise distribution of sampled biogas plants

S.No.	Village	Number of biogas plants
1.	Girdhapur	20
2.	Masana	9
3.	Singhpura	9
4.	Dhurala	4
5.	Kaulapur	4
6.	Pratapgarh	3
7.	DheruMajra	3
8.	Kheri Brahman	2
9.	Bahri	2
10.	Haripur	1
	Total	57

Source: Sub Divisional Officer (Biogas), Kurukshetra.

In the selected villages, the biogas plant owners were classified into small (0-2 ha), medium (2 ha-5 ha) and large (more than 5 ha) farmers according to their operational holdings.

Source of data

Data were collected from both the primary as well as secondary sources. Primary data were collected from the selected biogas plant owners. Secondary data were collected from the Department of Agriculture, Government of Haryana through the Division of Agricultural Engineering, Deputy Director of Agriculture, Kurukshetra and Sub-Divisional Officer (Biogas), Kurukshetra.

Data collection

A suitable questionnaire was prepared to collect information from farmers on size of holdings, number of animals, size of family, size of plant, year of installation, establishment cost, operational cost, consumption of gas, quantity of manure and other benefits accrued to the family, amount of subsidy and loan obtained, etc. The data were collected by personally interviewing the owners of biogas plants.

Secondary data were collected from the concerned departments about district-wise list of biogas plants in the State and the number and other details of biogas plants installed in selected villages.

Analytical techniques

Benefit-cost (B/C) ratio analysis was done to examine the economic feasibility of installing different sizes of biogas plants on various sizes of holdings.

In the benefit-cost ratio analysis, the following components of costs and benefits were considered:

A. <u>Cost-components</u>

i) <u>Depreciation:</u> Depreciation was calculated on the masonary work and steel structure separately considering the life of masonary work as 20 years and of steel structure as 10 years. Salvage value was taken as 10 per cent of initial cost. Formula used for calculating depreciation was as follows:

$$\text{Depreciation} = \frac{C - S}{n}$$

where

C = Initial cost;

S = salvage value; and

n = life of plant in years.

ii) <u>Interest:</u> Interest on average investment was calculated @ 12 per cent per annum generally charged by banks for such advances. Formula used was as follows:

$$\text{Interest} = \frac{C + S}{2} \times i$$

Where

C = Initial cost;

S = salvage value; and

i = rate of interest.

iii) <u>Repairs and maintenance cost</u>

iv) <u>Labour cost:</u> Biogas plants in the selected sample were of various sizes and the time spent each day varied accordingly.

Actual labour put in by farm family per day was converted into man-day equivalents and priced at the prevailing wage rate in the locality.

The cost of dung was not included in costs and therefore, only additional gains in nutrients level of the slurry through biogas plant was considered on the benefits side.

B. Financial benefits

i) Gas: Value of gas was taken in terms of firewood. 1m^3 of biogas is equal to 3.5 kg of firewood. Annual utilization of gas was converted in terms of firewood and priced at prevalent prices.

ii) Manure: Only the value of additional nutrients in the slurry obtained through biogas plant was considered. It has been found in many studies that the manure obtained by converting fresh dung in the traditional pit method is 50 per cent of the dung quantity, while it is 73 per cent from the biogas plant. Studies have also revealed that there is a significant increase in the amount of nitrogen in the slurry of biogas plants over the manure obtained through the traditional pit method, but the increase in other nutrients like potash and phosphorus is not so significant. Therefore, only additional quantity of nitrogen in slurry was considered. Nitrogen was valued at the rate of Rs.4.65 per kg of Nitrogen nutrient (N in urea equivalent).

The benefit-cost ratio was calculated with the help of following formula:

$$\text{Benefit-cost ratio} = \frac{\text{Annual benefits}}{\text{Annual cost}}$$

Benefit-cost ratio more than unity indicates that the biogas plants are economically viable.

For finding out savings in the other fuels and utilization pattern of financial assistance tabular analysis was done.

Limitation for evaluation of benefits.

It was observed during the study that firewood was not purchased by almost all the sampled families. The sources of fuel for domestic use were dung cake and crop residues like arhar sticks, dancha sticks, cotton sticks and other woody material collected by the families from the fields. These materials did not possess a market in the villages but they carry some cost and save the families from purchasing firewood from adjoining markets. In consideration of this the gas obtained by the farm families was converted into firewood equivalent and priced at the prevailing prices of firewood. The application of the findings of this study is therefore, limited to the assumptions made regarding the conversion of gas into firewood and prices thereof.

RESULTS AND DISCUSSION

The main objective of the study was to work out the economics of biogas plants. But, information pertaining to some other factors such as size of holding, size of family, number of animals, year of installation was also collected. These factors have a bearing on the success/ failure of a plant. These features are discussed in detail here.

4.1 Background information

4.1.1 Size of plants and holdings

From Table 4.1, it is clear that 88.24 per cent of the plants installed were of 210 c.ft size, indicating thereby that this size of plant is most popular among the farmers followed by 140 c.ft size (7.84%) and 105 c.ft (3.92%). No other size of plant was found in the sampled villages.

Table 4.1: Distribution of plants of different sizes according to farm size groups

Size of holdings	105 c.ft	140 c.ft	210 c.ft	Total
0-2 ha (Small)	1	1	17	19 (33.33)
2-5 ha (Medium)	1	2	14	17 (29.83)
Above 5 ha (Large)	-	1	20	21 (36.84)
Total	2 (3.92)	4 (7.84)	51 (88.24)	57 (100.00)

Note: Figures in parentheses are the percentages of total number of biogas plants.

It was found that biogas plants are by and large equally popular in all the size groups of farm holdings as 33.33, 29.83 and 36.84 per cent of the plants were found on small, medium and large holdings, respectively.

No 105 c.ft sized plant was found installed on large holdings.

4.1.2 <u>Year of installation</u>

The installation of Janta Model biogas plants was started by the State Government in 1980-81,but in the sampled villages biogas plants installed during the period 1982-85 only were found. The year-wise split of different sizes of plants in the sample is given in Table 4.2.

Table 4.2: Year-wise installation of different sizes of biogas plants

Year	105 c.ft	140 c.ft	210 c.ft	Total
1982-83	-	1	24	25 (43.86)
1983-84	-	-	24	24 (42.10)
1984-85	2	3	3	8 (14.04)
Total	2	4	51	57 (100.00)

4.1.3 Number of cattle

Dung is the main input for the biogas plants, the supply of which is dependent on the number of livestock available with a farm family. The information regarding the dung which can be obtained from different animals was collected from the department of Livestock Production and Management of this University. Since the livestock generally go out for field work or grazing purposes, the quantity of collectable dung was worked out for individual biogas plant keeping in view the period the livestock were stable bound. On the basis of dung availability, the number of animals available with sampled families were converted in terms of cattle (cow) equivalent. The total quantity of dung available per family was worked out and is presented in Table 4.3.

As per the specifications, the average requirement of dung for 105 c.ft, 140 c.ft and 210 c.ft plants is 65, 90 and 140 kgs per day which can be made available from 4, 6 and 9 cattle, respectively.

Table 4.3 Distribution of sampled plants according to number of cattle and dung availability

Size of plant	Distribution of plants as per number of cattle				Average number of cattle	Plant owners having sufficient dung(%age)
	1-4	5-8	9-12	>12		
105 c.ft	-	1	1	-	10	100.00
140 c.ft	-	2	1	1	8	50.00
210 c.ft	-	26	13	12	10	47.06
Total	-	29	15	13	9	49.12

It is evident from Table 4.3 that on an average, only 49 per cent of the plant owners had adequate quantity of dung. All the 105 c.ft sized plants had sufficient dung quantity, while on 140 c.ft and 210 c.ft sized plants only 50 and 47 per cent had sufficient dung to feed biogas plants.

It implies that on an average, 50 per cent of the 140 c.ft and 53 per cent of the 210 c.ft plants are not getting adequate dung to be fed with because of lesser number of cattle available on the farm. It is also clear that about 50 per cent of the farms in the sample possessed cattle population between 5-8, 26 per cent between 9-12 and 24 per cent more than 12 cattle.

4.1.4 Size of family

According to studies conducted, on an average, a person requires 12-15 c.ft of biogas per day for cooking purpose. Therefore, the family size has a direct bearing on the biogas plants' size. The data pertaining to the size of family on different plant sizes in adult equivalents, taking children below 12 years equivalent to half adult, is presented in Table 4.4.

Table 4.4: Size of family on different sizes of plants

Size of plant	Number of family members
105 c.ft	6.50
140 c.ft	6.62
210 c.ft	6.87
Average	6.84

It was found that biogas plants were installed irrespective of the family fuel needs as average size of family was nearly similar on all the three sizes of biogas plants, though the number of family members varied from family to family. In the sample, 18 families were having less than five members, 35 families between 5-10 members and the remaining four families had more than 10 members.

4.1.5 <u>Utilization of gas</u>

Although biogas can be put to various uses like cooking, lighting, running engines, etc., but on the sample forms it was used only for cooking purpose.

4.2 <u>Utilization of installed capacity</u>

It is clear from Table 4.5 that only 76.19 per cent of installed capacity was utilized in case of 105 c.ft plants, while it was 60.71 per cent and 49.31 per cent in case of 140 c.ft and 210 c.ft plants, respectively. On an average, 50 per cent of installed capacity was found to be utilized. The main reasons for the underutilization of installed capacity was inadequate feeding of the plants and low gas production during winter months.

Table 4.5: Utilization of installed capacity of different sizes of plants

Size of plants	No. of observations	Installed capacity (c.ft/day)	Actual utilization (c.ft/day)	Utilization (%)
105 c.ft	2	105	80	76.19
140 c.ft	4	140	85	60.71
210 c.ft	51	210	103.68	49.38
Average	57	201.40	101.53	50.41

4.3 <u>Economics of biogas plants</u>

To study the economics of biogas plants, benefit-cost analysis was done for different sizes of plants from the point of view of individual farmers. Since the number of 105 c.ft and 140 c.ft plants was very small, their economic evaluation on different sized farm holdings could not be done.

4.3.1 Annual cost of running a plant

The four major components of the cost of running a plant are depreciation, interest on investment, repairs and maintenance cost and labour charges. The first two components are fixed cost and the other two are operational costs.

In case of 210 c.ft plants, of the total cost, 51 per cent was on account of fixed cost and the remaining 49 per cent was operational cost. Out of the total cost, labour cost accounted for about 41 per cent and interest on capital investment for about 32 per cent. Thus, these two components of the annual cost of running a plant together accounted for about 73 per cent of the total cost. No considerable difference was observed in various cost components on different farm holdings.

More or less, the similar trend was observed in case of 140 c.ft and 105 c.ft sized plants also, with a small variation in case of 140 c.ft plants, where the ratio of fixed cost and operational cost was 55 per cent and 45 per cent, respectively.

Table 4.6: Annual cost of running of different sizes of biogas plants

	105 c.ft	140 c.ft	210 c.ft			
	Average (Rs.)	Average (Rs.)	Small (Rs.)	Medium (Rs.)	Large (Rs.)	Average (Rs.)
A. Fixed cost						
i) Depreciation	175.50 (18.61)	205.00 (19.22)	270.53 (18.93)	279.77 (18.66)	267.68 (18.69)	272.66 (18.76)
ii) Interest on capital investment	308.00 (32.64)	379.86 (35.62)	470.60 (32.95)	470.80 (31.40)	463.30 (32.37)	468.23 (32.24)
Sub total A	483.50 (51.25)	584.86 (54.84)	741.13 (51.88)	750.57 (50.06)	730.98 (51.06)	740.89 (51.00)
B. Operational cost						
i) Repairs and maintenance cost	95.00 (10.07)	105.66 (9.91)	107.53 (7.54)	109.85 (7.34)	116.50 (8.13)	111.29 (7.66)
ii) Labour charges	365.00 (30.68)	376.00 (35.25)	579.70 (40.58)	638.75 (42.60)	584.00 (40.81)	600.82 (41.34)
Sub total B	460.00 (48.75)	481.66 (45.16)	687.23 (48.12)	748.60 (49.94)	700.50 (48.94)	712.11 (49.00)
Total cost	943.50 (100.00)	1066.52 (100.00)	1428.36 (100.00)	1499.17 (100.00)	1431.48 (100.00)	1453.00 (100.00)

Note: Figures in parentheses are the percentages of the total cost.

4.3.2 Benefits from different sizes of plants

It is evident from Table 4.7 that average economic benefits to 210 c.ft sized plant owners were Rs.3330.23 per annum, out of which about 56 per cent were contributed by the gas consumed for domestic uses and remaining 44 per cent on account of additional quantity of nitrogen from enriched manure. The benefits on large, medium and small holdings with 210 c.ft sized plants were Rs.3488.57, Rs.3479.57 and Rs.3022.57 respectively. The average contribution of gas and additional quantity of nitrogen varied between 59 per cent to 54 per cent and 46 per cent to 41 per cent respectively on different sizes of plants. On 105 c.ft and 140 c.ft sized plants, the total annual economic benefits were Rs.2147.05 and Rs.2375.26 respectively. The comparative contribution by gas and additional nitrogen on 105 c.ft sized plants was about 54 per cent and 46 per cent respectively, while on 140 c.ft sized plants it was 58 per cent and 42 per cent.

It is evident from the above discussion that the contribution made to the total economic benefits of biogas plants by domestic consumption of gas was about 55 per cent while that of additional quantity of nitrogen from manure was about 45 per cent.

4.3.3 Benefit cost ratio of different sizes of plants

It isevident from Table 4.8 that the installation of biogas plants on individual farms was economically a sound

Table 4.7: Annual economic benefits from different sized biogas plants

	105 c.ft	140 c.ft	210 c.ft			
	Average	Average	Small	Medium	Large	Average
A. Benefits from gas						
i) Daily consumption (cu.m)	1.80	2.14	2.56	3.00	3.21	2.92
ii) Annual consumption (cu.m)	661.47	784.93	936.33	1096.82	1172.56	1068.57
iii) Value in terms of firewood (Rs.)	1157.58 (53.92)	1373.63 (57.84)	1638.58 (54.21)	1919.42 (55.16)	2051.98 (58.83)	1869.99 (56.16)
B. Benefits from manure						
i) Additional quantity of nitrogen available (kg)	211.88	214.47	296.35	334.07	307.62	312.68
ii) Value (Rs.)	989.49 (46.08)	1001.63 (42.16)	1383.99 (45.79)	1560.15 (44.84)	1436.59 (41.17)	1460.24 (43.84)
Total economic benefits (Rs.)	2147.05 (100.0)	2375.26 (100.0)	3022.57 (100.0)	3479.57 (100.0)	3488.57 (100.0)	3330.23 (100.0)

Note: Figures in parentheses are the percentages of total economic benefits.

Table 4.3: Benefit-cost ratio of different sizes of plants

	105 c.ft	140 c.ft	210 c.ft			
	Average	Average	Small	Medium	Large	Average
1. Total annual cost (Rs.)	943.50	1066.52	1428.36	1499.17	1431.48	1453.00
2. Total annual benefits (Rs.)	2147.05	2375.26	3022.57	3479.57	3488.57	3330.23
3. Benefit-cost ratio	2.27	2.22	2.11	2.32	2.43	2.29

investment on all the size groups of farm holdings as the B/C ratio was more than unity in all the cases. The average B/C ratio was 2.27, 2.22 and 2.29 on 105 c.ft, 140 c.ft and 210 c.ft plants, respectively.

It is significant to note that 210 c.ft sized plants were found to be most economical on large farms followed by on medium holdings and small holdings. This was due to the fact that larger farm holdings generally had bigger families because of joint family system and therefore used more of the available capacity of gas production. Moreover, the availability of dung and as such the feeding of plant was higher on large farms due to a large number of animals. Average number of animals on large farms was 11.00 whereas on small and medium farms it was 8.63 and 9.52 respectively.

4.3.4 Frequency distribution of sample biogas plants on benefit-cost ratio basis

Table 4.9 reveals that 60 per cent of the working plants had a benefit-cost ratio in the range of 2.0-2.5 and only 10 per cent of the plants had a benefit-cost ratio lower than 2.0. Benefit-cost ratio was between 2.5-3.0 in case of 30 per cent of biogas plants. All the plants of 105 c.ft and 140 c.ft size had a benefit-cost ratio between 2.0-2.5. On 210 c.ft plants the benefit-cost ratio of about 55 per cent was in between 2.0-2.5 and that of 33 per cent in between 2.5-3.0. The benefit-cost ratio of only 12 per cent was in between 1.0-2.0. The benefit-cost ratios were more than unity in all the cases which indicates that the installation of biogas plants is economically beneficial on individual farms.

Table 4.9: Frequency distribution of benefit-cost ratio on different sizes of plants

B/C ratio	105 c.ft	140 c.ft	210 c.ft	Total
1.0-1.5	-	-	1 (1.97)	1 (1.75)
1.5-2.0	-	-	5 (9.80)	5 (8.78)
2.0-2.5	2 (100.00)	4 (100.00)	28 (54.90)	34 (69.65)
2.5-3.0	-	-	17 (33.33)	17 (29.82)
Total	2 (100.00)	4 (100.00)	51 (100.00)	57 (100.00)

Note: Figures in parentheses are the percentages of total number of biogas plants.

The benefits considered for the study were only those which could easily be quantified and monetised while there were many other intangible benefits of biogas plants, on which it was difficult to assign monetary value. These intangible benefits are pollution free and smokeless fuel, better sanitary conditions, readily available fire, etc. If we consider these benefits also along with the economic benefits, biogas plants appear to be very beneficial to the farmers.

4.4 Savings in fuel

4.4.1 Savings in other sources of fuel

It is evident from Table 4.10 that only dung cake, firewood, plant stalks and kerosene were used by the farmers as fuel. Before the installation of plant around 90 per cent of the sample farmers in all the three size groups of holdings were using both dung cake and firewood. Small and medium farmers were using more of dung cake as compared to firewood whereas in case of large farmers the case was just reverse.

After the installation of biogas plants around 80 per cent of the farmers were found to be using dung cake but comparatively in small quantities for condensing milk because of slow burning property of dung cake which does not boil the milk. Only 12.28 per cent of the plant owners were using firewood after installation of plant. Kerosene was found to be used by 17.54 per cent and 10.52 per cent of farmers before and after installation of biogas plants, respectively.

After installation of biogas plants savings were more than 93 per cent in case of firewood and more than 84 per cent in case of dung cake. Saving was 64 per cent in the use of kerosene oil. More than 88 per cent of expenditure on traditional fuels was saved. Total savings on other sources of fuels were found to be 88.64, 87.39 and 89.89 per cent on small, medium and large farm holdings, respectively.

Table 4.10: Monthly consumption of fuel before and after installation of biogas plants on different farm holdings

Size of holding	Sources of fuel	Before installation			After installation			Savings (Rs.)
		% Users	Quantity	Value (Rs.)	% Users	Quantity	Value (Rs.)	
Small	Dung-cake	100.00	257.89	30.94	89.47	37.89	4.54	26.40 (85.32)
	Firewood & plant stalks	94.73	107.89	37.76	10.52	4.73	1.65	36.11 (95.63)
	Kerosene	15.78	2.10	4.83	15.78	0.94	2.16	2.67 (55.27)
Total expenditure				73.53			8.35	65.18 (88.64)
Medium	Dung-cake	88.23	255.88	30.70	73.68	34.70	4.16	26.54 (86.44)
	Firewood & plant stalks	94.11	126.47	44.26	11.76	7.60	2.66	41.60 (94.00)
	Kerosene	5.88	1.17	2.70	11.76	1.29	2.97	-0.27 (-10.00)
Total expenditure				77.66			9.79	67.87 (87.39)
Large	Dung-cake	90.47	158.57	19.03	71.42	31.90	3.82	15.21 (79.92)
	Firewood & plant stalks	100.00	211.90	74.16	14.28	16.97	5.94	68.22 (92.00)
	Kerosene	28.57	2.86	6.57	4.76	0.14	0.32	6.25 (95.12)
Total expenditure				99.76			10.08	89.68 (89.89)

... contd.

contd... Table 4.10

Size of holding	Sources of fuel	Beforeinstallation			After installation			Saving (Rs.)
		% Users	Quantity	Value (Rs.)	% Users	Quantity	Value (Rs.)	
Total	Dung-cake	92.98	220.70	26.48	78.94	34.73	4.16	22.32 (84.29)
	Firewood & plant stalks	96.49	151.75	53.11	12.28	10.09	3.53	49.58 (93.35)
	Kerosene	17.54	2.10	4.83	10.52	0.75	1.72	3.11 (64.39)
Total expenditure				84.42			9.41	75.01 (88.85)

Note: 1. Quantity of dung-cake and fire-wood in terms of Kilograms and kerosene in terms of litres.

2. Figures in parentheses are savings in percentage terms.

4.4.2 Monthly saving in fuel cost on different sizes of plants

Table 4.11 reveals that in absolute terms the savings in fuel cost of other sources was Rs.77.16 on 210 c.ft sized plants, while on 140 c.ft and 105 c.ft plants it was Rs.60.60 and Rs.55.60 respectively. On average, a monthly saving of Rs.75.23 was observed. In percentage terms however, there was no difference in the savings on fuel consumption on different sizes of plants because in all the three cases, it was about 88 per cent. Though the savings in absolute terms on 210 c.ft plants was more than other two sizes of plants but in percentage terms it was similar because the initial expenditure on fuel was higher.

Table 4.11 Monthly savings in fuel costs after the installation of different sizes of plants

	105 c.ft	140 c.ft	210 c.ft	Average
Expenditure on fuel before installation of plant (Rs.)	63.20	68.85	87.69	85.50
Expenditure on fuel after installation of plant (Rs.)	7.60	8.25	10.53	10.27
Savings in fuel cost (Rs.)	55.60 (87.97)	60.60 (88.01)	77.16 (87.99)	75.23 (87.98)

Note: Figures in parentheses are the percentage savings in fuel cost.

It can be safely inferred from the above findings that installation of biogas plants effected a saving in the consumption of such precious national wealth like firewood and animal dung. The dung fed into the biogas plants provided enriched organic manure for increasing crop productivity and also gas for domestic consumption.

4.5 Utilization pattern of financial assistance

4.5.1 Utilization of financial assistance

It is evident from Table 4.12 that subsidy was obtained by all the farmers in the sample. The percentage of beneficiaries who obtained loan was 41.66, 59.09 and 90.00 in case of large, medium and small holdings. It is thus clear that about 60 per cent of large farmers, 40 per cent of medium farmers and only 10 per cent of small farmers did not avail any loan facility. On an average, 62 per cent of the total plants were installed with loan assistance.

It was found that on an average, 86 per cent of the plants were working. The percentage of working plant to the total plants financed was found to be maximum on small farms (95%), followed by large farms (87%) and medium farms (77%). Out of the total plants financed, 4.5 per cent plants were not installed at all, 7.5 per cent plants were left incomplete and 1.5 per cent plants were complete but not working due to technical faults.

There was 100 per cent utilization of assistance in case of working biogas plants. Misutilization of assistance was

Table 4.12: Utilization pattern of financial assistance for biogas plants on different sizes of farm holding in the sample

Sizes of holdings	Number of biogas plants				
	Total plants	Working	Not installed	Left incomplete	Complete but not working
i) <u>Small holdings</u>					
Total plants financed	20 (100)	19 (95)	-	-	1 (5)
Subsidy cases	20 (100)	19	-	-	1
Loan cases	18 (90)	17	-	-	1
ii) <u>Medium holdings</u>					
Total plants financed	22 (100)	17 (77.27)	1 (4.54)	4 (18.19)	-
Subsidy cases	22 (100)	17	1	4	-
Loan cases	13 (59.09)	11	1	1	-
iii) <u>Large holdings</u>					
Total plants financed	24 (100)	21 (87.5)	2 (8.33)	1 (4.17)	-
Subsidy cases	24 (100)	21	2	1	-
Loan cases	10 (41.66)	9	1	-	-
Total plants financed	66 (100.00)	57 (86.36)	3 (4.54)	5 (7.58)	1 (1.52)
Subsidy cases	66 (100.00)	57	3	5	1
Loan cases	41 (62.12)	37	2	1	1

Note: Figures in parentheses are percentages of total plants financed.

Table 4.13: Assistance provided and utilized on non-working biogas plants

Stages of plant installation	No. of plants	Assistance provided			Assistance utilized (Rs.)	Utilization (%age)
		Subsidy (Rs.)	Loan (Rs.)	Total (Rs.)		
Work not started	3 (33.33)	2586.67	1383.33	3970.00	-	-
Pit dug but left incomplete	3 (33.33)	2263.33	686.67	2950.00	600.00	20.33
Masonary work started but left incomplete	2 (22.22)	2425.00	-	2425.00	2000.00	82.47
Plant complete but not working	1 (11.12)	2910.00	2090.00	5000.00	5000.00	100.00
Average	9 (100.00)	2478.88	922.22	3401.10	1200.00	35.28

Note: Figures in parentheses are the percentages of total number of plants.

observed only in case of non-working biogas plants. 86 per cent of the subsidy cases plants were found to be working, whereas 90 per cent of the plants out of loan cases were working. It indicates that the percentage utilization of assistance provided under both the loan and subsidy components was more or less similar.

4.5.2 Study of non-working plants

Out of the nine non-working plants, no work was started in 33 per cent cases. These farmers were provided with an average assistance of Rs.3970.00, which was completely misutilized for other purposes. There were 33 per cent cases where only pit was dug. In such cases, an average assistance of Rs.2950 was provided out of which only 20 per cent was utilized. The cases where masonary work was started but left incomplete were 22 per cent which utilized 82 per cent of assistance. It was also found that in 11 per cent cases, the plants were complete but not working because of technical faults. On an average, it was found that 35 per cent of the assistance provided (Rs.3401.10) was utilized on non-working plants also.

It can be concluded from the discussion that it is economically beneficial to invest in the installation of biogas plants by all categories of farmers as the B/C ratio was found to be more than unity in all the cases. The B/C ratio can further be improved if the proper care is taken for adequate feeding of the plant and installation of proper size keeping in view the size of family and the number of livestock. Installation of biogas plants has also resulted in the savings in the conventional sources of fuel on all sizes of farms and plants. In the sample, from which the data was collected, about 86 per cent of the financed plants were found working. Which indicates that the farmers were by and large conscious of the benefits of biogas plants.

SUMMARY

Presently Indian agriculture is facing shortages of fertilizers and a large amount of foreign exchange is being spent on their import. Inadequacy of fuels in rural as well as urban areas, is causing the deforestation and in turn an ecological imbalance. Cattle dung is being burnt as fuel which could otherwise be used as manure. To overcome these two shortages of fuels and fertilizer, the Government of India has started a large scale programme for installing biogas plants. A large amount is being spent on this project as subsidies, loans and in promotional efforts. During the 7th Five Year Plan an annual amount of Rs.168 crore is to be made available as subsidy only. Thus, the present study

had the following objectives:

1. To study the economics of different sizes of biogas plants on various sizes of holdings.
2. To study the savings in the consumption of other sources of energy on the farms having biogas plants.
3. To study the utilization pattern of financial assistance on different sizes of farm holdings.

The study was conducted in the district Kurukshetra of Haryana, as it had the maximum number of biogas plants in the State. In this district, Thanesar block was selected randomly and 10 villages which had biogas plants were selected at random. Data were collected in pre-tested questionnaires. Since almost all the plants being installed for the last five years are of fixed dome (Janata) model, only this model was considered for the study. The plant owners were classified into three categories depending on their operational holdings viz., small (0-2 ha), medium (2-5 ha) and large (more than 5 ha).

The sizes (and numbers) of plants were 105 c.ft (2), 140 c.ft (4) and 210 c.ft (51). Thus 88 per cent of the plants in the sample were of 210 c.ft size. The distribution of biogas plants was 33, 30 and 37 per cent on small, medium and large farms, respectively.

Dung availability was sufficient only on 49 per cent of the plants. The percentage of plant owners having sufficient dung was 100, 50 and 47 on 105 c.ft, 140 c.ft and 210 c.ft sized plants. Family size was too small to use all the installed capacity of the plants.

On an average, only 50 per cent of the installed gas capacity was being utilized perhaps due to inadequate feeding of the plants with dung, because of unavailability. The percentage utilization of 210 c.ft, 140 c.ft and 105 c.ft size plants was found to be 49, 61 and 76 per cent, respectively.

In the annual cost of running 210 c.ft plants, 51 per cent was on depreciation and interest and the remaining 49 per cent on repairs, maintenance and labour costs. Interest and labour together accounted for 73 per cent of the total costs. Similar trend was observed on othersizes of plants.

Of the benefits, 56 per cent from the 210 c.ft plant was on account of gas and 44 per cent due to additional quantity of nitrogen in enriched slurry. On 140 c.ft and 105 c.ft plants, this percentage share of gas and enriched manure was 54 and 46 per cent and 58 and 42 per cent, respectively.

Installation of all sizes of biogas plants was found to be an economically sound investment on all the categories of farms as the benefit cost ratio varied between 2.11 and 2.43. It implies that it is highly remunerative on individual farms to invest on biogas plants as the benefit-cost ratio was more than unity in all the cases. Of the plants, 60 per cent had a benefit cost ratio of 2.0-2.5 and about 30 per cent 2.5-3.0.

Installation of biogas plants has effected a saving of 85, 86 and 80 per cent on small, medium and large farms in the consumption of dung cake as fuel. Firewood saving ranged between 92 and 96 per cent. Overall, savings in the consumption of dung cake, firewood and kerosene was 84, 93 and 64 per cent, respectively. Savings on different sizes of plants was around 88 per cent.

Subsidies were obaiined by all the farmers in the sample and loans by 62 per cent. It was found that 86 per cent of the plants were working. The percentage of working plants to the total plants financed was 95, 77 and 87 for small, medium and large farm holdings. There was 100 per cent utilization of assistance in case of working plants and on non-working plants, 35 per cent of the assistance was utilized.

It is concluded that it is economical to install biogas plants on all size groups of farms to save precious sources of fuels like dung cake, firewood and kerosene.

LITERATURE CITED

Bhatia, Ramesh. 1977. Economic appraisal of biogas units in India. Economic and Political Weekly, 12(33 & 34): 1503.

Bhavani, S. 1976. Biogas for fuel and fertilizers in rural India, a social benefit-cost analysis. Ind. J. Agric. Econ., 31(3): 68.

Biswas, T.D. 1974. Cow dung gas plant for energy and manure. Fertilizer News, 19(9): 3.

Bohra, C.P. and Maheshwari, R.C. 1983. Draft Copy of a Manual on Biogas Plant Management. Central Institute of Agricultural Engineering, Bhopal.

Chawla, O.P., Laura, R.D. and Idnani, M.A. 1969. Note on stimulation of anaerobic fermentation of dung in the cow-dung gas plant. Ind. J. Agric. Sci., 39:1040.

Chawla, O.P. 1972. Gobar gas plant: its efficiency and manurial returns. Khadigramodyog, 18(10):547.

Indian Farmers Fertilizer Cooperative Limited (I.F.F.C.O.). 1982. Biogas Plant.

Jain, M.K. and Mishra, M.M. 1978. Biogas plant an alternative technology for energy and manure. Food, Farming and Agriculture, 9(10): 292.

Joglekar, V.R. 1982. Gobar gas plant - a source of manures, cooking fuel and cleaniness of villages. Financing Agriculture, 14(2 & 3): 64.

Khadi and Village Industries Commission 1979. Gobar-gas Retrospect and Prospects. Directorate of gobar gas scheme, K.V.I.C., Bombay.

Khadi and Village Industries Commission 1983. Gobar-gas: Why and How ? Directorate of gobar gas scheme, K.V.I.C., Bombay.

Mann,G.S., Chaudhary,K.C. and Mangat,S. 1972. Evaluation of slurry (bio-gas plant) for its manurial value. Journal of Research, (P.A.U.) 9(3): 464.

Misra,S.P. 1974. Economic feasibility of gobar gas plants,a case study. Khadigramodyog, 21(6): 286.

Nahar,Shanti Lal 1975. Gobar-gas plants in developing rural economy. Khadigramodyog, 22(6): 271.

Patel,S.M. 1974. Performance of bio-gas plants in Gujrat. Khadigramodyog, 21(11): 493.

Patil,S.J. and Dhangade,M.P. 1984. Economics of gobar gas plants in Ahmednagar district of Maharashtra. Khadigramodyog, 30(4): 195.

Prasad,H.K. and Sharma,A.N. 1982. Biogas plants and their prospects. Indian Farmers' Digest, 15(4): 28.

Rao,A.R. and Malik,R.K. 1982. Biogas as an option for dung utilization. Urja, 12(6): 321.

Rakib,A., Kochar,A.S. and Bhatia,I.S. 1968. Bio-gas plants saves manurial value of cow-dung and house-wives from trachoma. Progressive Farming, 5(1): 41.

Sirohi,A.S. and Singh,Ikbal 1981. Biogas energy: economic feasibility. Eastern Economist, 77(6): 264.

Srinivasan,H.R. 1973. History of development of gobar gas plant. Khadigramodyog, 20(3): 176.

The Tata Energy Research Institute 1982. A Review of the Literature on Promotion of Biogas Systems. United Nations Educational Scientific and Cultural Organisation (UNESCO), Paris.

Varma,Neeraj 1983. Biogas in rural energy development. Energy Development in India, ed. Mahajan,V.S. pp. 130-141.

APPENDIX . I

Replacement value of Bio-gas

Name of fuel	Unit	Biogas $1m^3$
Biogas	m^3	1.0
Kerosene	Litre	0.620
Firewood	Kg	3.474
Cow-dung cakes	Kg	12.296
Charcoal	Kg	1.458
Soft coke	Kg	1.605
L.P.G.	Kg	0.433
Furnace Oil	Litre	0.417
Coal gas	m^3	1.177
Electricity	Kwh.	4.698

$1m^3$ (Cubic meter) = 35.315 Cubit feet.

Source: Gobar gas - Why and How
Published by the Directorate of Gobar Gas Scheme, Khadi & Village Industries Commission Bombay.

APPENDIX II

Requirements for installation of biogas plants of 3, 4 and 6 cu.m. sizes

	3 cu.m. 105 c.ft	4 cu.m. 140 c.ft	6 cu.m. 210 c.ft
Bricks	2300	3500	4000
Bricks bate	40 cu.ft	50 cu.ft	70 cu.ft
Sand	80 cu.ft	125 cu.ft	150 cu.ft
Badarpur	40 cu.ft	50 cu.ft	60 cu.ft
Cement	25 bags	30 bags	40 bags
Animals	4-5	6-7	9-10
Dung	65-70 kg	90-100 kg	140-150 kg
Estimated cost (Rs.)	4200	5600	6500
Subsidy for scheduled tribes/small & marginal farmers including landless labourers (Rs.)	2860	3220	3920
Subsidy for all others (Rs.)	1900	2140	2610
Subsidy for scheduled castes (Rs.)	2860	3220	2610

Source: Department of Agriculture, Haryana.

APPENDIX III

Amount of central subsidies for different sizes of biogas plants(effective from 1984)

Size of plant (cu.m.)	Amount of central subsidy (Rs.)			
	For north-eastern region states, Sikkim and notified hilly areas and desert districts	For other areas		
		For scheduled tribes/ small and marginal farmers including landless labourers	*For all* others	*For scheduled* castes
2	2940	2350	1560	2350
3	3660	2860	1900	2860
4	4390	3220	2140	3220
6	5350	3920	2610	2610
8	6460	4640	3100	3100
10	8080	5540	3700	3700
15	11440	8150	5430	5430
20	15260	10960	7300	7300
25	17640	12280	8190	8190

Source: Department of Agriculture, Haryana.

APPENDIX IV

Statewise distribution of biogas plants in India (uptil 31st March, 85

S. No.	State/Union Territory	Number of biogas plants
1.	Andhra Pradesh	34247
2.	Assam	1176
3.	Bihar	30919
4.	Delhi	233
5.	Gujarat	32133
6.	Haryana	18114
7.	Karnataka	28571
8.	Kerala	8075
9.	Madhya Pradesh	20051
10.	Maharashtra	100144
11.	Orissa	6522
12.	Punjab	10511
13.	Rajasthan	14713
14.	Tamil Nadu	38470
15.	Uttar Pradesh	99049
16.	West Bengal	8686
17.	Other States/Union Territories	5486
	Total:	457100

Note: Department of Non-Conventional Energy Sources, Ministry of Energy, New Delhi.