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A VIABLE ALTERNATIVE ENERGY FOR RURAL NEPALESE VILLAGES: A CASE STUDY OF GOBAR GAS

Govinda Prasad Devkota

HMG-USAID-GTZ-IDRC-FORD-WINROCK PROJECT

STRENGTHENING INSTITUTIONAL CAPACITY IN THE

FOOD AND AGRICULTURAL SECTOR IN NEPAL

FOREWORD

This Forestry Research Paper Series is funded through the project, "Strengthening Institutional Capacity in the Food and Agricultural Sector in Nepal," a cooperative effort by the Ministry of Agriculture (MOA) of His Majesty's Government of Nepal and the Winrock International Institute for Agricultural Development. This project has been made possible by substantial financial support from the U.S. Agency for International Development (USAID), the German Agency for Technical Cooperation (GTZ), the Canadian International Development Research Centre (IDRC), and the Ford Foundation.

One of the most important activities of this project is funding for problem oriented research by young professional staff of agricultural agencies of the MOA and related institutions, as well as for concerned individuals in the private sector. In particular, funding is provided by the Ford Foundation to support research activities related to the human aspects of natural resource management. This research is carried out with the active professional assistance of the Winrock staff.

The purpose of this Forestry Research Paper Series is to make the results of the research activities related to forestry available to a larger audience, and to acquaint younger staff and students with advanced methods of research and statistical analysis. It is also hoped that publication of the Series will stimulate discussion among policymakers and thereby assist in the formulation of policies which are suitable to the management of the natural resource systems upon which the development of Nepal's agriculture depends.

The views expressed in this Forestry Research Paper Series are those of the authors, and do not necessarily reflect the views of their parent institutions.

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A VIABLE ENERGY ALTERNATIVE FOR RURAL NEPALESE VILLAGES: A CASE STUDY OF GOBAR GAS

Govind Prasad Devkota*

INTRODUCTION

The use of biogas as a source of fuel is a recent phenomenon. The first plant in Nepal was built at St. Xavier's School, Godavari, Lalitpur about 20 years ago by late Father B. R. Saubolle. Since 1972, several farm households have installed private biogas plants which are operating satisfactorily. However, the use of biogas has not expanded due to the lack of technical expertise in the country.

The introduction of biogas energy in Nepal must be viewed in the context of the global energy crisis and in terms of the rapidly deteriorating forest resources in Nepal. Traditionally, wood has been the major source of fuel in Nepal. With the rapid population growth, the depletion rate of forest resources has surpassed the level of natural regeneration. At the same time wood demand for purposes other than fuelwood is still growing. As wood becomes less available people burn dried dung cakes and crop wastes which could be used as fertilizer. These alternatives are much less efficient in generating heat and produce excessive smoke.

Gobar gas is a viable alternative fuel both for the household economy and the national objective of forest preservation. Two buffalo, a little open space near the kitchen, and a source of water nearby are enough to maintain a gobar gas plant. It will not only produce fuel and fertilizer but also provide various social benefits. These include improved sanitation, declining incidence of eye diseases, especially among women, easy and efficient cooking, and reduction in the indiscriminate felling of trees for fuel.

About 1950 biogas plants are already constructed in 48 districts of Nepal. Thirty-two of the plants were built at the community level, for milling, pumping, and generating electricity. A private company, Gobar Gas Tatha Krishi Yantra Vikash (P) Ltd. has been involved in fabrication, installation, research and development of biogas technologies since 1977.

Biogas Technology

Biogas is a mixture of methane (50-60 percent), carbon dioxide (20-45 percent), and hydrogen sulfide (less than one percent). Biogas is a wet gas because it picks up water vapor from slurry, however, this vapor must be removed. Biogas is a flammable gas produced by microbes when organic materials are fermented under specific temperature, moisture content, and pH conditions in an air tight space.

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Process

The process of digestion involves two stages: a) the breakdown of complex animal waste or cattle dung into simpler chemicals, and b) organic materials and carbon dioxide are either oxidized or reduced to methane by methanogenic microorganisms.

Cattle dung, containing the correct bacteria to produce biogas, is the most commonly used feedstock. Other feedstocks, such as ricestraw, Eupatorium species, water hyacinth, and other agricultural wastes, also can be used.

Methane-forming bacteria have many physiological properties in common, but they are heterogenous in cellular morphology. All methane-forming bacteria are grouped into the Methano bacteriaceae with three species: Methano coccus, Methano sarcina, and Methano spirillum. Anaerobic fermentation is the process for the production of the methane in biogas.

A biogas plan consists of an inlet, a digestic pit, a dome or gas holder, and an outlet. When biogas is produced it must be conveyed to where it will be used through pipes which are often laid underground.

Uses of Biogas

Since biogas is a high quality fuel, it can be used for many purposes. The main uses of biogas are summarized below:

1. Cooking: More than 95 percent of the people in Nepal use firewood for cooking. If the trend continues all forests will disappear in less than 25 years.

2. Lighting: Most Nepalese use kerosene for lighting lamps. Nepal has no indigenous source of kerosene. As such, the country has to expend scarce foreign exchange and supplies are often unpredictable.

3. For operating dual fuel engines: About 70 percent of the diesel requirement can be replaced by biogas for running dual fuel engines, such as Kirloskar and Usha brands. Each engine costs about NRs.10,000 and is available from the Agriculture Development Bank/Nepal (ADB). The fuel engine can be used for running a pump-set for irrigation, for various agro-processing equipment, for a generating set to produce electricity, and for boilers, refrigerators, milk coolers, and vehicles.

Uses of Slurry

Livestock Feed Supplement. Slurry can be used for feeding pigs, ducks, and fish. For pigs it is mixed with feed, such as rice husk. Fish can be fed by passing it directly from the plant to the pond. Ducks can be fed either from the reservoir of the plant or from the pond. However, deficit nutritive elements should be added to the slurry, especially for pigs.

Fertilizer. Fertilizer is the most essential factor for any crop. Nitrogen remains in the effluent of biofertilizer from the slurry, while some escapes as ammonia gas. When the effluent is dried, most of the nitrogen is lost. As a fertilizer, slurry greatly increases soil acidity and improves the nitrogen content of cattle dung and compost.

The slurry from the anaerobic fermentation of a biogas digester improves the physical, chemical, and biological properties of the soil. Since there are no more parasites and pathogens in the slurry, it is highly recommended for use in farming. Slurry's uses can be diversified for feeding and fermentation.

Advantage of Biogas on Family Level

The immediate beneficiaries of a gobar gas plant in a family are the women who cook. The cooking fuel is easier to obtain and use than firewood. In addition, the burning of wood or dung cakes produces smoke which causes eye and dung diseases, as well as increasing cooking time.

Biogas provides efficient fuel for lamps. The gas fuel lamp is brighter than any other nonelectric lamps. The value of fertilizer is another advantage of biogas plants.

The major disadvantage of a biogas plant for a family is the initially high capital cost. The majority of people in Nepal cannot afford to bear the average cost of NRs.15,123 for a small family plant of 10 cu.m. However, owning a plant is within reach of many farm households if they can collect together the amount of money they would spend on fuel on the given year to repay the loan for installing such a plant. Either the cost of the plant should be drastically cut or a higher percentage of subsidies should be provided to encourage the use of biogas plants. Furthermore, to reduce the cost of the plants, technical improvements are needed for the production of gas through composting, solar radiation, and other means.

Biogas plant owners should have four to six cattle or enough feedstock for the plant. Crop residue and plant materials can be used if the plant is to be fed in sequences. Water is needed to mix the slurry on a 1:1 ratio.

A larger community biogas plant can be used to drive engines for income generating activities, by which more people can benefit from biogas technology. Dual fuel engines can be used to drive grain mills and irrigation pumps, both of which can give good returns to the owners.

Latrines can be attached to biogas plants to increase gas production. This will ultimately improve sanitation and village health.

Advantage of Biogas at the National Level

Biogas offers an alternative energy source to wood and fuel petroleum oil. Nepal's energy problems reflect the imbalance between the country's natural energy endowment and its utilization. Since 1963, the country's forests have been depleted by 33 percent. Deforestation not only threatens future energy supplies, but causes serious soil erosion, resulting in reduced agricultural land area in the hills.

Energy consumption in Nepal during 1980/81 was estimated at about 2.8 million tons of oil equivalent (TOE), of which the household consumption was 1 million TOE. Household consumption accounted for 98 percent of the fuelwood consumed.

The cattle population in the 1970/71 was estimated at 10 million, producing 27.7 million metric tons of dung. If all this dung could be used to produce biogas, the theoretical yield would be about 1136 million cu.m. This could replace 4.8 million tons of fuelwood or 75 percent of the fuelwood used in Nepal. Alternatively, it could be used to replace 433 million liters of diesel fuel, about 15 times Nepal's requirements in 1970/71. The value of this replaced oil would be over 2 billion rupees or about US $700 million.

If the current annual capacity of Gobar Gas Tatha Krishi Yantra Vikash (P) Ltd. expanded to 1000 family-size units, a total of 7000 units could be in operation by 1990. These plants, operating at the designed capacity, would save nearly 67,000 tons of fuelwood annually. However, the present manpower at Gobar Gas Company can only install about 300 biogas plants per year.

Factors Affecting Biogas

Temperature. The optimum temperature for methane-producing bacteria is about 35 degrees Celsius. When the slurry temperature is lower, gas production is greatly reduced. At 10 degrees Celsius, the production of biogas is more or less stopped.

Retention Time. The retention time is temperature dependent. The higher the temperature, the faster the bacterial consumption of feed in the slurry and the sooner it needs replacing. This process can be summarized by R = V/F, where R = retention time, V = effective volume of digester, and F = feed ratio.

Air. Methane-producing bacteria are anaerobic, so air should be excluded from the process.

Bacteria. The fermentation process involves two stages. First, bacteria breakdown complex organic materials and second, the production of methane by methanogenic microorganisms. If the correct type of bacteria are not present, methane cannot be formed.

Carbon-Nitrogen (C:N) Ratio. Carbon and nitrogen are the chief nutrients for anaerobic bacteria. Carbon is used for energy and nitrogen for building cell structures. Bacteria use carbon 25-30 times faster than they use nitrogen. If the C:N ratio is not appropriate, the ratio can be altered by adding urea.

Gobar Water Ratio. There should not be any stratification within the digester. This can be assured by calculating the dry matter (DM) percent. If there is a great variation in the DM percent between the top and bottom layers of the slurry in the digester, stratification occurs. Generally, the gobar water ratio should be 1:1, is dependent upon the DM percent of gobar which ranges from 14-20 percent.

Volatile Acids. Volatile compounds such as acetic acid, propionic acid, and butaric acid are more important than pH because they give the actual situation inside a plant. They are not easily measured and need further research.

Solid Content. The solid content of raw materials is 7.9 percent. It is lower in summer when the gas production is high and higher in winter when the gas production is low.

pH. The pH for the bacteria is usually 7-8, plus or minus 0.5. The pH can be easily checked either with pH paper or a pH meter.

SAKHAWANI, A GOBAR GAS VILLAGE

Background

Sakhawani is located in the Sour Farsatikar Village Panchayat about 15 km. southwest of Butwal. Brahmins are the major caste group living in the village. There are 31 households, eight of which have installed family-size biogas plants. The households were convinced in December 1984 by the joint efforts of ADB Nayagaun subbranch manager Mr. Keshav Regmi and his staff as well as the Gobar Gas Company Regional Office Butwal Regional Manager Mr. G. P. Devkota and his staff.

All the necessary documents were taken to the field. Materials were supplied from Gobar Gas Company one week after the order was received. On that day, two missions were sent to install biogas plants. Within two weeks, all except one had been completed. The one incomplete plant was due to a high water table.

A series of follow-up visits to these plants are being made to find out how the plants are working. It is expected that these inspection visits will be useful in determining the need for improving the design specifications of future plants.

The present survey shows that most of the owners are very pleased with their plants. Similarly, some of the nonusers are also impressed and are willing to install gobar gas plants this year.

Most of the villagers in Sakhawani migrated from different places and are summarized in Table 1.

Economic Status

The socioeconomic status of the gobar gas plant owners is well above the average for rural Nepal. Most of the owners had already seen a gobar gas plant before installing their own.

Almost all the owners of the gobar gas plants are farmers whose main source of income is agriculture. Very few have secondary sources of income. They were motivated to install gobar gas plant primarily because fuelwood was far from the village, and too expensive.

The average family size of the individual plant owners and non-owners is eight persons. The average landholding per family is 3.4 ha which is well above the national average of 1.1 ha. The average landholding per nonuser family is about two bighas, as shown in Table 2.

Table 1. Village Migration

Migrated from	Gobar gas users	Nonusers
Syangja	5	4
Parbat	3	1
Gulmi	2	1
Baglung	-	1
Anandanagar	-	3
Pillgung	-	2
Tansen	-	1
Dharmapur	-	2
India	-	3

Table 2. Average Family Landholding

Family members	No land	1-2 Bighas	2-4	4-6	Above 6
Gobar gas plant owners	-	-	3	4	1
Nonowners	1	13	6	2	1

Livestock holdings are higher among the owners than among the non-owners. This is because having sufficient cattle is a prerequisite for installing a biogas plant as cattle dung is the principal raw material for its operation. Two of the biogas plant owners have four to six livestock, three have seven to nine livestock, and three have more than nine livestock.

Educational Level

A higher percentage of the plant owning family members are literate, and have more schooling than the members of the nonowner households. The following table displays the educational status of the people in Sakhawani Village.

Table 3. Educational Level

	Literate	Illiterate	Schooling	Total
Owners	10	41	20	71
Nonowners	21	114	37	172
Total				243

Energy Demand and Supply

The survey revealed that almost all gobar gas plant owners are using gobar gas stoves which consume about .46 cu.m. of gas per hour.

In addition to gobar gas stoves, they have traditional chulos for cooking livestock feed. They use the gobar gas stove three to eight hours a day. Each individual owner has saved about 100 packs (about 5360 kg.) of firewood. Assuming the price of firewood to be NRs.15 per pack, an average of NRs.2250 has been saved annually by each gobar gas plant owner. Eighteen lamps were installed in the eight plant owners' houses. These lamps save kerosene for the plant owners, and burn brighter than other kinds of traditional lamps.

Estimating total energy consumption per household was not possible because of relevant data and information unavailability.

Owners' Perspective on Techno-economic Viability

A farmer having 100 cu.ft. of gobar gas is using the equivalent of 1.2 liters of kerosene, 2.1 kg. of coal, 7 kg. of firewood, 26 kg. of dry dung cakes, or 9.4 kw. of electric power per day. The caloric value of biogas depends upon its methane content (4700-5500 Kcal/cu.m. gas).

Table 4. Cost of Fuel

Fuel	Cost/unit
Kerosene	NRs.6/lit.
Firewood	NRs.0.5/kg.
Charcoal	NRs.3/kg.
Coal	NRs.3/kg.
Briquetted coal	NRs.1.5/kg.
Dung cakes	NRs.0.2/kg.
Electric power	NRs.0.9/kw.

Note: These cost estimates are from Butwal Bazaar, December 1985.

User assessment was made with reference to gas production and slurry use. The gas production in summer was enough for cooking and lighting for six to eight family members from a 10 cu.m. plant and 12-15 members from a 15 cu.m. plant. In winter, gas production was usually insufficient by about 40 percent. Because the plants were built only last year, the owners did not have good experience handling the slurry. However, the nitrogen content in the slurry output is three times higher than in fresh dung. On the other hand, slurry output is reduced by about 27 percent in total solids and volatile solids.

The villagers are still not in a position to do simple repair and maintenance but they could within a few months if a short term training program is given. Gobar Gas Company and ADB are training between 25 and 50 individual plant owners each year, selected using a random sample of plant owners. A second difficulty with repair and maintenance is the unavailability of good quality spare parts and appliances.

The construction charge of the plant is quite high. This might be due to high overhead, manpower, and expensive machinery of the Gobar Gas Company. The excess costs are indirectly charged to the customers because the company has a monopoly business.

To make it economically viable, the cost of the plant should be reduced either by making mud or brick domes instead of concrete domes, by using polythene pipes instead of G.I. pipes, and by avoiding agitators and gobar mixing machines in family-size biogas plants. With a brick mortar dome, the cost can be reduced by about 15 percent and with a mud dome the cost is reduced by about 35-40 percent. The main gas pipe can be reduced to 1 1/4 from 2 inches in diameter. Similarly, low cost lamps can be used.

Impact of Biogas on User Households

In general, the housewives are impressed with the usefulness of biogas for cooking. Its advantages over conventional fuel are required cooking time is shorter by about 30 percent; kitchen and utensils take about 50 percent less time to clean when used with biogas; the kitchen and home are free from smoke; and biogas burners are considered a status symbol. Common grievances were that the gas pressure was not uniform and lamp mantles often burst, and complete reliance on biogas is not possible since there is often leakage from the main gas valve and gas cock. In addition, for about three months a year (December-February) the amount of gas is inadequate.

Reasons given for the slow adoption of biogas plants include high installation cost, low productivity during winter months when the fuel is needed most, the necessity of owning cattle, lack of suitable extension and maintenance services, and the lack of alternative sources of fuel for villagers who do not own cattle.

Fuelwood Consumption

The annual firewood consumption, firewood saving and kerosene saving in each household of Sakhawani Village are shown in Tables 5, 6, and 7.

Table 5. Annual Fuelwood Consumption

	No firewood consumption	50 bundles	50-100	100-150	150-200	Above 200
Owners	1	6	1	-	-	-
Nonowners	-	1	5	7	10	1

Note: 1 bundle = approximately 30 to 35 kg.

Table 6. Annual Firewood Saving

Family size	Annual firewood requirement before having gobar gas plant (average kg.)	Annual firewood requirement after having gobar gas plant (average kg.)	Annual firewood saving (average kg.)
1-5 members	6240	1660	4580
6-10 members	9000	3744	5256
11 and above	10920	4680	6240

Table 7. Annual Kerosene Saving

Family size	No. of lamp users	Annual keorsene requirement before gobar gas plant (average l.)	Annual kerosene requirement after gobar gas plant (average l.)	Annual kerosene saving (average l.)
1-5 members	2	52	-	52
6-10 members	2	145	52	93
11 and above	3	156	78	78

The above tables show the saving of firewood is highest for the larger families and the the saving of kerosene is highest among middle-sized households.

ECONOMICS OF BIOGAS PLANTS

The economic potentials of the biogas plants can be assessed in terms of pollution control, as a source of energy, and feed and fertilizer for food production.

Pollution caused by manure and farm waste can be reduced if organic fertilizer from sludge is used. Various communicable diseases can be transmitted by flies or by direct contact with manure. Biogas plant contribute to improved sanitation.

National energy policy requires both the public and private sectors to conserve energy. Scientists have redoubled their efforts to find substitutes for oil. Biogas is an alternative source of energy.

The sludge from the biogas plants retains most of the nutrients contained in manure, such as nitrogen, phosphorous pentoxide, and potassium oxide. These organic fertilizers are better than chemical fertilizers, which cause water pollution and soil pH problems. The sludge can also be used as feed for fish and fertilizer for food crops. In this way biogas helps save food production costs.

Other benefits, such as time saved, convenience in cooking without irritating smoke from firewood, and bright light from biogas lamps, were not taken into consideration for the economic analysis, since these benefits are not easily quantifiable.

Financial Analysis of a Domestic Biogas Plant

The main benefit of biogas is that it replaces fuel wood for cooking and kerosene for lighting. In a few cases it replaces diesel for dual fuel engines.

The market price of firewood varies considerably with location in Nepal. This analysis was done using the Sakhawani firewood price of NRs.0.5/kg. At this price, firewood is still a cheaper source of fuel than kerosene. A domestic plant is attractive only if firewood prices reach NRs.0.75/kg.

Through the ADB, many farmers have taken loans at 11 percent interest, repayable over seven years. These terms are by no means encouraging to prospective plant owners. In fact it is less appealing than investing one's money. Taking an average price of NRs.0.36/kg. for firewood (Campbell, 1983) in the hills, a 40 percent subsidy is required to make a domestic plant an attractive option for individual villagers.

It would be more attractive if the villagers had a community biogas plant for irrigation or grain milling. These systems yield a high cost-benefit ratio and the internal rate of return is greater at a 50 percent subsidy. With less than a 20 percent subsidy, the biogas system would not be attractive.

Studies conducted all over the world disagree considerably on the economics of biogas plants. Most of these analyses are concerned with the family-scale system or a hypothetical village system and make wide assumptions. These assumptions include: values assigned to capital and annual costs, calorific values for fuels and thermal efficiencies, per capita energy consumption, market prices and opportunity costs for labor, energy, organic residues, and capital.

Tables 8 and 9 indicate the costs charged by Biogas Company for installing biogas plants of different sizes and capacities until 1984. From 1985 onwards the costs of the plant have increased.

Table 8. Cost Component Until 1984 (NRs.)

Size plant	Materials cost	Construction cost	Guarantee charge	Farmer's contribution	Total
10 cu.m.	6534	2450	750	2760	12,494
15 cu.m.	8220	3220	1200	3720	16,340
20 cu.m.	10,274	4000	1800	4745	20,819
50 cu.m.	17,935	9200	4500	11,500	43,135

Table 9. Cost Component After 1985 (NRs.)

Size plant	Materials cost	Construction cost	Guarantee charge	Farmer's contribution	Total
10 cu.m.	8073	2800	1000	3250	15,123
15 cu.m.	10,054	3800	1500	4407	19,761
20 cu.m.	12,364	4600	2400	5610	24,974
50 cu.m.	21,058	9200	5500	13,150	48,908

Economic Analysis of a Domestic Biogas System

Capital Cost. The total cost of a 10 cu.m. fixed dome design biogas plant was NRs.12,494 in 1984. Assuming the farmer receives a loan at 11 percent interest to be repaid over seven years, the annual payment is NRs.2652.65. The total cost of the loan, including interest is, NRs.2652.65 x 7 = NRs.18,568.55.

Annual Cost. Assuming the life of the fixed dome design biogas plant is 40 years, and that the repair and maintenance costs are about 2 percent of the capital cost, the annual cost will be NRs.714.09.

Cost of Energy. Seventy-five percent of the gas is used instead of firewood for cooking, the remainder replacing kerosene for lighting. The efficiency of biogas stove is 55 percent--firewood is about 10 percent, and about the same for the lamp efficiency of both biogas and kerosene.

For kerosene costing NRs.6/liter and firewood of NRs.0.50/kg., the cost equivalent will be NRs.6 x 0.53 = 3.18 for kerosene, and 4 x NRs.0.50 = 2.00 for firewood (assuming .53 liters kerosene = 1 cu.m. biogas and 4 kg. firewood = 1 cu.m. biogas). The annual benefits of using biogas instead of kerosene and firewood are:

Kerosene: 3.18 x 2.17 x .25 x 365 = NRs.783.50
Firewood: 2.00 x 2.70 x .75 x 365 = NRs.1478.25

Total benefits of biogas as energy source. = NRs.2261.75

Fertilizer Value. The cost of urea is NRs.3.50/kg. and it is 46 percent nitrogen. Hence, the cost of nitrogen is NRs.0.60/kg. Fresh dung has initially 0.5 percent nitrogen and for each cu.m. of biogas, 22 kg. of cattle dung is needed per day, or 8030 kg./yr.

In 8030 kg. dung, there is 40.15 kg. nitrogen, which is equivalent to 87 kg of urea fertilizer. The cost of urea is NRS.3.50/kg while nitrogen is NRS.7.60/kg. The value of the nitrogen from that plant is 40.15 x 2.7 x 7.60 = NRs.823.90/year. Under the current method of making farmyard manure, the value of nitrogen will be decrease by about 50 percent to NRs.412.95. Under the proposed method of making manure, the value of nitrogen is 823.90 x 85 percent = NRs.700.30/year. The improved nitrogen value of the manure is thus NRs.700.30 - 412.95 = NRs.287.36/year.

The cost-benefit ratio is thus:

Total benefit = NRs.2261.75 + 287.36
= NRs.2549.11/year

Total cost = NRs.714.09

Benefit/Cost = 3.57/1

INSTITUTIONAL SUPPORT

There are two main supporting institutions for the installation of biogas plants: the Gobar Gas Tatha Krishi Yantra Vikash Company (P) Ltd. (GGCO), and the Agricultural Development Bank/Nepal.

The GGCO was established to build biogas plants and promote their use in Nepal. It offers training in biogas technology for farmers and provides a seven year guarantee for any plants they build. GGCO has a network of sales and service depots in 12 districts of Nepal and makes yearly follow-up visits to customers as part of the guarantee.

As of 1984/85, there were 1890 biogas plants already constructed in Nepal.

Table 10. Biogas Plant Installation in Nepal

Year	Drum type	Dome type	Total
1973/74	4	-	4
1974/75	199	-	199
1975/76	143	-	143
1976/77	122	-	122
1977/78	114	-	114
1978/79	127	-	127
1979/80	74	13	87
1980/81	57	77	134
1981/82	36	196	232
1982/83	21	260	281
1983/84	9	168	177
1984/85	20	250	270
Total	926	964	1890

Objectives of the Company

The main objectives of the company are

-- to be an enterprise for the development, promotion, planning, manufacture, construction, servicing, commissioning, and marketing of gobar gas plants and other agricultural equipment;

-- to research the construction, operation, and maintenance of gobar gas plants and other agricultural equipment;

-- to make fuel and fertilizer available;

-- to help prevent denudation of forest and soil erosion;

-- to improve social health; and

-- to enrich rural life.

Problems faced by the Gobar Gas Company have been related to the supply of materials, especially cement, G.I. pipe, and steel. Since there is often a shortage of these supplies in India, a licensing and quota system have been introduced. Estimating total energy consumption per household was not possible because of lack of data and information. In addition, the machines are very expensive. This means that careful planning and management are required to ensure availability of materials. To make biogas plants more affordable to farm households, the depreciation of the machine should be lowered, extra labor power (especially clerical staff) cut, a low cost design (brick mortar dome or rural dome) developed, and gas production further increased.

Agricultural Development Bank

One of the major shareholders of the Gobar Gas Company is Agricultural Development Bank. It provides loans for the installation of biogas plants throughout the whole kingdom. The interest rate was intitially six percent. In the last two years it has increased to 11 percent. Starting in 1985, His Majesty's Government (HMG) has given a 50 percent subsidy for the interest payments.

To create greater demand and to strengthen biogas technology, there should be maximum mobilization of staff in the extension and promotion of biogas plants in Nepal. A joint field program between ADB and the Gobar Gas Company staff would be more effective in selling biogas plants since the former is related with credit policy and the latter with technology. An incentive of NRs.50 should be given to the staff who create demand for the installation of biogas plants.

Government Policy on Biogas

Though His Majesty's Government plays a vital role in popularizing biogas use, it has not given serious attention to the promotion and extension of biogas technology.

In 1975/76, the government provided interest free loans for the installation of biogas plants. At that time, the Department of Agriculture, United Mission to Nepal, and other agencies were involved in constructing biogas plants (mostly drum types) in Nepal.

In 1982/83, under the special paddy crop program, the government provided subsidies for the installation of 88 gobar gas plants in three districts: Dhanusha, Sunsari, and Rupandehi. Though the objective was to provide subsidies to poor farmers, the rich mainly benefitted.

In 1985/86, the government announced a 50 percent interest subsidy for biogas plants in the budget. This is barely sufficient to attract farmers.

In the extention and promotion of biogas technology in Nepal, HMG should provide at least a 20 percent subsidy for the installation of gobar gas plants. Access to the forest to collect firewood should be strongly controlled, and the importing of petroleum fuel should be strictly regulated. An energy department should be set up and vigorous research should conducted on various uses of biogas.

RECOMMENDATIONS

1. The research and development wing should design smaller gas plants which will be enough for a small family for cooking and lighting.

2. There should be regular field visits and training program for the farmers, housewives, and the staff of the company.

3. Gas should be utilized commercially or industrially to generate income for the repayment of loan.

4. There should be limited import of chemical fertilizer, kerosene, and diesel.

5. HMG should allocate a portion of the budget for reforestation and preservation to the installation of biogas plants.

6. The Agricultural Department and the Agricultural Development Bank should be actively involved in promoting biogas and encourage and support the biogas companies.

7. GGCO should lower the cost of the plant by about 20 percent or double the gas production by composting or using heat exchanger. ADB/N should provide loans at about five percent. HMG should provide at least 35 percent subsidy for the plant and 100 percent subsidy for the transportation of the materials to make biogas plants affordable to individual farmers.

8. Access to the forest should be strictly controlled. Reforestation should emphasize the planting of high yielding and quick growing trees.

REFERENCES

Cambell, J. G. and T. N. Bhattarai. "Results from On-going Evaluation Survey's, 1982-83." Miscellaneous Document No. 14. Kathmandu, Nepal: Community Forestry Development Project. 1983.

Devkota, G. P. "Biogas as an Energy Alternative." Paper presented at the Seminar on the Energy Crisis in Nepal, Butwal, Nepal. 11-12 June, 1984.

----------. "Biogas Research and Development in Nepal." In Renewable Energy Sources. International Progress.

----------. "Compost for Heat Generation." Biogas Forum No. 15. West Germany. (1984).

----------. "Report on Utilizing Waste Heat from Biogas Power Generation." Biogas Forum No. 16. West Germany. (1984).

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