Development of Biogas in Nepal

Indira Shakya
Royal Nepal Academy of Science and Technology (RONAST)
G.P.O. Box 3323, Khumaltar, Lalitpur
NEPAL

ABSTRACT

The objective of this is paper is to assess the development trend of biogas technology in Nepal and highlight its advantages at rural and national levels considering financial, social and environmental aspects. The roles of government institutions, NGOs and INGOs in promoting the technology are introduced. In this context, the Biogas Support Programme (BSP), under the Netherlands Development Organisation, initiated, implemented and supported the biogas program in Nepal. Biogas plants are very profitable and hence popular in the country providing higher economic as well as financial returns and reducing burden on forest resource and fuelwood. Besides, the reliance on imported fossil fuel is also reduced remarkably. Despite its advantages and popularity, there are certain factors still deterring the technology from reaching the most needy. In order to make the system sustainable even in the absence of subsidy and affordable to the poorer section of the population, it is pertinent that proper R&D leading to cheaper technology and considerable reduction in the existing costs of the biogas plants, could help biogas sub-sector, especially in terms of demand.

1. INTRODUCTION

Most of the population of Nepal reside in the semi-tropical region and most of the energy needs of this rural population are for cooking and lighting. Firewood and dung cakes meet 88% of this requirement [1]. Use of firewood results in deforestation and use of dung burns valuable fertilizer. However, this problem can be resolved to an extent by installing biogas plants. Biogas is a mixture of gas produced by methanogenic bacteria while acting upon biodegradable materials in an anaerobic condition. It is mainly composed of 60% to 70% methane, 30% to 40% carbon dioxide, and other gases. It is odourless, burns like LPG gas and about 20% lighter than air [2].

2. HISTORICAL DEVELOPMENT

The first biogas plant was built in Nepal in 1955 by late Father B.R. Sauboll, a Belgian teacher at Godavari St. Xavier's School. The prototype, a demonstration plant, was fabricated from an old 200-liter drum and a gasholder made of mild steel sheet. In 1968, Khadi and Village Industries Commission (KVIC) of India built a plant for an exhibition at Kathmandu. During the Agricultural Year 1974-75, the Department of Agriculture set up a program to install 250 floating drum type of biogas plants and the Agricultural Development Bank of Nepal (ADB/N) provided interest-free loan. In 1974, Development and Consulting Services (DCS) built four floating drum plants of KVIC design. Gobar Gas Tatha Krishi Yantra Vikas Ltd. (Biogas and Agriculture Equipment Development Company Pvt. Ltd.) (GGC) was formed in 1977 with the joint investment of the United Mission to Nepal (UMN), the Agricultural Development Bank (ADB/N) and Nepal Fuel Corporation under the DCS biogas extension program [1, 3, 4]. The biogas company was backed up by a research and fabrication unit in Butwal and sales and services centers at strategic locations in the Tarai and inner Tarai regions [1]. The Tarai region is located in the plain areas of Nepal. With the success of biogas development program and the availability of government subsidies as well as the interest and involvement of NGOs and donor agencies, several private companies started to be involved [1]. A new impetus was added to the biogas program with the initiation and establishment of the Biogas Support Programme in 1992-93. This program was launched in collaboration with His Majesty's Government of Nepal (HMG/N), the Netherlands Development Organisation (SNV-Nepal) and the German Financial Co-operation (KfW) in co-operation with the ADB/N, Nepal Bank Limited (NBL), Rastriya Banijya Bank (RBB) and some recognized biogas companies. The support was for subsidies, quality control, training, and other purposes.

Research conducted for the development of the biogas technology started with testing and experimentation of various designs such as floating steel drum, concrete fixed dome, pre-cast tunnel, plastic bag bio-digester, ferrocement gas holder, brick mortar dome, and mud dome. For fixed dome design, a Chinese modification plant was introduced in Nepal in 1980. After several modifications, fixed dome design (GGC model 1990) was the only recognized design and was the most popular in Nepal.

Presently there are more than 90,000 plants installed in the country. It is estimated that about 90% of these plants are functional and are used on a regular basis producing about 40 million cm^3 biogas annually.

3. POTENTIALS OF BIOGAS

As an agricultural country, livestock plays an important role in the farming system of Nepal. The total cattle and buffalo population was estimated to be 9.3 million (i.e., 6.3 million cattle and 3 million buffaloes) in 1990-91. Based upon the study of technical biogas potential of Nepal, it is assumed that a total of 28.1 million tons of dung would be available per day for biogas production. This indicates that there is a high potential of biogas production in the country. The potential number of biogas plants is estimated to be about 1.3 million out of which 62% are situated in plains, 37% in hills and 1% in mountain region [5].

Table 1 Potential and status of biogas plants

Total technical potential	1.4 million plants
Total economic potential	600 000 plants
Total installation up to 2001	91 000 plants

Source: BSP, 2002 [7]

4. CHARACTERISTICS OF BIOGAS PLANTS

4.1 Technical Quality of Plants

The quality of plants constructed under the Biogas Support Programme (BSP) has been receiving due consideration for the overall sustainability of the biogas programs in Nepal. The quality of a biogas plant implies a package of benefits perceived by its users against the total costs incurred in its installation:

- Quality of construction design,
- Quality of operation and maintenance of the plants by the users, and
- Quality of after-sales services rendered by the construction company.

An evaluation study of biogas plants in Nepal has concluded that the design of the plant was satisfactory to 88% of the users. About 92% expressed their satisfaction over the location of the plant, 92% expressed that the construction materials used are of standard, while 92% expressed satisfaction with the after-sales services [6]. The evaluation also concluded that the overall success of the biogas program has been possible because of the following:

- Provision and continuity of subsidy for the plant owners;
- Creation of a conducive policy environment for the entry of significant number of private companies;
- Protection of the interest of the plant owners through provision of quality control of the plants constructed by companies, including the GGC; and
- Building of the institutional capability of the various actors involved in the biogas program.

4.2 Temperature

The optimum temperature for methane producing bacteria is about 35°C. When the slurry temperature is low, gas production is greatly reduced. At 10°C slurry temperature, the production of biogas is more or less halted. In fixed dome type plants, the temperature can be increased with composting whereas in floating drum plants, it can be increased by using solar energy or, if the gas is used for running engines, waste heat from the exchanger could increase the temperature. Gas production at various temperatures are shown in Table 2.

Table 2 Gas production at various digester temperatures

Digester Temperature	25°C	30°C	35°C
Gas production (m^3/kg total solid)	0.26	0.30	0.45

Source: BSP, 2002 [7]

4.3 Retention Time

Retention time is the ratio of the volume of digester and the feeding rate of biomass slurry; it indicates the length of time available for the organic matter to be digested inside the slurry. Retention time depends on the temperature. The closer the temperature to the optimum value, the faster the bacteria use the organic matter from the slurry and lower is the retention time. Different values of retention are used in the Tarai regions and the hills. In Nepal, floating drum plants are designed especially for Tarai regions where the temperature is higher and transportation of the drum is not a major problem. In these plants the retention time is 52 to 60 days. But in case of fixed dome plants, which were designed especially for the hilly regions where the temperature is comparatively lower, the retention time is 73 to 83 days. Table 3 shows the details of size, input and output of fixed dome plant.

Table 3 Size, input and output of fixed dome plant

Capacity (m^3)	Digester Volume (m^3)	Gas Storage Volume (m^3)	Daily Dung Feeding (kg)	Retention Time (day)	Gas Production/day (m^3)
4	2.8	1.2	25	80	1.4
6	4.4	1.7	40	75	1.8
8	5.8	2.2	48	83	2.2
10	7.5	2.8	60	83	3.1
15	11.4	3.9	90	83	4.2
20	14.2	5.8	120	83	6.4

Source: Devkota, 2001 [8]

4.4 Carbon/Nitrogen Ratio

Carbon and nitrogen are needed for anaerobic bacteria. Carbon is utilized for energy and nitrogen for the building of cell structures. Bacteria use carbon 25 to 30 times faster than they use nitrogen. So the optimum ratio is 25 to 30. If the carbon/nitrogen ratio is not appropriate, it can be adjusted adding urea or gypsum. Estimated amount of 3.7 g of urea is required for 1 kg of dung to acquire a C/N ratio of 20. The C/N ratio of some of the feeding materials are shown in Table 4.

Table 4 C/N ratio of various feeding materials

Material	C/N Ratio
Dung	25
Straw	87
Pig manure	14
Poultry droppings	8
Night soil	8

Source: Devkota,2001 [8]

4.5 Dung/Water Ratio

This ratio is dependent on the dry matter percentage (DM%) of the feeding material. In order to prevent stratification, it is pertinent that the DM% be maintained. The general practice is to maintain a ratio of 1:1 as the increase in water quantity reduces the production of gas. Further, it is impertinent to maintain the thickness of slurry between 14% and 6% of total solids (TS).

4.6 Feeding Rates and Operation Specification

The feeding rates for different plant capacity are shown in Table 5 while the biogas operation specifications for hilly areas and Tarai regions are shown in Table 6 and 7, respectively.

Table 5 Feeding rate of fixed dome design biogas plants

Capacity (m^3)	Initial Dung Requirement (kg)	Daily Feeding (kg)		Daily Water Requirement (liters)		Required Cattle Head
		Hills	*Tarai*	*Hills*	*Tarai*	
4	1450	24	30	24	30	2 to 3
6	2200	36	45	36	45	3 to 4
8	2900	48	60	48	60	4 to 6
10	3500	60	75	60	75	6 to 9
15	5550	90	110	90	110	9 to 14
20	7200	120	150	120	150	Above 14

Source: GGC, 2001 [5]

Table 6 Biogas operation specification for the hilly areas

Plant Capacity (m^3)	Initial Dung Feeding (kg)	Dung Requirement (kg/day)	Water Requirement (liters/day)	Consumption (stove/hour)
4	1450	24	24	2.5
6	2200	36	36	3.5
8	2900	48	48	5.0
10	3500	600	600	6.0

Source: BSP, 2002 [7]

Table 7 Biogas operation specification for the Tarai regions

Plant Capacity (m^3)	Initial Dung Feeding (kg)	Dung Requirement (kg/day)	Water Requirement (liters/day)	Consumption (stove/hour)
4	1450	30	30	3.0
6	2200	45	45	4.5
8	2900	60	60	6.0
10	3500	75	75	7.5

Source: BSP, 2002 [7]

5. ACHIEVEMENTS AND CHALLENGES

There are a total of 932 floating drum biogas plants in Nepal producing 6 m^3 to 60 m^3 gas per day. There are about 79,000 fixed dome biogas plants. Previously scum breaker was fixed inside the digester and the floor was curved, but in 1990, this was changed to flat bottom. These plants have about 4 m^3 to 50 m^3 digester volume. There are about 100 tunnel plants where the roof is made of concrete arch pieces lined with plastic sheets. These plants have been found to be feasible up to an altitude of 2100 m.

During the period 1992-2001, about 80,000 plants were installed; of these 50% use animal dung alone and the remaining 50% are connected to the toilets. The average plant size is 7.5 m^3. The total plant volume is 600,000 m^3. The annual gas production is 37.6 million m^3 with an annual energy production of 752,000 GJ [6].

5.1 Biogas Installation

So far 49 companies have installed about 80 thousand biogas plants in Nepal. Potentials and installation of biogas plants by geographical region are shown in Figs. 1 and 2, respectively. The growth trend of biogas plants and distribution by size and geographical regions are shown in Figs. 3 and 4, respectively.

The GGC has also installed about 60 community-level biogas plants. With an objective of encouraging income-generating activities, these plants were used for operating engines. Some of the activities promoted were agro-processing, electricity generation and pumping of water for irrigation.

Several dual-fuel engines were in use. The engines which were robust and reliable were purchased from India. A 5 HP engine uses about 2.1 m^3 of biogas and 0.2 liters of diesel in an hour as opposed to 1.2 liters of diesel alone. The gas from the plants was used to operate 5 and 8 HP engines. The most popular design is the dome design.

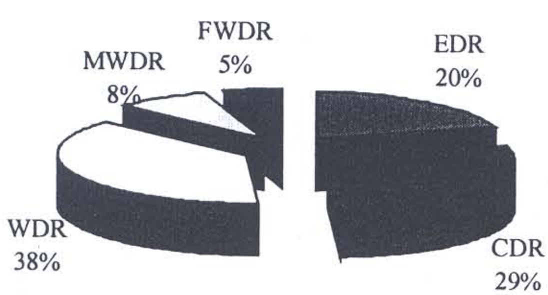

Fig. 1 Installation of biogas plants by development regions

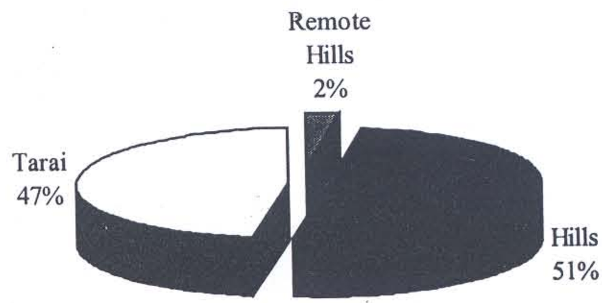

Fig. 2 Distribution of biogas plants by geographical regions

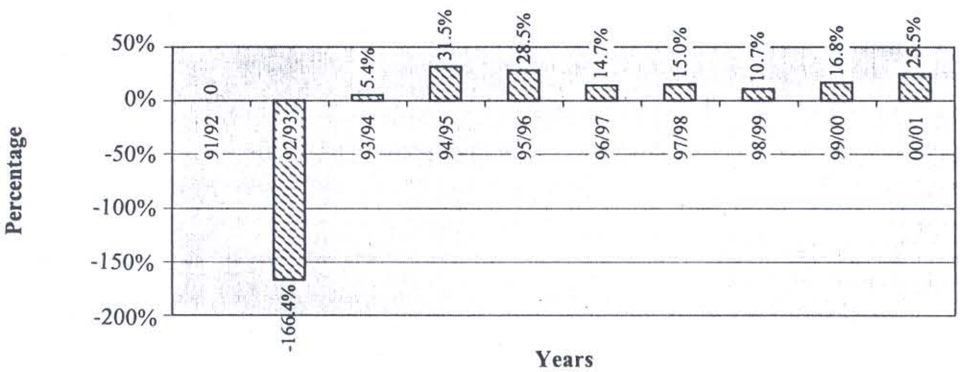

Fig. 3 Growth trend of biogas plants

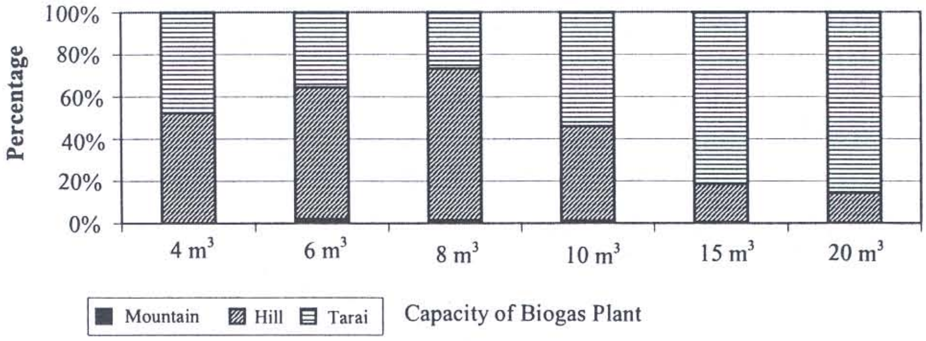

Fig. 4 Distribution of biogas plants by size and geographical regions

5.2 Night Soil Biogas Plants

The operation of plants using night soil was initiated in 1977 as an experiment at Tansen prison in Palpa. With the purpose of providing improvement of latrines as well as gas from the plants, efforts have been made to increase their number. Currently more than 90% of the plants operate on night soil.

6. BIOGAS APPLICATIONS AND DEVELOPMENT STUDIES

Biogas is a high quality fuel used for many purposes including cooling, lighting, running dual fuel engines, agro-processing, pumping water and generating electricity. A brief description of each use is shown in Table 8.

Table 8 Uses of biogas

Activity	Remark
Cooking	Biogas can be used with suitably designed burners to give a clean, smokeless, blue flame, which is ideal for cooking.
Lighting	Used for lighting especially in the hills.
Operation of dual fuel engines	
Running boilers refrigerators and vehicles	

6.1 Uses of Slurry

The nutrient contents of bio-slurry are as follows: 1.76% nitrogen, 2.07% phosphorous, and 2.30% potash while that of gobar (dung) are: 0.60% nitrogen, 1.3% phosphorous, and 1.7% potash. Thus slurry is a richer material compared to dung and can be used as follows:

- Fertilizer,
- Fish and animals feeds,
- Mushroom cultivation,
- Earthworm cultivation, and
- Slurry for decomposing chlorophyll of the leaves.

A comparative production of crops using various fertilizers indicates a higher yield from bio-slurry. The application of slurry was found to be better on vegetables rather than in cereals [6]. Table 9 shows the yield of crops using various fertilizers.

Table 9 Yield of crops by using various fertilizers (in kg)

Crops	Dung	Chemicals	Bio-slurry	Chemicals and Bio-slurry	Control
Potatoes		1.50	1.40	1.54	1.20
Onion		0.44	0.42	0.50	0.40
Cabbage		0.95	0.80	0.98	0.74
Lady's finger		0.35	0.34	0.36	0.30
Wheat	11.50	17.3	12.9		8.80
Maize	43.00	47.50	46.50		37.50
Paddy	44.50	47.50	43.50		37.50

Source: GGC, 2001 [5] and Devkota, 2001 [8]

There has been a remarkable impact of biogas on the life of users. Surveys have revealed that the tangible impact in terms of savings in firewood, kerosene and time that would be required in the absence of biogas plant, and the intangible benefits such as the reduction in respiratory disease plus other benefits are all perceived to be quite significant. The following are the benefits from the use of biogas:

- Annual savings of fuelwood and dung cakes,
- Saving of kerosene,
- Annual reduction of CO emission,
- Saving on NPK and organic matters, available to sustain soil fertility,
- Improvement of health leading to cleaner sanitation habits. Reduction of indoor pollution and smoke, and
- Reduction in workload of nearly 90,000 households.

It is also estimated that one 6 cm^3 biogas plant can replace the use of 3 tons of fuelwood or 38 liters of kerosene annually. It is also calculated that it produces 27 tons of digested slurry and reduces 4.2 tons of carbon dioxide equivalent per year. This shows the saving of 11.6 trees annually, i.e., 0.055 ha of forest [4].

On this basis, a comparative analysis was made on firewood consumption before and after biogas installation and the result showed savings in firewood. It is estimated that the operational biogas plants have reduced dependency on fuelwood by 80% and on kerosene by 60% [9]. This would result in a net reduction of approximately 300 thousand tons of carbon dioxide equivalent annually. This will help in savings of about 25 thousand tons of carbon dioxide equivalent per year. Similarly it is also calculated that savings of live trees due to installation of biogas plants in the program districts were estimated at about 869,000 soft trees of various species per year [8].

It has also been estimated that with the introduction of biogas, the national biogas program has contributed to reduce the consumption of 27 hundred thousand liters of kerosene by about thousand H/Hs. This has saved an outflow of NRs. 4.5 million in a year assuming the price of kerosene at NRs. 17 per liter.

The application of slurry from the biogas plants and its impact on agricultural production both on cereal and vegetable could not be quantified. However, it has been estimated that about 10 to 15 agricultural productions could be increased with proper composting and application of the slurry in the field. It also helps in improving the texture and structure of soil condition. Furthermore, it reduces the consumption of chemical fertilizers.

The installation of biogas plants has also helped improve household sanitation through cleaner cooking utensils and eradication of flies. Similarly construction of compost pit has also helped to improve the environment in the program areas [10]. Nearly 54,000 toilets [7] are connected with biogas production.

A study conducted on the impact of biogas plants on workload estimates a saving of nearly 2.8 hours a day. Nearly 60% time is saved on reducing fuel collection; 46% hours on cooking activities, and nearly 50% on time for cleaning of cooking utensils [10].

By the year 1999, biogas promotion in the country has generated employment of nearly 10,500 people [2, 7 and 11].

6.3 Technical Problems Associated with the Biogas System

A survey conducted in Tanahu District [10] identified the following as major recurring problems with the biogas systems:

- Leakage in the gas pipe: 3.4% to 9.7%
- Moisture condensation and blockage of gas: 3.2%to 3.4%
- Burning out of sieve for lighting: 3.4%
- Blockage of the holes of gas burner: 6.8% to 9.7%
- Breaking up of the handle of the dung mixing apparatus: 6.8%
- Improper passage of slurry through the outlet: 3.2% to 6.8%
- Development of cracks on the top of the digestor: 3.2% to 6.8%

6.4 Research and Development Activities

During the period 1981-1986, GGC developed and tested various designs of biogas plants such as floating drum, fixed dome, tunnel, plastic bag digester, and other designs. Similarly, various types of biogas appliances such as gas pipes, mixer machines, gas taps, stove lamps, water drains, gas meter, agitator, and manometers were developed, modified and tested. On the other hand, experiments with various alternative feed stocks such as water hyacinth, night soil and rice straw were experimented. Slurry coming from the plant was applied to various crops both vegetables and cereals. It was also used for feeding fish and animals. However, most of the research on the subject was limited to experiments and demonstration.

Research was conducted on the application of gas for running engines for agro-processing, pumping water for irrigation and generating electricity for the community. Until 1986, Gobar Gas Company had installed 60 such plants. But due to some social problems, such as unequal contribution of dung in comparison to family members, leasing agro-processing mills on rotation basis, and additional burden to the family members (less wear and tear in the first year and more in the later years), most of these plants are not currently in operation.

6.5 Training Programs

Various training programs were organized for biogas users, local masons as well as staff of GGC.

User and Owners

Training programs were designed for potential farmers and users especially focusing on female biogas users. The training programs were conducted at a local venue so that maximum participants could benefit at minimum cost. This greatly influenced the number of plants installed per year.

Masons

The masons were trained on installation of biogas plants. It also covered areas such as site survey, quality of construction materials to be used, storage of cement, layout of the plants, use of templates, dome casting and plastering, outlet construction and toilet attachment, operation of the plants, factors affecting the plants, and alternative feed stocks.

In order to reduce the burden of GGC, local masons were trained. This included construction as well as repair and maintenance of the plants. This helped in promoting the technology to a large extent. A total of 557 masons have been trained in different parts of the country.

6.6 Economics of Biogas Plants

A study report presents the technical potential of biogas per district. The cost of plants varies from one place to another as well between sizes of the plants. The costs of various sizes of fixed dome plants are shown in Table 10. The costs of 8 m^3 biogas plant including construction and labor are shown in Tables 11 and 12. The total cost is NRs. 27,204. The annual savings and expenditures are shown in Table 13. The payback period of the system with subsidy is 4.1 years and for system without subsidy is 6.1 years.

Table 10 Costs of various sizes of fixed dome plants (NRs)

Particulars	4 m^3	6 m^3	8 m^3	10 m^3
Biogas appliances and their fittings	4842	5399	6251	6601
Construction charge	4100	4800	5200	5800
Three-year guarantee	600	600	600	600
Promotional fee	525	525	525	525
Sub-total	10167	11424	12676	13626
Material cost in the hills	10194	11944	14705	17135
Material cost in the Tarai	9874	11624	14065	16495
Total cost in the hills	**20361**	**23368**	**27381**	**30761**
Total cost in the Tarai	**20041**	**23048**	**26741**	**30121**

Source: Devkota, 2001 [8]

Table 11 Costs of 8 m^3 biogas plant

Particulars	Amount (NRs)
Biogas appliances	5081
GI pipe and fittings	1170
Construction charge	5200
Guarantee charge	600
Promotional fee	525
Sub-total	12576

Source: Devkota, 2001 [8]

Table 12 Construction materials and labor costs for 8 m³ plant

Particulars	Quantity	Amount (NRs.)
Brick or stone	1700 PC	5100
Sand	80 bags	1200
Gravel	40 bags	480
Labor	30 man-days	1800
MS rod 8 mm	13.5 kg	378
Cement	21 bags	5670
Sub-total		14,628

Source: Devkota, 2001 [8]

Table 13 Annual savings and expenditures

Annual Expenditure		Annual Savings	
Total investment cost	NRs. 27,204	Saving of firewood	6 kg/day at NRs. 1.5/kg = NRs. 3240
Running cost		Saving of kerosene	2.5 liters/month at NRs. 17/liter = NRs. 510
Labor cost	15 minutes a day at NRs. 70/day = NRs. 800	Saving of chemical fertilizer	Estimated 17500 kg Gobar = NRs. 2000
Operation and maintenance cost	NRs. 400		
Miscellaneous cost	NRs. 100		
Total expenditure	NRs. 1300	Total savings	NRs. 5750

Source: BSP, 2002 [4] and Devkota, 2001 [8]

7. INSTITUTIONAL FRAMEWORK OF BIOGAS SUPPORT PROGRAMME (BSP)

Presently, a total of more than 50 gobar (dung) gas companies have been established. These were initiated, mostly by people who were associated with the parent organization, the GGC. In 1992, Biogas Support Programme was introduced at three different stages for wider dissemination of the technology in the country. In 1995, Nepal Biogas Promotion Group (NBPG) was established as an umbrella organization for all the construction companies for promotion and extension of the program. In 1996, His Majesty's Government of Nepal (HMG/N) set up the Alternative Energy Promotion Centre (AEPC) under the Ministry of Science and Technology. The role of AEPC is networking at central level for policy making. The institutional set up is represented in Fig. 5.

Currently 49 biogas plant installation companies and 16 manufacturers have been recognized by BSP for installation and supply of biogas appliance, respectively. About 80,000 biogas plants of mostly fixed dome types have been installed in 66 districts of the country (about 12,000 plants were installed before BSP). Although about 90% of the plants installed in Nepal have a provision for toilet connection in the future, only 60% of these have been attached to toilets at present. It is believed that burning biogas is much cleaner than burning biomass and the toilets are much safer than using the open ones.

Institutionally the biogas sub-sector in Nepal cannot be considered as strong. Putting the BSP aside, there remains three organisations, AEPC, AEF and NBPG, which have not been able to demonstrate desirable capacity. The BSP is just a temporary project office, which will be phased out in the future. At present, it has been playing a vital role in the promotion of biogas in the country. It was initiated, designed and approved by the government on a number of policies, including subsidy and privatization. It has been implementing quality control, which has been a key to overall success of the biogas program. Once BSP is phased out, a strong entity is needed to take up the work of policy formulation, regularization and monitoring, and supervision.

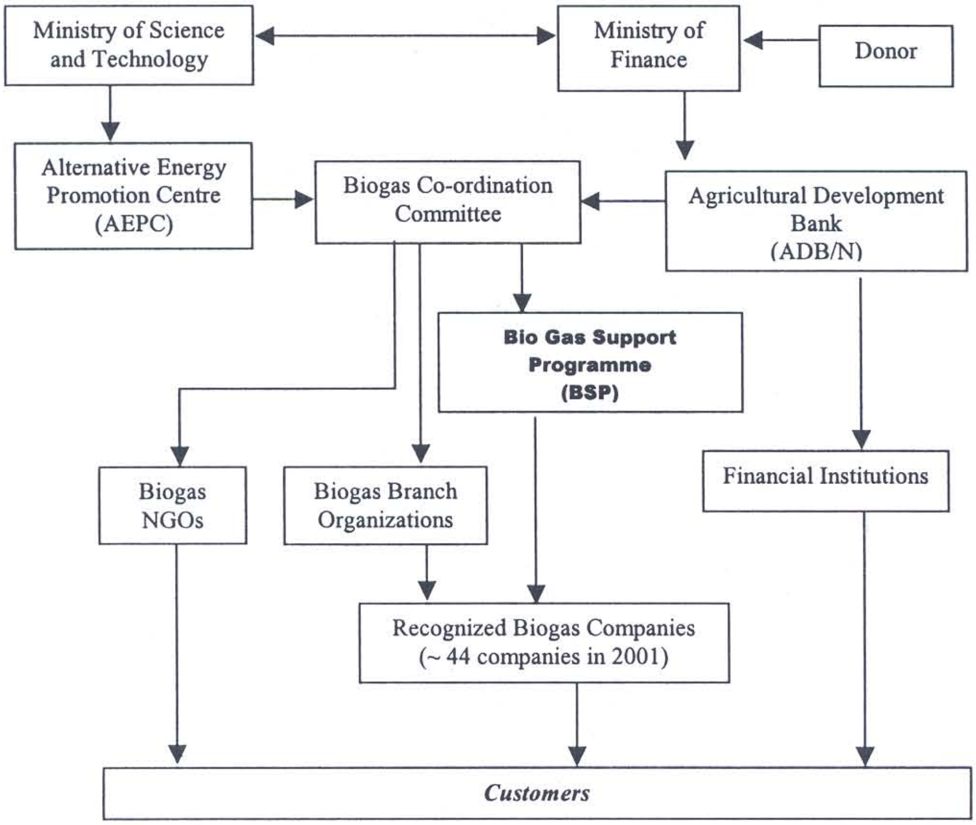

Fig. 5 Institutional set-up of biogas promotion program

On the financing side, there has been a very encouraging trend on the proportion of equities-financed plants. For instance, during the first year of the BSP (1992-93), the number of equities-financed plants was reported at 6%, which increased to 30% during 1995-96 and to 42% in 1997-98.

Regarding the source of credit, the ADB/N has been playing a pioneer role. Until the BSP I, it was the only source. Now some loans are reported to have been disbursed through NBL and RBB. Despite lower rates of interest on biogas loans offered by these two commercial banks, the borrower's preference is reported to still be ADB/N, which disburses more than 9% of the total annual biogas loans. The apparent reason for this is the simpler procedure and familiar atmosphere.

The rules that companies, including GGC, need to abide by are:

- Establish a standard design to be adopted by all companies,
- Ensure the provision of trained masons for construction,
- Guarantee quality appliances,
- Provide guarantee on structure and appliances,
- Submit plant completion report and annual maintenance reports to BSP,
- Visit the plants annually for quality control, and
- Comply with the quota of construction based on office network and availability of trained work-force

The market share of the plants was totally monopolized by GGC. However, over the years the trend has seen a transition of the market being more in the hands of the private sector as shown in Fig. 6. The strength of the companies is categorized according to their capacity to install a number of plants per year; those installing only 100 plants are classified as weak while those installing between 100 to 500 plants are classified as medium and those installing more than 500 plants are classified as strong. The market share of the participating companies is given in Table 14.

Table 14 Market share of companies participating in the BSP for FY 1998-99

Size of Companies	Number of Companies	Percentage of Companies	Total Number of Construction	Percentage of Total Construction
<100 plants (small)	16	41.03%	775	7.02%
100 to 500 plants (medium)	18	46.15%	3819	34.57%
> 500 plants (large)	5	12.82%	6453	58.41%
Total	39	100%	11047	100%

Source: Silwal, 1999 [2]

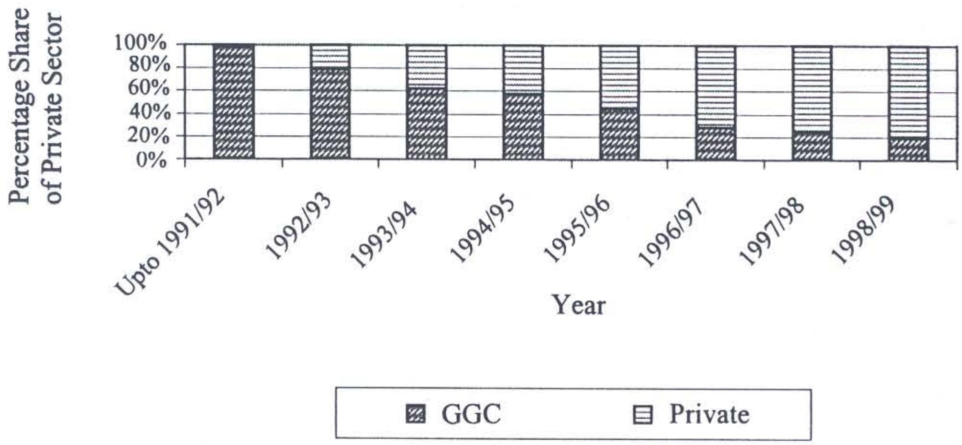

Fig. 6 Trend in the share of private sector

8. GOVERNMENT POLICY

The biogas program was launched to check the deforestation and to control burning animal dung for cooking. Over the years the government has adhered to subsidy and soft loan policy in order to promote this technology. In the initial years, 1974-75, interest-free loan was provided to individuals interested in installing the biogas plant. However, in subsequent years the policy changed and the prospective plant owners were charged a 6% interest on the loan. Over the years the biogas program has seen several changes in its development and promotional policies [10]. In 1986, the government decided to provide 50% interest subsidy for biogas installation. In 1989 decision was made to provide 25% grant on capital cost in addition to 50% interest subsidy. In 1990, the provision of 50% interest subsidy was withdrawn. In 1990-91 all kinds of subsidies on biogas were withdrawn. The subsidy scheme until 1999 is not without defects. For instance all the villages of Kathmandu, Bhaktapur and Lalitpur received subsidy at the rate of NRs. 7000 whereas Pokhara received NRs. 10,000. This was reported to be discriminatory against the people of remote areas of the former districts [11].

Studies show that the expected internal rate of return (EIRR) is higher than the financial internal rate of return (FIRR), which justifies continuation of the existing subsidy. The impact of the subsidy on increasing the number of plants has been remarkable. Even before BSP was implemented, the subsidy showed its distinct role in the promotion of the biogas, i.e., there was direct correlation between the number of plants installed and the provision of subsidy. The present program is subsidy-driven. With the implementation of BSP and continuation of the subsidy, the effect has been quite satisfactory. Besides the increase in the number of plants over time, another desirable impact of the subsidy has been the tendency towards installing plants of smaller sizes.

Within the framework of the government's policy to phase out the subsidy to all sectors, BSP is also planning to reduce subsidy on plants of larger sizes from FY 1999/2000, with the objective of discouraging larger size plants. The new subsidy layout is shown in Table 15.

Table 15 Subsidy category (NRs)

Plant Size	Tarai	Hill	Remote Hills
4 m^3	6,500	9500	11500
6 m^3	6500	9500	11500
8 m^3	5500	8500	10500
10 m^3	5500	8500	10500

Source: BSP, 2002 [7]

9. FACTORS SUPPORTING THE DEVELOPMENT OF BIOGAS IN NEPAL

The biogas program has become successful because of the close cooperation of the concerned government agencies, companies, banks and donor agencies. In order to generate better impact of the program it should start with planning from the National Planning Commission (NPC) and the Finance Ministry for setting targets for the plant construction and stable policy that provides subsidy. This is required for mobilizing and co-ordinating funds and the bank's activities for better utilization of the national and international resources available for biogas. Similarly, a linkage has to be developed with agriculture, energy, forest and other concerned sectors to increase the demands for biogas installation and capacity building of the companies/agencies for the purpose.

The following factors contributed to the successful implementation of biogas program in Nepal:

- Introduction of well proven design and appliances after several years of research, development, and experiences;
- Promotional and awareness activities have been carried out at different levels;
- Financial studies/analysis have been concluded and as a result subsidies have been provided continuously through local banks in case of plants installed on loan through BSP, and in case of the plants installed on cash payment basis;
- Technical capabilities have been properly examined and local masons have been trained;
- Companies were recognized for the installation as well as supply of biogas plants and the accessories;
- Quality control visits have been provisioned with a view to maintain the standards of the plants;
- A good organizational networking has been achieved through the biogas and slurry co-ordination committee;
- With the connection and use of toilets to biogas plants and through savings on firewood and kerosene, a significant improvement in health and environment has been noticed;
- Slurry Extension Program has been introduced to increase the effective markets for biogas plants by maximizing the benefits of operating biogas plants through improved use of slurry in crop production which has indirectly contributed in reducing the workload, especially of rural women and girls;
- Quality management measures of the plants have been introduced; and
- Generation and employment in rural areas have been enhanced.

The Biogas Program has also been supported with clear responsibilities by every organization involved in this technology. Some of the other factors that made important impact to ensure the success of this program are:

- Availability of both loan and subsidy funds for certain period of time;
- Privatization of biogas companies and commercialization banks;
- Awareness promotion activities conducted on timely basis; and
- Proper assessment of technical capacities.

10. CONCLUSIONS

Biogas plants are very popular in Nepal providing high economic and financial returns. This has made the popularity of biogas plants to grow over the years. Benefits from their use include the reduction of burden in the diminishing forest resource and fuelwood. Besides, the reliance on imported fossil fuel is also reduced remarkably. Despite the advantages and popularity factors such as the cost of installation and dung requirement, the number of animals needed are still deterring the technology from reaching the most needy.

A number of studies have indicated that owners of biogas plants are mostly owners of medium or large farms, with 80% of them educated or literate. For most users, shortage of fuelwood had driven them to install biogas plants. This has also led to time saving of 2 to 3 hours per day per household. The advantage of the biogas plants lies in the subsidy received for its installation. It should be noted that based on the achievements made in terms of the number of plants installed so far and the impact on the life of the users, the biogas program can be included among the few successful programs in Nepal. Moreover, of the various subsidized programs, biogas has multiplier-effects. It not only substitutes fuelwood and saves the nutrients lost through the use of dung cakes, but also reduce fuelwood consumption, thereby reducing environmental degradation and respiratory disease. Use of biogas for lighting facilitates the children to study at night and help rural men and women to carry out some cottage industries.

However, in order to make the system sustainable even in the absence of subsidy, and affordable to the poorer section of the population, it is pertinent that proper R&D leading to cheaper technology, and considerable reduction in the existing costs of the biogas plants could helps the biogas sub-sector, especially in terms of demand.

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