Biogas in rural household energy supply: The Nepal Biogas Support Program[1]

1. INTRODUCTION

Rural biogas production can be extremely effective. As well as offering a source of clean fuel, biogas has numerous environmental benefits, such as reducing fuelwood consumption, making valuable nutrients available to the soil, as well as benefits in health and hygiene. Yet biogas programmes have typically been hard to develop on a large scale. This paper basically describes the Nepal's Biogas Support Program, which established over 37,000 biogas plants from 1992-1998, serving over 200,000 people. An additional 80,000 units are to be installed over the next few years.

In developing countries, traditional fuels will continue to be used as the primary energy source for cooking by the majority of the rural population for the foreseeable future. The introduction of renewable energy options such as solar, wind and hydropower has not been successful in displacing the need for cooking energy in most developing countries, even for relatively wealthy rural populations. Thus, it is worthwhile to have a closer look at the Biogas Support Program in Nepal to help understand why and how a program that was originally producing only few hundreds of biogas plants per year has been able to successfully grow bigger while improving the quality of the plants that are being produced.

The Biogas Support Program (BSP) was initiated in 1992 by the Netherlands Development Organization (SNV) and funded by the Dutch Development Cooperation. The Program was formulated in close association with His Majestry's Government of Nepal (HMG/N), the Agricultural Development Bank of Nepal (ADB/N) and the Gobar Gas Company (GGC) of Nepal. The BSP is an example of a successful collaboration between government agencies, the financial sector, the private sector and interested donor assistance agencies to help meet rural house hold energy needs.

Petroleum products and coal are entirely imported, requiring almost 35% of Nepal's export earning but meeting only 8% of the total energy demand

About 86% of the 21.5 million population (1996) resides in rural areas, The per capita Gross National Product (GNP) in 1995 was estimated at only US$ 200. Energy sources in Nepal can broadly be classified into three groups: traditional (biomass), commercial (non-biomass) and alternative energy. Traditional energy includes fuelwood, agricultural residues and animal waste (dung cakes). Commercial energy comprises electricity, petroleum products and coal (the latter two are entirely imported, requiring almost 35% of the export earning but meeting only 8% of the total energy demand. Annual per capita consumption of primary energy in Nepal was estimated at 14 GJ (1992/93) or 271 million GJ in total. Out of this, over 90% was used in the residential sector and met almost completely by traditional sources. Wood was used most (72%), followed by agricultural residues (16%), animal waste (9%), kerosene (2%), electricity (0.4%) and LPG (0.1%). Slightly over 10% of the households in the country – nearly all in the urban areas – are connected to a power grid. In rural areas, lighting is fuelled mainly by kerosene.

In 1992/3 total wood consumption was estimated at 3.5 million tonnes greater than sustainable yield from Nepal's potentially productive forest, shrub and grassland; the deficit is met in a number of ways. Exploitation of the forest beyond its sustainable capacity ('mining') has a number of implications including higher cost (in terms of time and energy expended) to collect wood, loss of habitats, forest degradation, soil erosion and damage to the watershed. Collection of fuelwood is not the only factor in overexploitation of the forests. Other factors

[1] This paper is based on the Policy and Best Practice Document No. 4 of the Ministry of Foreign Affairs, the Netherlands and was written By Matthew S. Mendis (President Alternative Energy Development, USA) and Wim J. van Nes (NOVEM, the Netherlands)

include expansion of agricultural lands, fodder collection, resettlement programs, industrial use of fuelwood, timber harvesting and road construction. In short, forest and fuelwood resources in Nepal are under severe pressure of depletion.

As a result of the decline in the availability of fuelwood and its increasing costs, many rural households have started to use agricultural residues and animal dung as cooking fuel. However, using them in this way, rather than using them in the traditional manner as organic fertilizer, has obvious disadvantages. It results in declining soil fertility and reduced crop yields, thus increasing the economic plight of rural farmers.

Biogas technology

Biogas plants anaerobically convert animal dung, human excrement and other biomass wastes into a combustible methane gas. The 'biogas' can be effectively used in simple gas stoves and lamps to replace the use of scarce fuelwood, agricultural residues, 'dung-cakes' and kerosene. In addition, the resulting slurry from the biogas plants can be easily collected and used as a fertilizer to enhance agricultural productivity. Biogas technology is proven and established in many parts of the globe. There are reported to be over five million small biogas plants installed in the People's Republic of China and over 2.7 million biogas plants in India.

BSP design and implementation

SNV's involvement in Nepal's biogas sector was initiated in 1989 with the first posting of an SNV staff member to the GGC workshop, with a second SNV expert added to the Research Unit of GGC in 1990 to help develop lower cost biogas plants, affordable to a wider range of farmers. It was concluded that major cost reductions were not possible without adversely affecting the expected life, performance and reliability of the biogas plant.

As a result, all parties involved in the Nepal biogas program (HMG/N, ADB/N, GGC and SNV/Nepal) agreed on the need for financial assistance for the dissemination of biogas plants, and for that reason proposed the establishment of a Biogas Support Program (BSP) and requested co-funding from the Government of the Netherlands. The proposal was approved and an agreement was signed in 1992. Implementation of the BSP started in September 1992.

Objectives and Activities

The BSP was divided into two phases as at the time of the start of the programme, the terms and conditions for the involvement of the private sector still needed to be worked out. The major implementing agencies for Phase I were ADB/N, GGC and SNV/Nepal. This phase was designed to cover the period from July 1992 to July 1994, and pursued the following short-term objectives:

- Construction of 7000 biogas plants
- Making biogas plants more attractive to smaller farmers, and farmers in the hills, and
- Formulating recommendations on the privatization of the biogas sector in Nepal.

To assist in meeting the first two objectives, a flat rate subsidy of NRP 7000 was provided for biogas plants in the Terai districts and NRP 10,000 in the Hill districts The additional subsidy amount of NRP 3000 for the Hill districts was designed as a contribution to cover the higher transport cost of construction materials. At the start of the BSP, the opportunity was provided for farmers to receive the subsidy for biogas plants financed on a cash basis, i.e. without a loan of the ADB/N. In such cases, the subsidy was channeled to the farmer via the construction company.

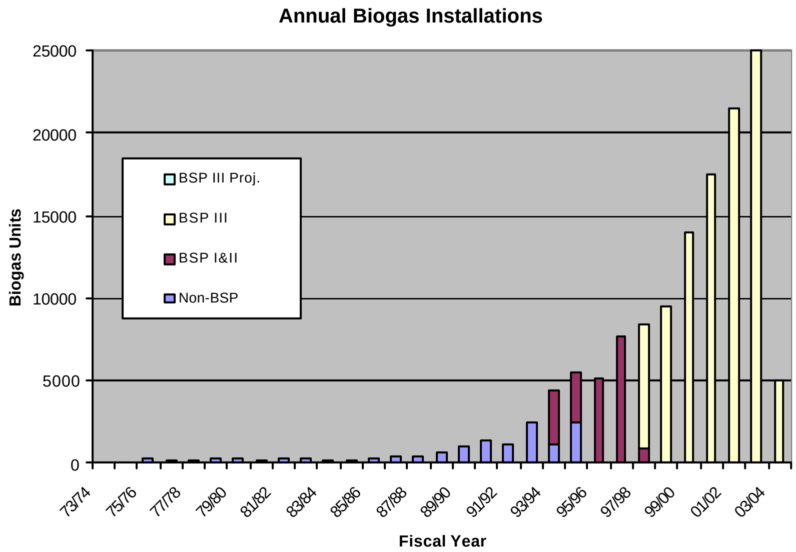
The second phase was designed to cover the period from July 1994 to July 1997 with the principal objectives of:

- Constructing another 13,000 plants
- Making biogas more attractive to smaller farmers, and farmers in the Hill districts, and
- Supporting the establishment of an apex body to co-ordinate the different actors in the biogas sector.

It was agreed that the implementing agencies for BSP II would be expanded to include other banks besides the ADB/N, other (private) companies besides the GGC, and SNV/Nepal. Gradually NGOs were also to be engaged to help in promotion of biogas in regions they worked in.

The first two objectives of BSP II were addressed by maintaining the subsidy scheme as applied in BSP I. From 1996/97 onwards, a third rate of NRP 12,000 was introduced for remote Hill districts whose headquarters were not connected by a road. To realize the third objective, support was provided for the drafting of a proposal for the establishment of an Alternative Energy Promotion Centre (AEPC).

To support the successful implementation of the BSP, a wide range of technical assistance and support activities were carried out. These included the development and introduction of strict quality control measures and standards, active training of biogas technicians and skilled labour, monitoring and inspection programs, establishment of extension services and other related support activities.



Thanks to the intensive and dedicated efforts of all parties involved, the short-term objectives of both stages of the programme were achieved six months ahead of schedule. The third phase became effective as of March 1997, being an ambitious follow-up effort to even further accelerate the dissemination of biogas systems in Nepal. The total number of biogas systems installed in Nepal up to July 1998 was approximately 49,000 units, of which more than 37,000 were constructed under the BSP benefiting more than 200,000 members of rural households.

Costs and financing

The total expenditure of BSP I & II amounted to NRP 530 million (US$ 9.5 million) excluding government tax on biogas accessories. Of the total expenditures, 55% was spent on credit through bank loans and cash payments; 33% on investment subsidies; and 12% on technical assistance including the cost of all other project activities and SNV.

The total financing was derived from a number of key sources. The Nepalese banks, mainly ADB/N, provided 43% of the funding principally through loans to farmers. The Dutch Development Cooperation through SNV/Nepal provided 44% principally for subsidy payments and technical assistance. Farmers making cash payments accounted for 12% of the total funds while participating companies, through the raising of so-called participating companies, through the raising of so-called participation fees, provided the remaining 1% of the funds. The BSP also received a gift from a Dutch natural gas company used to subsidize an additional 200 biogas plants. To ensure maximum use of funds, the government of Nepal granted an exemption of tax on all biogas accessories.

2. DISSEMINATION OF BIOGAS PLANTS

Promotion
The most important element of the promotion strategy was to have a satisfied customer telling friends, relatives and neighbours about the benefits of a biogas plant. To achieve this result, the program sought accurately to inform potential customers of the specific requirements of a biogas plant and not create any false expectations. In addition to satisfied customers, the program also relied on the network of local masons that were employed by companies to construct the biogas plants. In some cases, commissions were given to masons that referred new customers. Promotion activities were also undertaken in association with other organizations including banks, NGOs and rural development agencies.

One of the most important elements of the promotion program was the investment subsidy. The flat rate, two-tier subsidy structure (three-tier from 1996/97 onwards) made biogas plants attractive to small and lower-income farmers and to more farmers in the Hill districts.

TABLE 1 Distribution of Biogas plants Pre- and under BSP Phase I&II

Indicator	Pre-BSP	BSP I&II
Pecsent of plants installed in the Hills	27%	56%
Average land-holding of users in Hectares	4.9	1.6
Average number of cattle	8.3	5.5
Percent of households with servants using biogas	52%	21%
Average biogas plant size in cubic meters	12.9	9.0

Financing
Affordable financing was a key element in the promotion of biogas plants. The average cost of a biogas plant amounted to NRP 23,100 while the average subsidy provided amounted to NRP 8,700. The balance was the responsibility of the farmer. To assist poorer farmers, the BSP worked in close association with the ADB/N to help provide affordable financing to farmers. The ADB/N provided loans at 17% annual interest and a 7-year repayment term. As a result, 76% of the installed plants were constructed with loan financing. The ADB/N has a reported repayment record for biogas loans of 87% while its overall loan repayment rate is only 67%. As a result, the ADB/N is very supportive of its biogas loan program. Approximately 24% of all plants realized under BSP I & II were financed by farmers on a cash basis. During BSP II, other development banks were encouraged to participate in the program. As a result, the Nepal Bank Ltd (NBL) and Rastriya Banijya Bank (RBB) started lending to farmers for biogas plants.

Construction
Strict enforcement of carefully determined quality and design standards has been instrumental in achieving the relatively high operational success ratio for biogas plants in Nepal in terms of reliability, performance and expected life of the plants. Private companies were invited to participate on the basis of several terms and conditions aimed at maintaining the minimum quality and standards set by the BSP. In total, 73 quality standards were introduced relating to design, size construction materials, construction of inlet, digester, dome, turret, outlet and compost pits, toilet attachment, appliances and fittings, fitting and layout of the gas pipes, training of masons, and after-sales service. Penalties were imposed for non-compliance when found through random inspection.

Operation
The successful operation and maintenance of biogas plants was the shared responsibility of the owner, the constructing company and the BSP. The constructing company was responsible for providing the user with on-site training in the use and maintenance of a biogas plants. The company staff usually accomplished this at the time of plant construction. A simple, illustrated booklet on operation and maintenance was provided to the user on commissioning. In addition, users were trained in a group for one day by the staff of participating biogas companies. About 14,000 (mostly female) users of plants installed during BSP I & II were trained on operation and maintenance of plants. Additional advice on the

optimal functioning of the biogas plants was provided as part of the yearly maintenance visits paid by technicians of the companies. As a result, most users have reported that it is easy to operate a biogas plant. It was nevertheless observed that users needed further promotion and extension for the proper use of digested slurry as a fertilizer for agricultural production.

After-sales service

To ensure the success of biogas plants in Nepal, an after sales service program was designed that participating companies were required to follow, consisting of:

- One-year guarantee on pipes, fittings and appliances
- Six-year guarantee on the structure of the plant (reduced from 1996/97 onwards to three years)
- An annual maintenance visit in the last five years of the guarantee period (reduced from 1996/97 onwards to the last two years), and
- A response visit after the owner has lodged, in writing or verbally, a complaint at the office of the company valid for a period of six years (reduced to three years for units installed after 1996/97).

The shortening of the period of after sales from six to three years in 1996/97 was necessary to keep this service manageable in an expanding program. The annual maintenance visit to be paid by a technician of the company aimed to take stock of the problems faced by the user, to advise the user on how to improve the performance of the plant, to inspect the various parts of the plant and to repair possible defects. The quality of the participating companies' after sales service was enforced on the basis of inspection by random sampling.

3. BIOGAS BENEFITS

Biogas plants provide multiple benefits at the household, local, national and global levels. These benefits can also be classified according to their impacts on gender, poverty, health, employment and environment. Some of the more relevant direct and indirect benefits are briefly discussed below.

Gender benefits

Several studies have documented the decrease in the workload of rural women, which results from the addition of a biogas plant to their household. The principal benefit comes from the reduction of time and labour required for the gathering of fuel for cooking and cooking itself. Collection of fuelwood is generally the responsibility of rural women, requiring a lot of their time as well as the physical effort of carrying the fuelwood long distances and over steep terrain. In addition, biogas stoves are more efficient, shorten cooking time and do not soil pots and pans with soot, which is common with fuelwood stoves. On the negative side, biogas plants require some time for the collection of water and mixing of dung and water to keep the biogas plant operational. Time required for collection of dung, herding, collection of fodder and application of dung to the fields is not affected by the operation of a biogas plant. Table 1 indicates an average time saving of approximately three hours per household per day when a biogas plant is installed. This is equivalent to a total time saving of over one thousand hours a year per household. Actual savings per household may vary according the availability of fuelwood, dung and water

TABLE 2 Average time impact of a biogas plant for a typical rural household

Activity	Saving in time (hours/day)
* collection of water	-0.40
* mixing of dung and water	-0.25
* collection of wood	+1.40
* cooking	+1.60
* cleaning of cooking utensils	+0.65
Total	**+3.00**

In surveys, most women express great satisfaction, particularly with the cooking aspects of biogas, indicating that biogas is quicker and easier for cooking than fuelwood. They also state that biogas is smokeless and does not require constant attention or blowing on the coals. The women indicate that they can put a pot on the burner and do other activities while the food is cooked. Biogas stoves generate less ambient heat during cooking, which is appreciated for most of the year except during the winter months. Most women also reported noticeable improvements in their respiratory health and reductions in eye problems. In some cases, older women who were no longer able to cook over an open wood fire were able to cook again with biogas.

Introduction of biogas did not necessarily change entrenched traditional patterns in the division of labour. In the Nepalese context, reduction of workload is to be considered as a pre-condition to make opportunities available for women to earn additional income, organize and attend meetings, increase awareness, achieve literacy and gain financial security. The BSP contributed to the fulfillment of this objective.

Women own about 20% of all biogas plants. Female participation in institutions such as biogas companies, banks and NGOs is low. The number of female employees is on average less than 5%, with a higher share for the NGOs.

Environmental benefits

The introduction of biogas plants in Nepal has significantly contributed to the improvement of the local, national and global environment. From a local perspective, the use of biogas in place of wood stoves has helped significantly improve the indoor air quality of homes. In addition, installation of biogas plants has resulted in better management and disposal of animal dung and human excrement. This fact alone has helped improve the sanitary conditions in the immediate vicinity of rural homes employing biogas plants.

From a national perspective, biogas plants have helped reduce the pressure of deforestation. This in turn has important implications for watershed management and soil erosion. In addition, biogas plants, where the slurry is collected and returned to fields, have helped reduce the depletion of soil nutrients. This in turn reduces the pressure to expand the area of land cleared for agriculture that is a principal cause of deforestation in Nepal.

By July 1998, more than 37,000 biogas plants had been installed under BSP I & II and part of Phase III. It is estimated that more than 90% of these biogas plants are currently operational and are used on a regular basis, producing about 20 million m^3 of biogas annually. The operational biogas plants are estimated to displace the use of 100,000 tonnes of fuelwood and 1.27 million litres of kerosene annually. The savings in fuelwood help to slow the rate of deforestation in rural Nepal.

Biogas helps reduce greenhouse gas emissions by displacing the consumption of fuelwood and kerosene. The biogas is assumed to be produced on a sustainable basis, and therefore the CO_2 associated with biogas combustion is reabsorbed in the process of the growth of the fodder and foodstuffs. In the case of fuelwood, if it is consumed on a *non-sustainable basis*, then all the CO_2, CH_4 and N_2O emissions that are associated with the combustion of fuelwood can be accounted as being displaced when replaced by a biogas plant. The Intergovernmental Panel on Climate Change (IPCC) guidelines[2] suggest an emission coefficient of approximately 1.5 tonnes CO_2 per tonne of non-sustainable fuelwood, and approximately 2.5 tonnes CO_2 per 1000 litres of kerosene combusted – this would result in a net reduction of approximately 157,000 tonnes of CO_2 equivalent annually. If the fuelwood is produced on a sustainable basis, the biogas plants will only account for savings of 13,000 tonnes of CO_2equivalent per annum.[3]

The biogas plants installed by July 1998 are estimated to produce a million tonnes of digested dung (7% dry matter) as slurry. Properly stored, treated and applied to the fields, the biogas slurry has a higher fertilizing value than ordinary farmyard manure and is able to increase the soil fertility. Use of biogas slurry is more favourable when compared to the ashes of agricultural and animal waste collected after combustion. Besides savings in nutrients, the biogas slurry contributes to maintain the content of organic matter in the soil.

Health benefits
Several studies have shown that indoor air pollution and smoke exposure in rural Nepal, expressed in respirable suspended particulates (RSP), carbon monoxide (CO) and formaldehyde (HCHO), are amongst the worst in the world. Poor indoor air quality is one of the major risk factors for acute respiratory infections with infants and children which, in turn, is among the most important cause of child mortality in Nepal. A case study on the introduction of smokeless fuel wood stoves in a rural hill region of Nepal found such stoves to have a significant beneficial effect on the levels of RSP exposure and a considerable effect on CO and HCHO concentrations. Biogas stoves, because of their relatively clean combustion characteristics, have even more pronounced beneficial effects than smokeless fuel wood stoves.

The use of biogas stoves is expected to significantly reduce eye ailments associated with smoke for fuelwood stoves. Many biogas users have reported improved eye health. However, smokeless rooms are not always considered a benefit, as smoke is traditionally used to ward off both harmless and harmful insects. Some users of biogas stoves have indicated that the stoves fail to keep away insects, especially mosquitoes.

Improved sanitation and dung management leads to better hygienic conditions. Toilets were attached to some 40% of all plants constructed, not only improving the hygienic conditions in and around the farmyard but also offering privacy. The net result is a cleaner environment and a decrease in the opportunities for the spread of disease.

Attachment of a Toilet to Biogas Plants
Addition of human excrement to the biogas plant greatly improves the hygiene and sanitation conditions at the household and local level. Human excrement digests very well in biogas plants. The digester is a completely closed unit so there are no flies and smell. In the anaerobic process, pathogenic organism are destroyed and when the slurry leaves the compost pits to be carried to the field, it is relatively odorless and safe to handle. Attachment of a toilet to the biogas plant is an inexpensive option that can be easily accommodated by including an additional inlet pipe to the digester tank and saving on the costs of constructing a septic tank. The additional inlet pipe is constructed in most biogas plants, but actual attachment of the toilet to the biogas plant at the time of construction occurs in approximately 40 percent of the biogas plants. This is the result of a strong Hindu cultural bias against the adding of human excreta to the biogas plant. Many people in Nepal consider it taboo to cook with biogas or to handle the digested slurry produced by biogas plants also using human excrement as input.

Impacts on poverty
The primary impact of biogas plants on poverty alleviation has been to reduce the economic and, in many cases, the financial costs expended on fuel for cooking and lighting. Although most of the adopters of biogas technology have been among the larger and medium-scale farmers, smaller-scale farmers have been increasingly attracted to the program. The policy of a flat rate subsidy favours smaller plant use and smaller-scale farmers more than larger-scale farmers. In addition, the increasingly active involvement of NGOs in the promotion, organization, financing and construction of biogas plants on the basis of self-help, has the added benefit of bringing biogas plants within the reach of smaller farmers with fewer cattle. However, cattle-less, landless and marginal farmers may benefit only indirectly, from increased employment opportunities and greater availability of firewood.

Institutional implications
During the lifetime of the project the number of companies producing biogas plants increased from 1 to 39; the number of banks financing biogas plants has increased from one to three; the number of NGOs working in support of biogas has increased to 30 organizations. Finally, the number of manufacturers making and selling biogas appliances has increased from 1 to 10. In addition to the institutional developments, employment for skilled as well as unskilled labour in rural areas has been generated. Some 2500 person-years were required for the

production of appliances and building materials. Another 2500 person-years of unskilled labour were needed during the construction of biogas plants. At the end of phase II, the total number of staff of biogas companies including local masons amounted to approximately 2000 persons. This represents a significant employment impact, especially for the rural areas of Nepal.

The Dhitals – Profile of a 'biogas family'

The family of Ram Prasad Dhital is one of the Nepalese households using biogas. Ram Prasad, his wife Radika and their two sons, Padam and Prakash, live in the village of Mukundapur in Nawalparasi district. They cultivate one hectare of land, mainly to grow rice, maize, wheat and mustard seed. Two oxen and one buffalo are used for ploughing and for milk production. As there is no additional income, the family needs to live from their agricultural production.

For cooking, the family used to collect fuelwood from the forest: each week four back-loads of 30 kg. Gradually, wood became more and more scarce and at one time it would take a whole day to collect just one back-load. Some time age, a biogas company started the construction of a biogas plant for one of the Prasads' neighbours. Ram Prasad went to the construction site to collect more specific information. To install an 8 m^3 biogas plant, he discovered, he would need to invest NRs 20,000, plus an additional NRs 5,000 to attach a toilet. As Ram Prasad could not afford such an amount, he went to the Agricultural Development Bank, and discovered he could get a biogas loan on the basis of a piece of land as collateral. Once the construction was completed, the Bank would reduce the loan amount by the government subsidy of NRs 7,000. Repayment of the remaining amount would have to be made over the next seven years, with an interest rate of 17%. After careful consideration, the family decided to go for the biogas plant. Ram Prasad collected sand and gravel and excavated a ground pit. The biogas company sent a technician who constructed the plant with the help of a few unskilled labourers over a period of ten days. To start operation, the plant had to be fed with dung. Now, the family feeds the plant on a daily basis with 40 kg of dung and 40 litres of water. Also they have to spend some time maintaining the compost pits-work on the plant adds up to an hour a day.

The gas produced is used for cooking with the help of two stoves. Cooking with biogas is not only easier for Radika than cooking on fuelwood, but it saves her a lot of time: at least 3½ hours a day. She is very happy with the biogas plant for this reason alone. However, cooking on biogas is also clean so her eyes are no longer irritated by smoke from fuelwood. Also the fact that the cooking pots are less blackened makes cleaning them easier and less time-consuming. Finally, she also appreciates the privacy of a toilet.

Ram Prasad is satisfied as well. He is saving almost 100 kg of fuelwood per week so does not need to go to the forest nearly as often. He does not have a clear opinion as yet on the value of the digested dung as fertilizer – for that, he needs more experience in applying it.

4. FINANCIAL AND ECONOMIC ASSESSMENT

The biogas plants are estimated to displace the use of some 100,000 tonnes of fuelwood and 1.27 million litres of kerosene annually. The savings in fuelwood help to slow the rate of deforestation in rural Nepal, while reduce use of imported kerosene helps save valuable foreign exchange, estimated at about US$233,000 annually.[4]

An additional economic benefit from the use of biogas derives from the replacement of the practice of collecting and drying animal dung for fuel. These dung-cakes contain valuable soil nutrients that are lost when the dung is collected, dried and burnt as a fuel. When animal dung is processed through a biogas digester, the resulting slurry retains the nutrients originally in the dung and can be used as a fertilizer. The value of the biogas slurry as fertilizer has been estimated at approximately 188 NRP per year per cubic metre of biogas capacity.[5]

Financial analysis
The most popular units are in the range of 6-10 m^3, and a representative unit of 8 m^3 was selected for the financial analysis. The financial analysis was based on a biogas plant built in the Hill districts with an assumed capital cost of NRP 26,070 (1998/99) and the applied subsidy rate of NRP 10,000. The financial analysis for both the Hill and Terai districts indicates that the present level of subsidy is generally sufficient to attract potential farmers while not being significantly excessive as to result in relatively high financial internal rates of return (FIRR) for the farmer. The actual FIRR realized by the farmer is largely dependent on the current cost of fuelwood.

Economic analysis
An economic analysis (shown below – see also Annex 1) of both a representative 8 m^3 biogas plant built in a Hill district as well as the entire program was undertaken to assess the benefits to society of the use of biogas plants and of the grant support provided to the operation of the BSP.

Summary of the EIRR for an 8- m^3 Biogas Plant in the Hill Districts

EIRR for benefits from just fuelwood and kerosene savings = 15%
EIRR with the value of saved domestic labor added = 19%
EIRR with the value of nutrients saved added to all of the above = 38%
EIRR with the value of smoke reduction added to all of the above = 42%
EIRR with the value of reduced carbon added to all of the above = 57%

Summary of the EIRR for the BSP

EIRR for benefits from just fuelwood and kerosene savings = 11%
EIRR with the value of saved domestic labor added to the above = 15%
EIRR with the value of nutrients saved added to all of the above = 32%
EIRR with the value of smoke reduction added to all of the above = 36%
EIRR with the value of reduced carbon added to all of the above = 50%

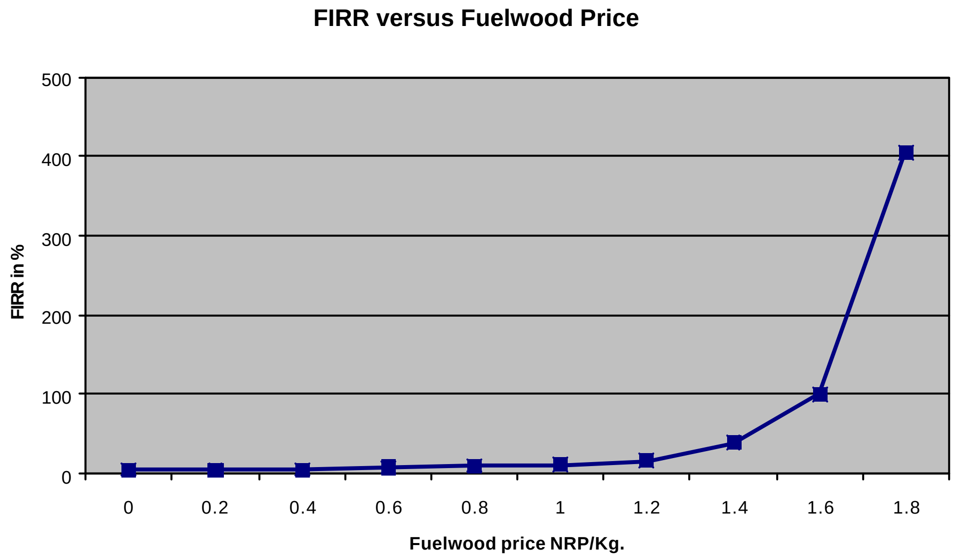
It is clear that there is an economic justification for the limited subsidy provided for the biogas plants and the grant support provided for the BSP Furthermore, it is unlikely that the Nepalese farmers would have sufficient financial incentives to adopt the biogas plants. The earlier financial analysis clearly indicated how sensitive the farmers' FIRR is to the price of fuelwood. As most farmers do not directly purchase fuelwood, their perception is that the price of fuelwood is at or near zero. As a result, their perceived FIRR is negative. Alternately, if the economic value of fuelwood is NRP 1.0/kg, then the resulting EIRR for the biogas plant is 15%. When the other principal non-market benefits of the biogas plant are added, the EIRR rises to 57%. This provides an additional justification for the subsidy for the biogas plants.

5. SUCCESS FACTORS

There are several important reasons why the program has succeeded in accelerating the adoption of biogas in Nepal. These fall into three main categories: *technical, institutional* and *financial.* A number of factors unique to Nepal have also contributed to the success: biogas plants fit very well into the Nepalese integrated farming system that combines crop production and animal husbandry; most rural households rear some cattle so have dung that can be collected to feed biogas plants; handling cattle dung is not a taboo in the context of the Hindu culture; finally, the increasing difficulty of obtaining fuelwood provides a strong incentive to look for alternative cooking fuels, such as biogas.

Technical factors
From the technical perspective, the BSP was instrumental in identifying and designing a more appropriate, cost-effective and reliable biogas system for Nepal. In the process, strict standards for quality and design were established that any producer was required to follow, and these have been a critical factor in the high success ratio experienced for biogas systems in Nepal. To ensure the implementation of these quality and design standards, a training program for biogas producers was launched to train their masons and staff. Local materials

and labour helped to reduce biogas plant construction costs. Additionally, a certification process and financial incentives were introduced to ensure that biogas producers meet the quality and design standards. The net result has been the establishment of appropriate, cost-effective and reliable biogas systems for Nepal.



Institutional factors

The BSP has worked in close partnership with the key institutional players who Nave supported the growth of biogas in Nepal, including financial, technical, private sector, government and non-government institutions. The careful orchestration of the support and inputs of these key institutions has been a critical factor in the success of the BSP.

One of the most important institutional reasons for the success of biogas in Nepal is the long-term support of the ADB/N for credits to biogas systems in Nepal. It was in fact the ADB/N that in 1975 was initially responsible for the promotion of biogas in Nepal and in 1977 created the GGC of which ADB/N is still the major shareholder. Additionally, the ADB/N has over 700 branch offices located in the rural areas of Nepal and has established long-term relationships with the farmers of Nepal. As a result, the bank has been a principal and critical financial partner. This kind of strong commitment to the promotion of biogas in Nepal is a crucial factor in the overall success. To broaden this financial support, other banks such as NBL and RBB have started to provide loans for biogas plants.

An equally important institutional player has been the producers of biogas plants. Initially, the GGC was the sole producer of biogas plants in Nepal. However, in recognition of the value and benefits of competition, the market for other private sector companies to enter into the production of approved biogas plants has been opened. A year ago 39 certified companies were involved in producing biogas plants in Nepal. As a result, overall costs of biogas plants have declined by approximately 30% when measured in real terms.

The BSP is actively working to help train and strengthen companies that are active in biogas production to commercialize the biogas industry. In addition, the Nepal Biogas Promotion Group (NBPG) has been established to co-ordinate and assist the activities of the certified companies. The NBPG is an industrial association that has the overall objective of representing the interests of the biogas producers in the development of the biogas market in Nepal. To help in the promotion of biogas plants in the rural areas, rural based NGOs have recently been engaged. Through their interaction, the market for biogas plants may be opened further - the initial results are very promising.

Financial factors

Providing uniform, transparent and direct financial incentives for the rural farmer to finance a biogas plant have been an important factor in the success of the BSP At present, a uniform (independent of capacity) subsidy (varying according to district) is applied. This subsidy represents approximately 35% of the total cost of constructing a biogas plant. The uniform, transparent and careful administration of this subsidy - available only to plants built by certified companies - has been an important factor in convincing farmers to purchase biogas plants while ensuring that the plants are produced according to the strict quality and design standards established by the BSP The plants must be inspected during construction to ensure that all design and quality standards are met and must receive after sales service in order to be eligible for the subsidy. Furthermore, the BSP maintains strict administration and control to ensure that the farmer is the ultimate recipient of the subsidy.

Providing a uniform and fixed subsidy has greatly simplified the administration of the subsidy. The uniform subsidy (regardless of capacity) has had two positive impacts: it benefits smaller farmers with fewer cattle, who generally have lower household incomes, and has resulted in lower average capacity of biogas plants, which in the past tended to be oversized. Finally, the program was designed in such a way that is has reached the target group directly. Approximately 90% of the allocated funds have reached the target group and only 10% were used for operational expenses. This represents a truly effective use of project resources.

6. DESIGN AND CHALLENGES OF PHASE III

Program objectives

The mid-term evaluation of BSP I & II strongly recommended the continuation and expansion of the biogas program in Nepal, and a proposal for a third phase was formulated[6] requiring a total budget of NRP 3,500 million (US$ 58 million). The majority (66%) of this financial requirement is needed to finance the loans to farmers and cash payments by farmers adopting biogas plants. The remainder is needed to support the subsidy program and the operational expenses. Financial support for BSP III was received from the government of Nepal, the Dutch Development Cooperation and the Federal Republic of Germany through the German Development Bank (KfW). These governments have assigned financial support comprising NRP 140 million from HMG/N, NLG 11 million from the Dutch Development Cooperation and DM 14 million from KfW As a result, the BSP III became effective as of March 1997.

The overall objective of phase III is to further develop and disseminate biogas as an indigenous, sustainable energy source for rural areas of Nepal. Specific objectives are to:

- develop a commercially viable, market-oriented biogas industry in Nepal
- increase the number of installed quality, small(er)-sized biogas plants by 100,000 units
- ensure the continued operation of all biogas plants installed under BSP
- conduct applied research and development
- Maximize the benefits gained from operating biogas plants, including optimizing the use of the resulting
- biogas slurry for productive purposes
- establish and strengthen appropriate institutions to help continue and sustain the development of the biogas sector in Nepal.

Program challenges

The acceleration of biogas dissemination in Nepal will face a number of significant challenges if it is to meet its principal objectives. The key program challenges include:

- accelerating market demand to finally reach 25,000 units per year
- strengthening Nepalese institutional capabilities
- strengthening the financial and managerial viability of the private sector biogas producers to ensure a sufficiently robust supply base
- maintaining biogas system standards for quality, performance and maintenance services in an expanding market
- reducing the amount and eventually phasing out the need for financial subsidies.

Accelerating market demand: The rate of dissemination has to be increased by approximately 2.5 times by 2001/02. This will not be an easy task. There clearly is a need to increase support for a market driven approach; local, national and international NGOs will help to increase marketing and outreach efforts. The best marketing resource, satisfied biogas users, needs to be further involved to accelerate market demand. This could be achieved by providing financial and other incentives to biogas users for references of new customers. Finally, the private sector producers of biogas systems are to be encouraged to actively market their products rather than just waiting for the customer to approach the producer.

Strengthening Nepalese institutions: One of the objectives is to help strengthen appropriate Nepalese institutions to eventually take over the functions of the BSP. One of the most important functions of the Program has been the development, application and monitoring of the quality standards and after-sales service programs for the biogas plants. It has provided a broad base of training for many of the key players in program. Related to this effort has been the role in ensuring that the subsidy program achieved its objectives. The process of certification has ensured that subsidy payments are made only for biogas units that meet quality criteria and benefit directly the end-user. The BSP needs to identify the appropriate Nepalese institutions that are best suited to take over its various program responsibilities and to work closely with these institutions to strengthen their capabilities. Encompassed in this challenge is the need to ensure that the financial resources required for these institutions to carry out their responsibilities are recoverable. There should be a demonstrated value for these services, for which there should be a willingness to pay within the process of the biogas market transactions. The details of this process have to be worked out at an early stage.

Strengthening the private sector: A key component of the biogas market is the expansion of private sector biogas producers from one dominant company, the GGC, to the present level of 39 certified companies that are capable of producing biogas plants in Nepal. Of the 39 companies, only a few are presently capable of producing more than 500 biogas units per year. Many of the 39 registered companies are financially, organizationally and managerially weak and are not yet 'significant players' in the biogas market place.

If the biogas program is to achieve the rate of 25,000 unit per year, there will need to be either a large increase in the number of certified biogas producers or the present producers will need to significantly increase the volume of their production to an average of 650 unit per producer. Monitoring the performance of even the present 39 certified producers would be a significant challenge. If the number of producers increase, this challenge will be difficult and time consuming. A more realistic approach is to encourage the sound financial and managerial development of a sufficient but not large number of private sector producers that can adequately and competitively supply the growing biogas market.

Maintaining quality standards: One of the principal achievements has been the establishment and implementation of standards for quality, performance and after-sales service. It is very important that no compromises are made in the implementation of these standards as the market for biogas systems in Nepal expands. The innovative design of a dose working partnership between the BSP, the biogas producers and the banking institutions has helped the implementation of the quality assurance program. Past experience has clearly demonstrated the value of these consumer protection measures. The BSP must work to strengthen this process and must designate a successor Nepalese institution to eventually adopt the coordinating role. The newly established Alternative Energy Promotion Centre would appear to be a possible candidate for this role. The costs associated with monitoring and enforcement of established standards would need to be recovered through a fee that could be attached to the price of biogas systems. The initiated system of charging biogas producers a participation fee of NRP 500 per unit constructed could finance these services. The adequacy of this fee needs to be assessed.

Reducing the financial subsidy: The biggest challenge to the BSP is to reduce and possibly eliminate the financial subsidy that is presently provided for biogas end-users. During the period 1999/2000 the BSP might take the initial step by reducing the average subsidy amount per plant from NRP 9000 to NRP 8000. In addition, the subsidy will remain fixed in nominal terms even when the nominal price for biogas plants increases due to monetary inflation. As a result, the relative amount or real value of the subsidy will decrease. It is estimated that the relative contribution of the subsidy for a 10 m3 unit will decline to approximately 16 % of total costs at the end of 2001/2 as compared to 35% of total costs at the start of the BSP The issue of reducing or eliminating the subsidy associated with biogas plants must be carefully evaluated since there are many economic, social and environmental benefits that result from the use of biogas which are not captured in the associated financial transactions. A strong case can be made for continuing some level of subsidy to compensate end-users for benefits that do not directly accrue to them. For example, the level of subsidy could be based on the estimated value of national and global environmental benefits that result from the use of biogas systems. The resources for conserving the national environment could be derived from a tax on the use of commercial fuelwood, timber and fossil fuels. The resources for the global environment benefits may be derived in the future from the sale of the greenhouse gas benefits of the project through the proposed Clean Development Mechanism of the UNFCCC Kyoto Protocol.

7. LESSONS LEARNT

In conclusion, the BSP has become a successful and beneficial endeavour for Nepal. It has helped successfully commercialize and increase the use of an indigenous renewable and sustainable energy resource. Biogas plants have positively affected the lives of farmers and especially women and children in the rural areas. The social and environmental conditions of thousands of rural families have been improved. In addition, a number of economic benefits are generated making the Program an interesting example of conservation of public goods through a commercial, market approach. Finally, a number of important lessons can be learnt regarding implementation of alternative energy technologies:

- Understanding the end-user/market and designing a product that meets the needs and addresses the concerns.
- Identifying the most appropriate and cost-effective design for the product before launching a; wide-scale dissemination program.
- Establishing and enforcing solid design, quality and service criteria that will ensure the reliable and cost-effective operation of installed plants.
- Identifying the key institutional players and assisting in strengthening the capacity of these players to effectively carry out their respective roles.
- Securing the commitment and support of financial institutions to work in close partnership for the dissemination and financing of the product.
- Identifying the financial incentives needed to stimulate the market and attract qualified buyers.
- Designing and applying financial incentives in a uniform, transparent manner and easy to administer. Ensuring that financial incentives reach the target groups and are not diverted to manufacturers.
- Providing technical and management support to all key players.
- Instituting co-ordinating committees to ensure the co-operation and partnership of stakeholders. Maximizing the use of program resources for product support and market development.

In addition to the general points that are listed above, one of the most important achievements of the BSP is the sense of ownership in the program that the key stakeholders appear to display when discussing their role. This single achievement is a key factor in the overall success of the BSP

Notes

1. Assumes 33,300 operational units with average savings of 3 tonnes fuelwood/unit/year and 38 litres of kerosene/unit/year.
2. 'Greenhouse Gas Inventory Reference Manual- IPCC Guidelines for National Greenhouse Gas Inventories', Intergovernmental Panel on Climate Change, 1995. Total C02 equivalent emissions are estimated on the basis of the fuelwood containing 45% C and only 87% of the carbon being oxidized in combustion. In addition, CH4 and N20 emissions from fuelwood combustion are estimated based on IPCC methodology and converted to C02 equivalent.
3. Resulting from the CH4 and N20 emissions from fuelwood combustion and the C02 emissions from kerosene combustion.
4. Assumes NRP 11/litre of kerosene.
5. Derived from data in a report by Silwal, Bishnu B., and Pokharel, Ram K., 'Evaluation of Subsidy Scheme for Biogas Plants', CODEX Consultants (P) Ltd., Katmandu, Nepal, December 1995.
6. 'Proposal Biogas Support Program Phase III, HMG/N and SNV/Nepal, Katmandu, Nepal, February 1996.

ANNEX 1

Basic Data for the Financial Analysis of 8 M^3 Biogas Plant for Hill Districts

The data in this Appendix provides the information on the costs and savings associated with an 8-m^3 biogas plant in the Hill districts. The capital cost of an 8-m^3 biogas plant (1998/99) is assumed to be NRP 26,070. The annual maintenance costs are assumed to be one percent of the total capital costs. The base subsidy is NRP 10,000. A down payment of 10 percent of the net cost to the farmer is assumed required and the remaining costs are financed at 17 percent annual interest over a seven-year term.

The savings associated with the use of the biogas plant derive primarily from the savings in expenditures for fuelwood and kerosene. The base price for fuelwood is assumed to be 1.0 NRP/kg and the base price for kerosene is 11 NRP/liter. The resulting annual savings for fuelwood and kerosene amount to 3,085 NRP/year. The value of the saved labor and the recovered nutrients in the biogas slurry are assumed to be zero for the financial analysis. The financial is carried out over a 15-year period, which is the assumed life of the biogas plant.

Costs	NRP	Remarks
Capital costs	26,070	
Annual maintenance costs	261	1 % of capital costs
Subsidy	10,000	
Net costs	16,070	
Down payment	1,607	10% of net costs
Loan amount	14,463	
Annual loan payment	3,687	17% interest, 7 years term

Annual savings	Unit	NRP/unit	Total NRP
Fuelwood (kg)	2,700	1.00	2,700
Kerosene (lt)	35	11.00	385

Basic Data for the Economic Analysis of 8 M^3 Biogas Plant for Hill Districts and the entire BSP

The data given here presents the information on the economic costs and benefits associated with a representative 8-m^3 biogas plant built in a hill district. The financial data was provided by the BSP and is derived from actual quotes (1998/99) for the construction of 8-m^3 biogas plant in the hill districts.

Cost/Benefit Breakdown	Financial	Economic factor or Shadow value	Economic
Costs:	(NRP)		(NRP)
Cement	5,120	0.60	3,072
Materials	10,345	0.75	7,759
Labor	6,300	0.75	4,725
Appliances	2,565	0.90	2,309
Fees & charges	1,740	1.00	1,740
Total capital costs	26,070		19,604
Annual maintenance costs	261		196
Benefits:	(NRP)		(NRP)
Fuelwood savings	2,700	1.00	2,700
Kerosene savings	385	1.00	385
Nutrient savings	0	(1.00)	1,971
Domestic labor savings	0	(0.75)	548
Reduced carbon*	0	(1.00)	1,356
Toilet attachments	0		0
Indoor smoke reduction	0	(1.00)	400
Employment generation	0		0
Total annual benefits	*3,085*		*7,360*

- non-sustainable production of fuelwood

Data on the expenditure for TA and capital for the BSP is presented below. The data is derived from information provided by the BSP.

Year	1	2	3	4	5
Number of Plants Constructed	3318	3506	5115	7160	1101
Technical Assistance (Million NRP)	6.20	9.84	11.37	18.53	18.19
Capital Expenditures (Million NRP)	64.00	58.71	86.89	132.28	22.05
Commutative Capital exp. (Million NRP)	64.00	122.71	209.60	341.88	363.93