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The Nepal Biogas Support Program:
Elements for Success in Rural Household Energy Supply

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Colophon

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Foreword

Depleting forest resources coupled with increasing population presents the Government of Nepal with an important challenge to outline appropriate policies with regard to energy supply, especially in the rural areas of Nepal. The Alternative Energy Promotion Centre (AEPC) was created in 1996 to accord higher priority to the renewable energy resources among which biogas is one of them.
The ongoing assistance provided by the Government of the Netherlands through the SNV Netherlands Development Organization to the Biogas Support Program (BSP) in Nepal has resulted in a wide-scale use of biogas for cooking and lighting needs of rural households. The Federal Republic of Germany through the German Development Bank (KfW) provided additional support to the implementation of the third phase of the Program. By the end of 1998, this Program has already improved the quality of life of more than 200,000 people. The importance of the biogas sector is at present recognized at all levels of our Government and a target is set to install 90,000 biogas plants in the 9th Five Year Plan covering the period of July 1998 to 2002.

This paper is issued by the Ministry of Foreign Affairs of the Netherlands and presents the accomplishments of the Program in a comprehensive manner. We like to recommend this paper for reading by a wider audience of organizations and individuals in the Netherlands, Germany, Nepal and other countries involved in rural energy in developing countries.

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Matthew S. Mendis is president of Alternative Energy Development, Inc. (AED) which is based in Silver Spring, Maryland, USA. He has over 25 years of experience in renewable energy and project finance. He has helped develop, implement and assess renewable energy projects in over 30 developing countries throughout the globe. Mr. Mendis had no affiliation with the BSP prior to his assessment of the Program. Mr. Mendis is a Malaysian national.

Wim J. van Nes was from 1990 onwards engaged in the biogas program in Nepal through the SNV Netherlands Development Organization. Firstly, he was detached at the Research Unit of the Gobar Gas Company and coordinated the formulation of the proposal for the first and second phase of the Biogas Support Program. Upon approval of the proposal, he was assigned as BSP Program Manager up to 1997 and coordinated also the formulation of the third phase of the Program. At present, Mr. Van Nes is affiliated with the Netherlands Agency for Energy and the Environment (Novem) in the Netherlands working on stand-alone photovoltaic solar energy. Mr. Van Nes is a Dutch national.

Executive Summary

The Nepal Biogas Support Program (BSP) is a successful model of development cooperation, technological innovation, financial engineering and market development that has helped address some of the social, economic, energy and environmental needs of the rural areas of Nepal. The BSP also represents a working partnership between His Majesty's Government of Nepal (HMG/N), the Dutch Development Cooperation, the German Financial Cooperation through the German Development Bank (KfW), the Agricultural Development Bank of Nepal (ADB/N), the Netherlands Development Organization (SNV), the Gobar Gas Company (GGC), the private sector of Nepal and the rural farmers of Nepal. As a result, there are a number of lessons to be learnt from the BSP that can be applied to other development assistance programs targeted at the dissemination of small-scale rural and renewable energy technologies.

The principal objective of the BSP is to promote the wide-scale use of biogas as a substitute for wood, agricultural residues, animal dung and kerosene that is presently used for the cooking and lighting needs of most rural households. The rising demand for fuelwood, agricultural residues and dung, by the rapidly increasing population of Nepal, has helped accelerate the rates of deforestation, soil degradation and environmental decline in the densely inhabited areas of Nepal. In addition, use of biomass fuels and kerosene has significantly impacted the health and welfare of especially women and children who are most often subjected to the smoke and fumes associated with the use of these fuels.

The BSP, in its first and second phase, has successfully constructed more than 20,000 biogas units. This compares to only 6,000 units that were installed at the initiation of the preparations of the Program in July 1990. The third phase of the BSP envisions the construction of an additional 100,000 biogas plants by the end of fiscal year 2002/2003. Up to July 1998, in total 37,000 units have been installed under BSP benefiting more than 200,000 members of rural households. This substantial increase in the deployment of biogas plants has been accomplished while simultaneously reducing the costs and increasing the reliability and efficiency of biogas plants.

The BSP has helped open the market for the production of biogas plants in Nepal. At the initiation of the Program there was essentially only one state-owned company, the Gobar Gas Company (GGC), producing biogas plants. At the end of 1998, as a direct result of the approach of market development, 38 private companies besides GGC had entered into this business. All participating companies must meet strict production quality and service standards for their biogas plants to be eligible to receive the subsidy that is provided to farmers. As a result of the growing competition, technical design modifications and quality control measures initiated, the overall cost of biogas plants in Nepal has declined by over 30 percent in real terms since the inception of the BSP.

One of the important features of the BSP has been its innovative financial engineering and judicious application of consumer subsidies to help develop the market for biogas plants. Working with the ADB/N, and more recently the Nepal Bank Limited (NBL) and the Rastriya Banijya Bank (RBB), a loan and subsidy program was structured that is targeted at supporting the small and medium-scale rural farmers. This loan and subsidy program has been a very critical element in developing the commercial market for biogas plants in Nepal. The subsidy, fixed at three levels (for the Terai, Hill and Remote Hill Districts), at present represents approximately 35 percent of the total cost of the biogas plant. As the amount of subsidy is fixed, its relative contribution to the total price of the biogas plant is expected to decline with rising inflation in the economy of Nepal. The objective of the third phase is to eventually decrease the dependency of the biogas program on subsidy.

The Program has also strengthened the institutional support for the development of the biogas market. Specifically, it has helped HMG/N establish an apex body, the Alternative Energy Promotion Centre (AEPC), to support biogas and other alternative energy applications in Nepal. Additionally, the establishment and activities of the Nepal Biogas Promotion Group (NBPG), an association of companies that produce biogas plants, were supported. The BSP has also assisted in the formation of an NGO Coalition for Biogas and Alternative Energy Promotion. This Coalition could be instrumental from their grass-roots access to rural farmers to help disseminate biogas plants to eligible farmers.

Biogas plants provide multiple benefits at the household, local, national and global level. The key benefits are related to gender, environment, health and institutional strengthening. The monetary values of most of these benefits are not quantifiable. However, the financial and economic analysis of the costs and benefits that are quantifiable clearly demonstrate the value of biogas plants and the BSP. The financial internal rate of return (FIRR) for an average size (8-m^3) biogas plant is estimated at 14 percent. The FIRR is very sensitive to the price of fuelwood which is estimated to be NRP 1.0/kg in the base case. The FIRR is negative when the price of fuelwood is below NRP 0.6/kg and nearly 100 percent when the price of fuelwood is NRP 1.6/kg. The economic internal rate of return (EIRR) for the biogas plant is 15 percent in the base case.

An economic analysis of the entire BSP I & II results in an estimated EIRR of 11 percent when only the benefits of fuelwood and kerosene savings are accounted for. If the benefits of saved labor are added, the EIRR rises to 15 percent. Adding the total value of the nutrients saved by the BSP increases the EIRR to 32 percent. Including the conservative estimates for the health benefits of smoke reduction (US$ 6.67/household/yr) increases the EIRR to 36 percent. Finally, adding the value of the reduced carbon provides an EIRR of 50 percent. It is clear that there is a strong justification for the limited subsidy provided for the biogas plants and the grant support provided for the BSP. Without the subsidy support for the biogas plants, it is unlikely that the Nepalese farmers would have sufficient financial incentives to adopt the biogas plants. Without the grant support for the BSP, it is certain that the standards, quality and dissemination rates for biogas plants in Nepal would not have risen.

The acceleration of biogas dissemination in Nepal will face a number of challenges in the future. These include the need to further stimulate market demand for biogas plants, strengthen Nepalese biogas institutions, bolster the private sector biogas firms, maintain high plant quality standards and reduce the relative input of the financial subsidy given to farmers.

Inspection of a new-built biogas plant (photo: B&U International Picture Service)

Abbreviations and Acronyms

AEPC	Alternative Energy Promotion Centre
ADB/N	Agriculture Development Bank of Nepal
BSP	Biogas Support Program
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CODEX	Consortium of Development Experts
DDC	District Development Committee
DM	German Mark
EIRR	Economic Internal Rate of Return
FIRR	Financial Internal Rate of Return
FY	Fiscal Year
GDP	Gross Domestic Product
GGC	Gobar Gas Company
GHG	Green House Gasses
GJ	Gigajoules
GNP	Gross National Product
HCHO	Formaldehyde
HMG/N	His Majesty's Government of Nepal
IPCC	Intergovernmental Panel on Climate Change
KfW	Kreditanstalt für Wiederaufbau
MTE	Mid-term Evaluation
NBL	Nepal Bank Limited
NBPG	Nepal Biogas Promotion Group
NLG	Netherlands Guilder
NRP	Nepalese Rupees
O&M	Operation and Maintenance
PPP	Purchase Power Parity
RBB	Rastriya Banijya Bank
RSP	Respirable Suspended Particulates
SNV	Netherlands Development Organization
TA	Technical Assistance
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States Dollar
VDC	Village Development Committee

Exchange Rate: 1 US$ = NRP 60

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1.0 Introduction

The future prospects of household energy for cooking and lighting in rural Nepal are getting brighter as a direct result of the efforts of the Biogas Support Program (BSP). The 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 Majesty'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 the rural household energy needs.

There are many lessons to be learnt from the BSP that may be applied to other renewable energy programs for Nepal and for other developing countries. This paper highlights the successful accomplishments of the BSP[1] and discusses some of the lessons learnt. The paper also illustrates how a well designed and executed technical and financial assistance support program can lead to the successful commercialization of small-scale renewable energy technologies for rural energy needs.

A lot has been written about the problem of providing energy to rural populations in developing countries. The World Bank estimates that around a third of all energy consumption in these countries comes from burning wood, crop residues and animal dung[2]. These traditional fuels are mostly used in rural areas. The gathering of fuelwood and animal dung takes time, while the efficiency of burning these fuels in traditional stoves is very low. Moreover traditional fuels can damage people's health as they give off smoke that contains many hazardous particles. Also, traditional fuels used in an unsustainable way will damage the environment.

Traditional fuels will continue to be used by the majority of the rural population in the developing countries as the primary energy source for cooking 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. Most of these renewable energy options produce high-cost electricity that is not an affordable option for displacing cooking fuels for even the well to do rural populations of most developing countries. Even in many cases where solar cookers or biogas plants have been introduced to displace the use of traditional cooking fuels, the results of pilot projects have been disappointing. Thus, it is worthwhile to have a closer look at the BSP in Nepal to help understand why and how a program that was originally producing only

1) *W.J. van Nes and J. Lam, "Final Report on the Biogas Support Program (phase I and II). Development through the market." SNV Netherlands Development Organization, Katmandu, June 1997.*

2) *"Rural Energy and Development. Improving Energy Supplies for Two Billion People." The World Bank, Washington, D.C., September 1996.*

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.

1.1 Country Background

Nepal is a landlocked country situated on the southern flank of the Central Himalayas. It is bounded on the north by the Tibetan Autonomous Region of China and on the east, south and west by India. Nepal is 835 kilometers long and between 90 to 230 kilometers wide, covering a total land area of about 141,000 square kilometers (see Figure 1).

Figure 1: Map of Nepal

The population of Nepal in 1995 is estimated to be 21.5 million with an annual growth rate of approximately 2 percent. The number of households is estimated at 3.6 million with an average of 5.6 persons per household. About 86 per cent of the population resides in rural areas. The per capita Gross National Product (GNP) in 1995 is estimated at only US$200. Further information on the country background is included in Appendix 1.

1.2 Energy Consumption

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 per cent of the export earning but meeting only eight per cent of the total energy demand.

Per capita consumption of primary energy in Nepal is estimated to be 14 gigajoules (GJ) for the Fiscal Year (FY) 1992/93 or 271 million GJ in total. Out of this, over 90 percent 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 an electrical grid. In the rural areas, kerosene is mainly used for lighting.

Nepal had an estimated area of 9.2 million hectares of potentially productive forest, shrub and grassland in FY 1992/93, of which 3.4 million hectares were considered to be accessible for fuelwood collection. Sustainable yield from this accessible area is estimated to be about 7.5 million tonnes while the total wood consumption for the same year was estimated to be about 11 million tonnes. The deficit of 3.5 million tonnes is met in a number of ways including felling of live trees, increasing the radius of fuelwood collection areas and switching to other fuels. Use of more efficient stoves and private tree planting is also believed to have increased as a result of the fuelwood scarcity.

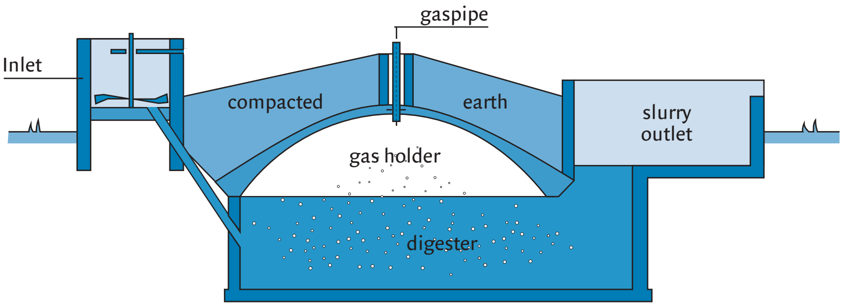
Exploitation of the forest beyond its sustainable capacity ('mining') has a number of implications including higher cost (in terms of time and energy expended) to collect wood, loss of habitats, forest degradation, soil erosion and damage to the watershed. Collection of fuelwood is not the only factor in overexploitation of the forests. Other factors include expansion of agricultural land, 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 been turning to the use of agricultural residues and animal dung as a source for cooking fuel. However, the use of agricultural residues and animal dung for cooking purposes, rather than its traditional use as an organic fertilizer, has obvious disadvantages. It results in declining soil fertility and reduced crop yields and thereby increases the economic plight of the rural farmers.

1.3 Biogas Technology

Biogas plants anaerobically convert animal dung, human excrement and other biomass wastes into a combustible methane gas. This "biogas" can be effectively used in simple gas stoves and lamps to replace the use of scarce fuelwood, agricultural residues, "dung-cakes" and high cost subsidized kerosene. In addition, the resulting slurry from the biogas plants can be easily collected and used as a fertilizer to enhance agricultural productivity. The biogas technology is a proven and established technology in many parts of the globe. There are reported to be over five million small biogas plants installed in the Peoples Republic of China and over 2.7 million biogas plants in India. An illustration of a typical biogas plant, designed for Nepal, is presented in Box 1.

Box 1: Typical Biogas Plant Designed for Nepal



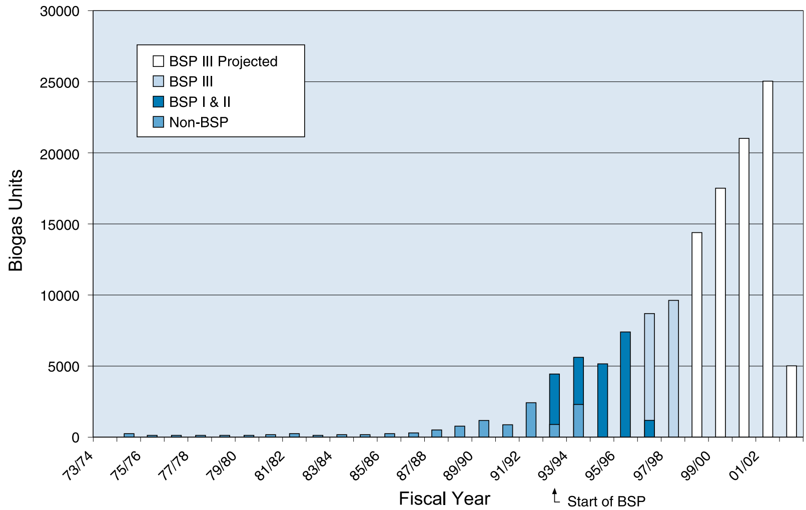
The amount of dung to be fed into the digester depends on the size of the plant and the ambient temperature. Sizes are available in the range of 4, 6, 8, 10, 15 and 20 m^3. At moderate temperatures as found in the hills of Nepal, the corresponding daily input of dung amounts to 6 kg per m^3 of plant. Prior to feeding, the dung should be mixed in the inlet with an equal amount of water to make homogeneous slurry. Depending on the ambient temperature the slurry will retain in the digester for 50-70 days on an average. After leaving the outlet, it will flow to a compost pit. The produced gas is used for cooking and to a lesser extent (by half of the users) also for lighting.

1.4 History of Biogas in Nepal

The Reverend Saubolle constructed the first known biogas plant in Nepal on an experimental basis in 1955. The first official biogas program was launched by HMG/N in 1974. Under this and subsequent programs, construction loans were offered to potential customers by the ADB/N. In addition, in 1977, the Government established the Biogas and Agricultural Equipment (P) Ltd. popularly known as Gobar Gas Company (GGC). The GGC, a state owned entity, was charged with the responsibility of advancing the development and promoting the wide-scale dissemination of the biogas technology.

The installation rate for biogas plants before 1985 ranged between 100 and 300 units per year (see Figure 2). The target for the seventh five-year plan period (1985/86 to 1989/90) was to construct 4,000 units or an average of 800 units per year. For this, the government provided the ADB/N with funds to provide a 25 percent subsidy for the capital costs of biogas plants as well as a 50 percent subsidy for the interest payments on loans used to finance the construction of biogas plants. The capital cost subsidy got increased to 50 percent, but finally all subsidies were briefly suspended in 1990. This resulted in a virtual standstill in the construction program and in a high number of complaints of biogas owners who were deprived of the interest subsidies on their outstanding loan balances.

Figure 2: Rate of Annual Biogas Plant Installations



The performance of the dome-type biogas plants constructed by GGC was found to be good. A baseline survey conducted in 1990/91 revealed that 90 percent of the plants were still in operation. The principal constraints to the wider use of biogas plants included high costs due to a tendency for over-sizing, frequent maintenance due to the low quality of appliances, limited supply infrastructure, lack of promotional activities and incentives and an inconsistent policy of subsidies and support.

The number of households with cattle and/or buffaloes in Nepal in 1992 was estimated at 2.3 million. Installation of biogas plants was considered technically possible at 69 percent of these households, which translates to a technical potential of 1.5 million units. Yet in July 1990, less than 6,000 biogas units were installed in Nepal representing 0.4 percent of this potential.

In summary, biogas plants for rural household energy were considered to be a feasible option to help reduce the social, economic and environmental pressures caused by the declining fuelwood supplies. However, the biogas plants and promotional incentives available in Nepal were failing to convince and motivate the majority of rural farmers to adopt this technology as their primary source for household energy. It was evident to HMG/N and to the other actors involved in the biogas program in Nepal that a new approach was needed.

2.0 BSP Design and Implementation

The involvement of the SNV in the biogas sector of Nepal was initiated in 1989 with the posting of a SNV staff to the GGC workshop. The primary objective was to provide GGC with technical assistance to help improve their product and reduce its costs. In early 1990, a second SNV expert was posted to the Research Unit of GGC with the objective of helping in the R&D efforts to make lower cost biogas plants and thereby increase the affordability for a wider range of farmers. After detailed study, 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 biogas program in Nepal (HMG/N, ADB/N, GGC and SNV/Nepal) agreed on the need for financial assistance for the dissemination of biogas plants. The concerned parties prepared a proposal to secure financial assistance for the biogas sector in Nepal. They proposed the establishment of a Biogas Support Program (BSP) and requested co-funding to the Government of the Netherlands. The BSP proposal was approved and an agreement signed in 1992 between the Ministry of Finance on behalf of HMG/N and SNV/Nepal on behalf of the Dutch Development Cooperation. Implementation of the BSP started in September 1992.

2.1 Objectives and Activities

HMG/N and SNV/Nepal agreed that the active participation of private-sector entities in addition to the GGC and ADB/N were needed to realize and meet the vast potential for biogas plants in Nepal. However, the terms and conditions for the involvement of the private-sector had to be worked out and hence the BSP was divided into two phases. 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 7,000 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 was provided for biogas plants of NRP 7,000 in the Terai districts and NRP 10,000 in the Hill districts. The additional subsidy amount of NRP 3,000 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 through the construction company to the farmer.

To realize the privatization objective, independent local consultants were retained in 1993 to conduct a comprehensive study on the biogas sector. The study resulted in a proposal for the future structure of the biogas sector in Nepal.

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

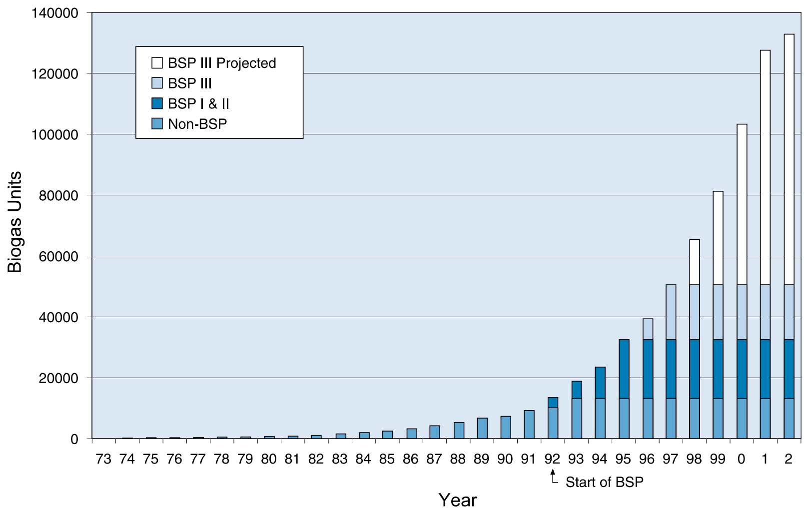
- Construct another 13,000 plants;
- Make biogas more attractive to smaller farmers, and farmers in the Hill districts; and
- Support the establishment of an apex body to coordinate the different actors in the biogas sector.

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, also NGOs were to be engaged to help in the promotion of biogas in regions they were working 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 labor, monitoring and inspection programs, establishment of extension services and other related support activities.

Figure 3: Cumulative Number of Biogas Plants Installed in Nepal



As a result of the intensive and dedicated efforts of all parties involved, the short-term objectives of the BSP I and II were achieved six months ahead of schedule. The best illustration of the success is the data presented in Figure 3 for the cumulative number of biogas plants built in Nepal from 1973/74 to 1997/98. This figure also shows the number of biogas units already installed (up to July 1998) and still to be installed in Phase III. This 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 (see section 7). The total number of biogas systems installed in Nepal up to July 1998 is approximately 49,000 units of which more than 37,000 were constructed under the BSP benefiting more than 200,000 members of rural households.

2.2 Costs and Financing

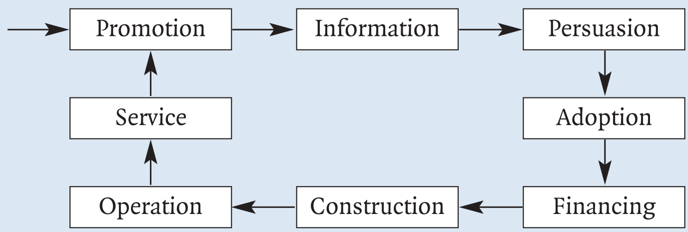
The total expenditure of BSP I & II amounted to NRP 530 million (US$ 9.5 million) excluding government tax on biogas accessories. Of the total expenditures, 55 percent was spent on credit through bank loans and cash payments; 33 percent on investment subsidies; and 12 percent on technical assistance 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 percent of the funding principally through loans to farmers. The Dutch Development Cooperation through SNV/Nepal provided 44 percent principally for subsidy payments and technical assistance. Farmers making cash payments accounted for 12 percent of the total funds while participating companies, through the raising of so-called participation fees, provided the remaining one- percent of the funds. The BSP also received a gift from a Dutch natural gas company used to subsidize additional 200 biogas plants. To ensure maximum use of funds, HMG/N granted an exemption of tax on all biogas accessories.

3.0 Dissemination of Biogas Plants

To assist in the dissemination of biogas plants in Nepal, the key steps for marketing biogas plants to potential users were identified. These steps illustrated in Box 2, show the sequential nature in which the marketing/dissemination process was carried out.

Box 2: Key Steps in the BSP Marketing/Dissemination Process



Promotion on biogas leads to awareness; information to evaluation; and personal persuasion to adoption. After adoption, financing and construction leads to installation of the biogas plant. Proper operation and after sales service are critical to keep the biogas plants functioning well which is a pre-condition for future credible promotion.

3.1 Promotion

A number of specific actions were undertaken to promote the adoption of biogas plants by potential users. The most important element of the promotion strategy was to have a satisfied customer telling friends, relatives and neighbors about the benefits of a biogas plant. To achieve this result, the program sought to accurately inform potential customers of the specific requirements of a biogas plant and to 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. A summary of key statistics to demonstrate the impact of the subsidy is given in Table 1. The data clearly indicates that the subsidy program was successful in extending the market for biogas plants to the smaller, lower income and more isolated farmers including farmers in the hill districts.

Table 1: Distribution of Biogas Plants Pre and Under BSP Phase I and II

Indicator	Pre-BSP	BSP I & II
Percent of plants installed in the Hills	27%	56%
Average land holding of users	4.9 ha	1.6 ha
Average number of cattle	8.3	5.5
Percentage of households with servants using biogas	52%	21%
Average biogas plant size	12.9 m^3	9.0 m^3

3.2 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 remaining NRP 14,400 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 percent annual interest and a 7-year repayment term. As a result, 76 percent of the installed plants were constructed with loan financing. The ADB/N has a reported repayment record for biogas loans of 87 percent while its overall loan repayment rate is only 67 percent. As a result, the ADB/N is very supportive of its biogas loan program. Approximately 24 percent of all plants realized under BSP I & II were financed by farmers on 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.

3.3 Construction

An important factor in the successful promotion of biogas plants in Nepal was a strict enforcement of carefully determined quality and design standards. 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. These terms and conditions were part of agreements signed between the BSP and the participating companies at the beginning of each fiscal year. In total, 73 quality standards were introduced that related to design, size, construction materials, construction of inlet, digester, dome, turret, outlet and compost pits, toilet attachment, appliances and fittings, fitting and lay-out of the gas pipes, training of masons, and after sales service. Enforcement of the quality standards was achieved by imposing penalties for non-compliance when found during inspection through random sampling. This enforcement 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. This high ratio was considered a prerequisite for the successful dissemination of biogas plants under the BSP.

3.4 Operation

The successful operation and maintenance of biogas plants was the common 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 plant. The company staff usually accomplished this at the time of plant construction. A simple and 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.

3.5 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. The required after sales service consisted of:

- One year guarantee on pipes, fittings and appliances;
- Six years guarantee on the structure of the plant (from 1996/97 onwards reduced to three years);
- An annual maintenance visit in the last five years of the guarantee period (from 1996/97 onwards reduced 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 service 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 advice 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.

4.0 Benefits

Biogas plants provide multiple benefits at the household, local, national and global level. 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.

4.1 Gender Benefits

It is clearly demonstrated that biogas plants provide direct benefits especially to rural women. 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 labor required for the gathering of fuel for cooking and cooking itself. Collection of fuelwood generally is the burden of rural women requiring a lot of their time in addition to the difficult labor of carrying the fuelwood long distances and up 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. An estimate of the average positive and negative time impacts of a biogas plant is presented in Table 2. The data 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 (h/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

The surveys showed that most women expressed great satisfaction, particularly with the cooking aspects of biogas. They indicated 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. This aspect 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 labor. 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 twenty per cent of all biogas plants. Female participation in institutions like biogas companies, banks and NGOs is low. The number of female employees is on average less than five per cent with a higher share for the NGOs.

4.2 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 has helped significantly improve the indoor air quality of homes employing biogas stoves in place of wood stoves. 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.

In July 1998, more than 37,000 biogas plants were installed under BSP I & II and part of Phase III. It is estimated that more than 90 percent 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 liters of kerosene annually.[3] The savings in fuelwood help to slow the rate of deforestation in rural Nepal.

The biogas fuel 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 the biogas combustion is reabsorbed in the process of the growth of the fodder and food for the animals and men. In the case of fuelwood, if it is consumed on a non-sustainable basis, then all the CO_2, CH_4 and N_2O

[3]) *Assumes 33,300 operational units with average savings of 3 tonnes fuelwood/ unit/year and 38 liters of kerosene/unit/year.*

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[4] suggests an emission coefficient of approximately 1.5 tonnes CO_2 per tonne of non-sustainable fuelwood and approximately 2.5 tonnes CO_2 per 1,000 liters 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_2 equivalent per annum[5].

The installed biogas plants (July 1998) are estimated to produce 1,000,000 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 the biogas slurry is more favorable when compared to the ashes of agricultural and animal waste that is collected after combustion. Besides the savings of nutrients, the biogas slurry contributes to maintain the content of organic matter in the soil.

4.3 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 its relatively clean combustion characteristics, have even more pronounced beneficial effects than smokeless fuel wood stoves. One attempt of estimating the economic value of smoke exposure reduction reported a value of US$ 100 per household.[6]

Eye ailments are commonly associated with smoke-filled rooms. The use of biogas stoves is expected to significantly reduce eye ailments associated with smoke for fuel wood stoves. Many biogas users have reported improved eye health. However, smokeless

4) *"Greenhouse Gas Inventory Reference Manual – IPCC Guidelines for National Greenhouse Gas Inventories", Intergovernmental Panel on Climate Change, 1995. Total CO_2 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, CH_4 and N_2O emissions from fuelwood combustion are estimated based on IPCC methodology and converted to CO_2 equivalent.*

5) *Resulting from the CH_4 and N_2O emissions from fuelwood combustion and the CO_2 emissions from kerosene combustion.*

6) *H.F. Reid, et. al., "Indoor Smoke Exposures from Traditional and Improved Cookstoves: Comparison Among Nepali Women", Mountain Research and Development, V6, no. 4, 1986.*

rooms are not always considered a benefit. Smoke is traditionally used to ward off harmless and harmful insects. Some users of biogas stoves have indicated that the stoves fail to keep away insects and especially mosquitoes.

Improved sanitation and dung management leads to better hygienic conditions. Toilets were attached to some 40 percent of all plants constructed (see Box 3). Attached toilets not only improve the hygienic conditions in and around the farmyard but also offer privacy. The net result is a cleaner environment and a decrease in the opportunities for the spread of diseases.

Box 3: 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 organisms 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.

4.4 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 favors smaller plant sizes and smaller-scale farmers more than larger-scale farmers. In addition, the increasingly active involvement of NGO's 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, biogas does not benefit those farmers without cattle who generally represent the very poorest strata of the society. Cattle-less, landless and marginal farmers may benefit only indirectly, from increased employment opportunities and greater availability of firewood.

4.5 Institutional Implications

The activities have had several important and beneficial institutional implications like the recommendations on the privatization of the biogas sector in 1993 and the establishment of the apex body to promote biogas and other alternative energy sources, the AEPC, in 1996.

Compared to the pre-project situation, a high number of institutions have gotten involved in the biogas sector. The number of companies producing biogas plants increased from one to 39. The number of banks financing biogas plants has increased from one to three. The number of NGO's working in support of biogas has increased to 30 organizations. Finally, the number of manufacturers making and selling biogas appliances has increased from one to ten. As a result of the increased institutional and private interests in the biogas market, an association of biogas companies called the Nepal Biogas Promotion Group (NBPG) was established in 1994. In addition, a Coalition for Biogas & Alternative Energy Promotion has also been established to coordinate the activities of the NGOs that are involved in biogas and other alternative energy promotion activities.

In addition to the institutional developments, employment for skilled as well as unskilled labor in rural areas has been generated. Some 2,500 person-years were required for the production of appliances and building materials. Another 2,500 person-years of unskilled labor 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 2,000 persons. This represents a significant employment impact especially for the rural areas of Nepal.

Collection of fuelwood is the burden of women
(photo: B&U International Picture Service)

5.0 Financial and Economic Assessment

The biogas plants (July 1998) are estimated to displace the use of 100,000 tonnes of fuelwood and 1.27 million liters of kerosene annually. The savings in fuelwood help to slow the rate of deforestation in rural Nepal. Additionally, the reduction in the use of kerosene helps save valuable foreign exchange, which is used to import the fuel. The estimated savings in kerosene imports amount to NRP 14 million or about US$ 233,000 annually.[7]

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 m^3 of biogas capacity.[8]

A net reduction of approximately 157,000 tonnes of CO_2 equivalent annually is derived from the displacement of the use of unsustainable fuelwood and from the reduced consumption of kerosene. Assuming an economic value of US$ 20/tonne C (equivalent to US$ 5.45/tonne CO_2) would result in a global economic value of US$ 0.86 million per year for the greenhouse gas displaced by the biogas units in Nepal. If the fuelwood is produced on a sustainable basis, the biogas plants will only account for savings of 13,000 tonnes of CO_2 equivalent with an economic value of only US$ 70,850 per year.

The financial and economic attractiveness of the BSP can be viewed both from the individual end-user or customer as well as from the program perspective. The subsidies are considered in the economic analysis as a cost-factor. The assessment is based on determining the financial and economic internal rates of return for the customer and the economic internal rate of return for the program. Only a representative analysis is presented in this paper to illustrate the financial and economic attractiveness of the BSP.

5.1 Financial Analysis

The financial analysis is based on the data for an average size biogas unit. Biogas plants are available in the range of 4 to 20 m^3 but the most popular units are in the range of 6 to 10 m^3. Therefore, a representative unit of 8-m^3 was selected for the financial analysis. The financial analysis is 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 basic data for the financial analysis is presented in Appendix 2.

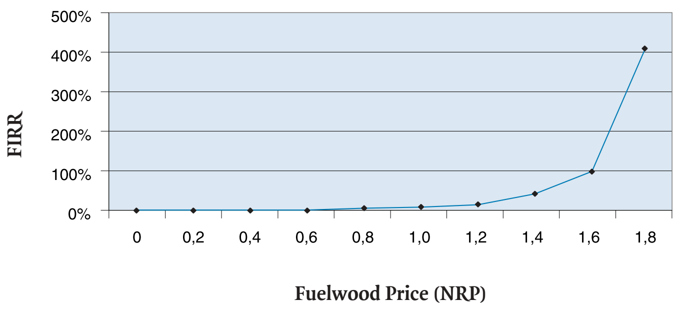
[7]) *Assumes NRP 11/liter of kerosene.*

[8]) *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.*

The benefits 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 value of the saved labor and the recovered nutrients in the biogas slurry are assumed to be zero.

The base analysis indicates a financial internal rate of return (FIRR) of 14 percent. Figure 4 presents the results of a sensitivity analysis on the assumed price of fuelwood. The data indicates that the resulting FIRR is extremely sensitive to the price of fuelwood.

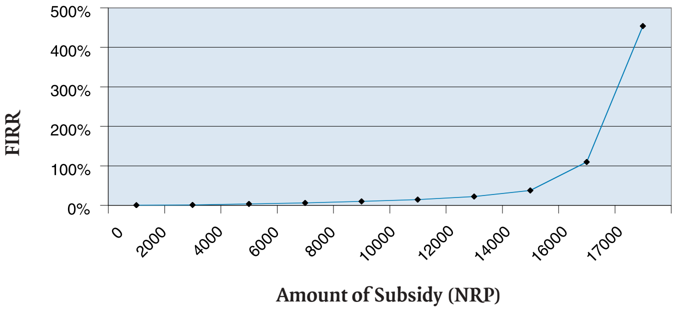
Figure 4: FIRR vs. Fuelwood Price



The FIRR becomes negative when the price of fuelwood is below 0.6 NRP/kg and over 400 percent when the price of fuelwood is 1.8 NRP/kg. The actual price of fuelwood in Nepal varies considerably from one area to another. The perception of the rural farmer is that the price of fuelwood is near zero since fuelwood can be collected by household labor which is not valued highly by the farmer.

A sensitivity analysis on the amount of the subsidy provided is presented in Figure 5. The data indicates that the FIRR is not as sensitive to the percentage change in the level of the subsidy as it is to the price of fuelwood. The FIRR becomes negative only when the subsidy drops below NRP 2,000 per biogas unit and is above 400 percent when the subsidy is over NRP 17,000 per unit.

Figure 5: FIRR vs. Amount of Subsidy



The average capital costs for an 8-m³ biogas plant in the Terai is estimated at NRP 25,430. The subsidy provided for biogas plants in the Terai is NRP 7,000. A similar financial analysis for biogas plants in the Terai result in a base FIRR of only 9 percent. The FIRR is also sensitive to the fuel wood price and the level of the subsidy.

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 FIRRs for the farmer. The actual FIRR realized by the farmer is largely dependent on the actual financial price for fuelwood.

5.2 Economic Analysis

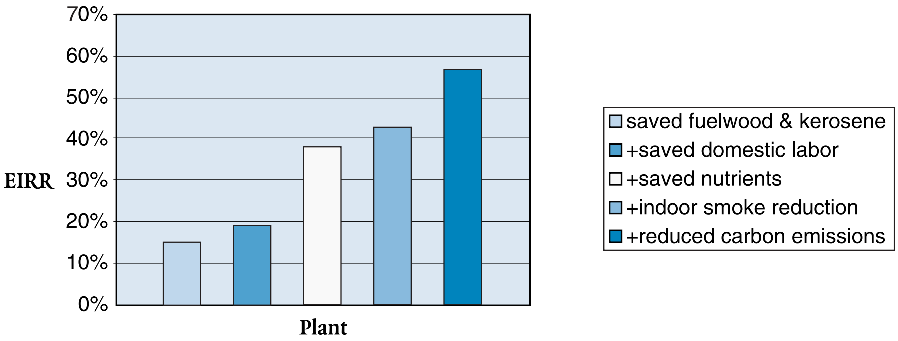
An economic analysis of both a representative 8-m³ biogas plant built in a Hill district and of the entire program was undertaken to assess the benefits to society of the use of biogas plants and of the grant support provided to the operation of the BSP. Due to the scope of this paper, the economic analysis had to rely heavily on data presented in a 1995 evaluation of the BSP carried out by CODEX[9]. This data provides a reasonable basis for the economic analysis.

Several assumptions were necessary to carry out the economic analysis. The principal assumptions relate to the conversion from financial prices to economic prices for both the costs and benefits associated with the biogas plants and the BSP. A summary of the conversion factors and resulting economic prices for the costs and benefits associated with the analysis is presented in Appendix 3. Economic benefits resulting from improved sanitation through toilet attachment and employment generation were left out of consideration. The analysis is based on calculating the economic internal rate of return (EIRR) for the net annual benefits associated with either the representative biogas plant or the entire BSP.

[9]) *"Evaluation of Subsidy Scheme for Biogas Plants", submitted to the Biogas Support Program by CODEX Consultants (P) Ltd., Katmandu, Nepal, December 1995.*

Economic Analysis of Biogas Plant: The economic analysis for the biogas plant was carried out assuming a plant life of 15 years. All capital costs for the plant were assumed to be expended in the first year and all O&M costs and all resulting benefits were assumed to be constant over the 15 year life of the plant. A summary of the resulting EIRR for an 8-m^3 representative biogas plant built in the hill district is presented in Figure 6.

Figure 6: EIRR for Biogas Plant (8 m^3)



The EIRR for just the economic benefits derived from the savings of fuelwood and kerosene that result from the use of a biogas plant is estimated at 15 percent. This EIRR, as in the financial case, is very sensitive to the assumption of the economic price for fuelwood. The economic price of fuelwood is assumed to be NRP 1.0/kg based on the analysis of the CODEX study. If the economic price of fuelwood is NRP 0.5/kg, the resulting EIRR is 2 percent and if the price is NRP 1.5/kg, the resulting EIRR is 27 percent.

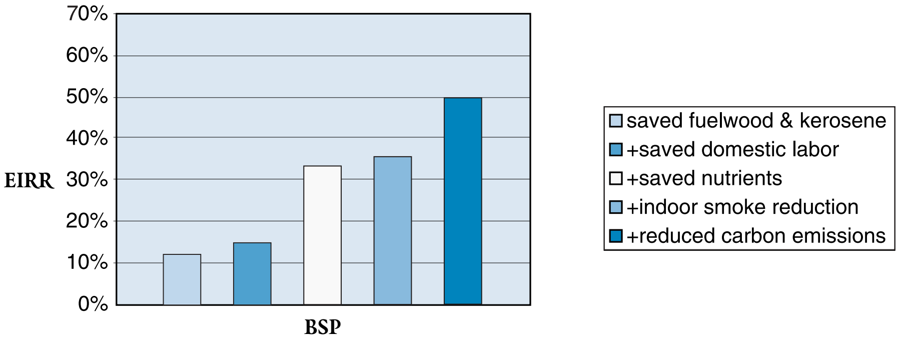
Working with the base economic price for fuelwood of NRP 1.0/kg and adding a saving of three hours a day of domestic labor valued at NRP 2.0/day results in increasing the EIRR to 19 percent. Assuming an annual value of NRP 1,971[10] for the nutrients in the dung that are saved and returned to the land as a result of the biogas plant, the EIRR increases to 38 percent. When the economic value of smoke reduction is added at NRP 400/year (equal to US$ 6.67/yr or US$ 100/household for the 15 year life of the biogas plant - Reid, 1986), the resulting EIRR increases to 42 percent. Finally, if the reduced carbon emissions associated with the use of a biogas plant are valued at US$ 20/tonne C, the resulting EIRR increases to 57 percent.

Economic Analysis of entire BSP: The results of the economic analysis of the costs and benefits of the entire BSP I&II are presented in Figure 7. The analysis was carried out for a period of 20 years to account for all the costs and benefits associated with the bio-

[10]) *Based on data in the CODEX study (Table 5, p.55).*

gas plants installed over the five year implementation period. An attrition rate of two percent per year was assumed for the installed biogas plants with the remaining plants retired after 15 years. The expenditures for technical assistance and capital were disbursed over the first five years in accordance with the TA expenditures and capital expenditures associated with the number of units constructed in the same five years period. The annual O&M costs and associated benefits were calculated based on the rate of plant constructions. A summary of the five-year TA and capital expenditures is presented in Appendix 3.

Figure 7: EIRR for BSP



The EIRR for the BSP is 11 percent when accounting for just the program's savings of fuelwood and kerosene. For the base case, fuelwood is valued at NRP 1.0/kg. When fuelwood is valued at NRP 0.5/kg, the EIRR is negative. Alternately, when it is valued at NRP 1.5/kg, the EIRR is 22 percent. Taking the base case value of fuelwood of NRP 1.0/kg and adding the benefits from saved domestic labor results in an EIRR of 15 percent. Adding the total value of the nutrients saved by the BSP increases the EIRR to 32 percent. Including the conservative estimates for the health benefits of smoke reduction (US$ 6.67/household/yr) increases the EIRR to 36 percent. Finally, adding the value of the reduced carbon provides an EIRR of 50 percent.

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 percent. When the other principal non-market benefits of the biogas plant are added, the EIRR rises to 57 percent. This provides an additional justification for the subsidy for the biogas plants. A similar argument can be presented to support the TA grant for the BSP. The EIRR of the net benefits for the BSP reach as high as 50 percent when the principal non-market benefits are accounted for in the analysis. This latter number is once more a clear indication of the economic justification of the grants.

Daily feeding of the biogas plant with fresh dung (photo: Jan Lam)

6.0 Success Factors

There are several important reasons why the program has succeeded in accelerating the adoption of biogas in Nepal. These can be classified into three main categories: **technical, institutional and financial.** Prior to the elaboration on these categories, it is important to understand that there are a number of factors unique to Nepal that have also contributed to the success. Biogas plants fit very well into the Nepalese integrated farming system combining crop production and animal husbandry. Most rural households rear some cattle and as a result have dung that can be collected to feed biogas plants. The handling of cattle dung is not a taboo in the context of the Hindu culture. Finally, the increasing difficulty of obtaining fuelwood in Nepal is a strong incentive to look for alternative cooking fuels like biogas.

6.1 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. Initially, research and development was supported to the principal biogas producer, the GGC. In the process, strict standards for quality and design were established that any producer was required to follow. These strictly enforced quality and design standards 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 labor helped to reduce biogas plant construction costs. Additionally, a certification process and financial incentives were introduced to ensure that the 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.

6.2 Institutional Factors

The BSP has worked in close partnership with the key institutional players who have supported the growth of biogas in Nepal. These include 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. In 1998, there were 39 certified companies that were involved in producing biogas plants in Nepal. As a result, the overall costs of biogas plants have declined by approximately 30 percent when measured in real terms.

The BSP is actively working to help train and strengthen companies that are active in biogas production to commercialize biogas industry. In addition, the Nepal Biogas Promotion Group (NBPG) has been established to coordinate 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 focus the activities of the government, the AEPC has been established in 1996. This Centre will coordinate all alternative energy development in Nepal and hosts the Biogas Coordination Committee.

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 might be further opened. The initial results are very promising.

The BSP has successfully built and strengthened the institutional framework to support the wide-scale commercialization of biogas systems in Nepal. This has resulted from its working in close partnership with key financial institutions, qualified private sector firms, responsible government agencies and active non-government organizations. In addition, the support of international donor agencies such as the Dutch Development Cooperation and KfW has helped to secure the commercialization process.

6.3 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 of NRP 7,000 in the Terai districts, NRP 10,000 for the Hill districts and NRP 12,000 for the remote Hill districts is applied. This subsidy represents approximately 35 percent of the total cost of constructing a biogas plant. The uniform, transparent and careful administration of this subsidy has been an important factor in convincing farmers to purchase biogas plants while at the same time ensuring that biogas plants are produced according to the strict quality and design standards established by the BSP. The subsidy is only eligible for plants built by certified companies. In addition, 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. The first has been that it benefits smaller farmers with less cattle, which generally have lower household incomes. Second, it has resulted in lowering the average capacity of biogas plants built in Nepal, 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 percent of the allocated funds have reached the target group and only 10 percent were used for operational expenses. This represents a truly effective use of project resources. **The BSP has helped develop a successful financial mechanism for the commercialization of biogas systems in Nepal.**

Supervision of a biogas plant under construction (photo: B&U International Picture Service)

7.0 Design and challenges of Phase III

The mid-term evaluation of BSP I & II strongly recommended the continuation and expansion of the biogas program in Nepal. In response to this recommendation, a proposal for a third phase was formulated[11] 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 remaining 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.

7.1 Program Objectives

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

Efforts will be undertaken in promotion and marketing, lending, quality control, research and development, training, extension, and monitoring and evaluation. Promotion and marketing are tasks to be taken up by participating biogas companies and banks. In addition, NGOs and possibly also line agencies, District Development Committees (DDCs) and Village Development Committees (VDCs) can play an important advocacy role. Efforts will also be undertaken to promote and install a larger number of smaller biogas plants, as these are more affordable to lower-income farmers.

[11]) *"Proposal Biogas Support Program Phase III", HMG/N and SNV/Nepal, Katmandu, Nepal, February 1996.*

7.2 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 two and one-half 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 the 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 for the services 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 private sector biogas producers expanded 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 units 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 units 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 close 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 AEPC 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. The BSP might take in 1999/2000 the initial step by reducing the average subsidy amount per plant from NRP 9,000 to NRP 8,000. In addition, the subsidy will remain fixed in nominal term's 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-m^3 unit will decline to approximately 16 percent of total costs at the end of 2001/02 as compared to 35 percent 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 GHG benefits of the project through the proposed Clean Development Mechanism of the UNFCCC Kyoto Protocol.

8.0 Lessons Learnt

In conclusion, the BSP has become a successful and beneficial endeavor 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 coordinating committees to ensure the cooperation 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.

Appendix 1: Background Information on Nepal

Nepal can be divided into three parallel bands trending northwest to southeast. Closest to China is the Great Himalayan Range, where average elevations exceed 4,750 meters. This is a largely inaccessible area, with glaciers and peaks exceeding 8,000 meters, including Sagarmatha (8,848 meters), or Mount Everest, the highest mountain on earth. The second band is dominated by the Mahabharat and Churia ranges and includes the broad upland valleys of the Lesser Himalayas. Elevations in this band average 2,500 meters. The third and southernmost region is the Terai, an area of plains, swamps and forests. The alluvial soils of the Terai are fertile, unlike those of the mostly barren uplands. Other than the Terai, the only sizeable areas of flat land are a few valleys among which is the Valley of Katmandu, a broad basin in the center of the country.

The climate of Nepal varies widely and depends on altitude and location. Generally, temperatures decrease from south to north and run almost parallel to the topographic features of the country. As a result the Terai and low river basins have higher temperatures throughout the year. Annual rainfall ranges from a low of about 250 millimeters to highs of 4,500 millimeters, at some places. June to September is the monsoon, in which eighty percent of all rainfall occurs.

The Central Bureau of Statistics estimates the population of Nepal to be 21.5 million in 1995 with an annual growth rate of approximately 2 percent. The number of households is estimated at 3.6 million with an average of 5.6 persons per household. About 86 per cent of the population resides in rural areas, with fairly high densities in the Terai and in broad upland valleys. The nation is predominantly Hindu. Its hierarchical caste system plays a significant role in social organization. The adult literacy rate of the population in 1995 was reported to be 27 percent divided into 41 percent for males and only 14 percent for females. The average life expectancy at birth was estimated at 55 years (World Bank, 1997).

About 90 percent of the people in Nepal depend on agriculture for their income and survival. Farming is based on an integrated system combining crop production and animal husbandry. Livestock serve multiple purposes and are an important element of rural life. Cattle are kept for dairy products, as draught animals and as a main source of fertilizer. Dung is used to make compost for the fields and, usually under conditions of resource stress, as a raw material for fuel.
In 1992, the number of land holdings amounted to 2.7 million cultivating 2.6 million hectares of land, which constituted 18 per cent of the total land area of the country. Thus, small-scale farms are the norm with an average size of 0.96 hectares per holding (1992). Despite the increase in the total cultivated area, the per capita holding declined from 0.18 to 0.14 hectares in the period 1962-1992 as a result of the increasing population pressure.

The per capita Gross National Product (GNP) in 1995 is estimated at only US$200. As a result, 53 percent of the population are estimated to live on less than US$1 per day.

The growth in GNP is estimated at 2.4 percent over the past decade but per capita income has been offset by the growth of the population. In 1995, it was estimated that 42 percent of the Gross Domestic Product (GDP) was derived from agriculture, 22 percent from industry and 36 percent from the service sector. Nepal's development is impeded by its mountainous geography and limited infrastructure which place several constraints on transport and communication. Its relative isolation limits its economic access to international markets.

Summary of Basic 1995 National Statistics for Nepal

Surface Area ($x10^3$ km^2)	141	Per Capita GNP (US$)	200
Population ($x10^6$)	21.5	Per Capita PPP (US$)	1,170
Percent Rural	86%	Average Annual Growth of GNP	2.4%
Adult Literacy Rate	27%	GDP ($x10^6$ US$)	4,232
Average Annual Growth Rate of Population	2.1%	Agriculture	42%
Number of Households ($x10^6$)	3.6	Industry	22%
Persons per Household	5.6	Services	36%

Appendix 2: 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 analysis 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

Appendix 3: Basic Data for the Economic Analysis of 8 M³ Biogas Plant for Hill Districts and the entire BSP

The data in this Appendix presents the information on the economic costs and benefits associated with a representative 8-m³ 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-m³ 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
Expenditures for TA (NRP x million)	6.20	9.84	11.37	18.53	18.19
Expenditures for Capital (NRP x million)	64.00	58.71	86.89	132.28	22.05
Cumulative Expenditure for Capital (NRP x million)	64.00	122.71	209.60	341.88	363.93

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%