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May 2007

Bolivia:
National Biomass Program

Report on Operational Activities




ESMAP

Energy Sector Management Assistance Program

Energy Sector Management Assistance Program (ESMAP)

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The Energy Sector Management Assistance Program (ESMAP) is a global technical assistance partnership administered by the World Bank and sponsored by bi-lateral official donors, since 1983. ESMAP's mission is to promote the role of energy in poverty reduction and economic growth in an environmentally responsible manner. Its work applies to low-income, emerging, and transition economies and contributes to the achievement of internationally agreed development goals. ESMAP interventions are knowledge products including free technical assistance, specific studies, advisory services, pilot projects, knowledge generation and dissemination, trainings, workshops and seminars, conferences and round-tables, and publications. ESMAP work is focused on four key thematic programs: energy security, renewable energy, energy-poverty and market efficiency and governance.

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Acronyms and Abbreviations

ANED	Asociación Nacional Ecuménica de Desarrollo (National Association for Development)
ASE	Asociación Sucrense de Ecología (Ecological Association of Sucre)
BTG	Biomass Technology Group
CAS	Country Assistance Strategy
CEE	Comisión Episcopal de Educación (Episcopal Educational Commission)
CEEDI	Centro de Estudios Ecológicos y de Desarrollo (Center for the Ecological and Developmental Studies)
CEITHAR	Centro Integral Técnico Humanístico Acelerado Rural
CETHA	Centro de Educación Técnica, Humanística y Agropecuaria
CNI	Cámara Nacional de Industrias (National Chamber of Industries)
CPTS	Centro de Promoción de Tecnologías Sostenibles (Center for the Promotion of Sustainable Technologies)
CRE	Cooperativa Rural de Electrificación de Santa Cruz (Rural Electrification Cooperative of Santa Cruz)
DECOS	Desarrollo Comunitario Sostenible (Sustainable Community Development)
EIA	Environment Impact Assessment
ESCO	Energy Services Companies
ESOs	Energy Services Organizations
ESMAP	Energy Sector Management Assistance Program
FADES	Fundación para Alternativas de Desarrollo (NGO for Alternative Development)
FERIA	Facilitadores de Educación Rural Integral Alternativa (Facilitators of Integrated Alternative Rural Education)
FI	Financial Intermediary

FUNDA-PRO	Fundación para la Producción (NGO for the Production)
GDP	Gross Domestic Product
GoB	Government of Bolivia
IDA	International Development Association
IRRs	International Rate Returns
LPG	Liquefied Petroleum Gas
MAGDR	Ministerio de Agricultura, Ganadería y Desarrollo Rural (Ministry of Agriculture and Rural Development)
MTR	Mid-Term Review
NBP	National Biomass Program
NET	Net Present Value
NGOs	Non Governmental Organizations
NOGUB-COSUDE	Agencia Suiza para el Desarrollo y la Cooperación-No Gubernamental (Swiss Agency for Cooperation and Development, NGO)
OTB	Organización Territorial de Base (Territorial Base Organization)
PCI	Programa de Crédito Institucional (Institutional Credit Program)
PISA	Pan American Investment S.A.
SAT	Servicio de Asistencia Técnica, Programa de Apoyo al Desarrollo de la Pequeña y Microempresa, Ministerio de Economía (Technical Assistance Service to Support the Development Program for Small and Medium Enterprises, Ministry of Finance)
SBEF	Superintendencia de Bancos y Entidades Financieras (Superintendence for Finance Entities and Banks)
UMA	Unidad de Medio Ambiente (Environmental Unit)
USAID	United States Agency for International Development
VEA	Viceministerio de Educación Alternativa (Vice Ministry for Alternative Education)
VMEH	Vice Ministry of Energy and Hydrocarbons

Currency Equivalents

Currency	Boliviano (b$)
b$1.0	= US$0.13
US$1.0	= b$7.68

Preface

The Bolivia National Biomass Program (NBP), through the Energy Sector Management Assistance Program, was financed with a Netherlands grant equivalent to US$2,660,394 (Trust Fund TF022188—BO011101, approved in December 1997).

The NBP was executed by the World Bank and implemented by the National Secretariat of Energy of Bolivia's Vice Ministry of Energy and Hydrocarbons. The World Bank provided a Task Manager and an Energy Specialist (Mr. Kilian Reiche) to oversee program implementation. The activities of NBP were carried out by a number of local and international consultants, under the coordination and orientation of Mr. Juan Carlos Guzman, a rural energy specialist operating in the National Secretariat of Energy.

The report on operational activities includes an Executive Summary and a main body of text comprising sections on Background, Program Objectives, Components, Costs and implementation of NBP in Rural Industries and the Household Sector. The Annexes provide a more detailed information on the impact and sustainability of the activities implemented under NBP, the different components and the program costs.

The report was prepared by Mr. Alvaro J. Covarrubias (Consultant), on the basis of contributions made by Mr. Juan Carlos Guzmán, coordinator of NBP in Bolivia, and was reviewed by Mr. Philippe Durand (Task Manager, LCSFE). Ms. Marjorie Araya and Ms. Ananda Swaroop of Energy Sector Management Assistance Program (ESMAP) coordinated the production and dissemination of the report.

Executive Summary

Overview of the National Biomass Program

ESMAP support to the energy sector in Bolivia. Over the past two decades, the Energy Sector Management Assistance Program (ESMAP) has financed several projects to assist Bolivia in the development of its energy sector, including through the Bolivia Country Program Phase I which contributed to the design of a national energy plan, the definition of policies and actions applicable to rural energy and energy efficiency, and a significant structural reform of the energy sector, and also supported the preparation of the Bolivia National Biomass Program (NBP) aimed at enhancing the efficient use of biomass as an energy source, while improving the quality of life of the rural population – in consistence with the objectives of the World Bank Country Assistance Strategy (CAS) in Bolivia regarding accelerated growth and development of private sector activities. An agreement subscribed in November 1997 between the Government of the Netherlands and the World Bank assigned the execution of NBP to ESMAP, with the Vice Ministry of Energy and Hydrocarbons (VMEH) as its counterpart in Bolivia.

Biomass as energy source in rural areas. In the year 2000, biomass energy (firewood, dung, charcoal and forestry and vegetal residues) represented about one-third of the total national energy consumption in Bolivia, mostly in rural areas in the form of firewood (about 965,000 tons per year) and dung (about 263,000 tons per year) corresponding to about 78 percent of the total household consumption of energy. Biomass accounts for approximately 90 percent of total household energy consumption. Rural industries consume the equivalent of about half a million tons of firewood, almost entirely supplied through commercial channels. The efficiency of biomass use by rural industries is very low, often due to low technological development. The principal problems faced by biomass on the supply-side are the low level of production of firewood in the highlands and the lack of regulations on access, control and exploitation of forestry resources for energy purposes, leading to unsustainable supply patterns. On the demand side, the principal problem is the inefficient use of biomass.

Many rural industries require large quantities of biomass and, sometimes, lack access to commercial energy sources other than biomass. The annual biomass demand of the estimated 4,000 rural industries in Bolivia would be about half a million tons of firewood. The economic impact of these establishments is important, both in terms of value added to the local economy, and nonagricultural sources of rural employment.

Objectives of the National Biomass Program. The NBP was designed to meet broad objectives, which included contributing to: (a) reducing negative environmental impacts of inefficient and unsustainable use of biomass as an energy source; (b) improving the quality of life of the rural population; and (c) increasing economic and social benefits derived from efficient production and use of biomass as an energy source. These objectives were to be achieved by implementing demonstration projects for biomass efficient use or biomass substitution in rural industries, establishing financing mechanisms to facilitate implementation of biomass efficiency projects by small-scale rural industries, promoting the efficient use or substitution of fuelwood in the household sector, implementing demonstration projects to improve the supply of biomass in rural areas, promoting biomass-based power generation, strengthening the capacity of public and private stakeholders in the biomass energy sector and establishing biomass energy in the policy agenda of central and local authorities.

Institutional set-up for the NBP. The NBP was placed under VMEH's Directorate of Energy and Hydrocarbons, as the VMEH environment management unit focused exclusively on environment impacts in the hydrocarbon sector. Its execution was performed by a national coordinator (local consultant) and local and international consultants (individuals and firms), under the supervision of a the World Bank team (including a task manager, an energy specialist and an administrative assistant). The local and the World Bank teams maintained close coordination with the Directorate of Energy and Hydrocarbons. NBP also developed partnerships and collaboration with local authorities and Non Governmental Organizations (NGOs).

Program cost and financing. The Netherlands financed NBP with a grant equivalent to US$2.66 million. The actual cost of NBP was US$2.51 million. The remaining amount of US$0.14 million was canceled when the grant was closed on June 30, 2002. The main budget items included consultants and training (US$1.2 million) and the Biomass Fund (US$0.8 million). The World Bank staff expenses amounted to US$0.29 million (time and travel), that is, about 11 percent of the total expenses (Annex 12 shows a detailed budget).

Mid-term review of the program. A mid-term review of the program conducted in September/October 2000 found that progress toward achieving the objectives was less than 50 percent, primarily due to the program's complex implementation arrangements.

The mid-term review recommended to extend the duration of the project and to reduce the number of activities originally included in NBP to those which could be completed before the revised project closing date. The Dutch Government agreed to the extension of NBP until June 30, 2002. Activities were refocused on: (i) the establishment of the Biomass Fund together with the identification of a portfolio of projects to be financed from this Fund; (ii) the finalization of biomass efficiency pilot projects in rice, sugar, gypsum, brick and ulexite industries; (iii) the finalization of the three pilot silvopastoral enclosures; and (iv) the documentation of project results and their transfer to project beneficiaries and stakeholders. NBP activities in the household sector and in biomass-based power generation were folded out due to unpromising perspectives.

Overall results and impacts of NBP. The NBP achieved significant results in line with its objectives. These results are detailed in the following chapters and can be summarized as follows:

- Establishment of the US$1 million Biomass Fund at *Fundación para la Producción* (FUNDA-PRO) – a second-tier financial organization which promotes lending to small industries; a portfolio of 236 biomass efficiency projects totaling US$1.1 million was developed at the prefeasibility level with NBP support, and financing of US$0.5 million for the first 99 projects was approved in 2002 by a first-tier financial institution Asociación Nacional Ecuménica de Desarrollo (ANED); Centro Integral Técnico Humanístico Acelerado Rural (CEITHAR); financial appraisal of projects and proponent industries was conducted by ANED, while the Centro de Promoción de Tecnologías Sostenibles (CPTS) at the National Chamber of Industries, Cámara Nacional de Industrias (CNI) verified the eligibility and quality of proposed projects from the biomass efficiency perspective. In 2002, the scope of the Biomass Fund was expanded to cover all types of energy efficiency projects or clean production projects, in industry, commercial and services sectors. In 2004, the Biomass Fund received supplementary financing of US$200,000 from the Danish Cooperation;
- Conclusion of several pilot projects in rural industries with good prospects for biomass efficiency, including: substitution of bagasse for fuelwood in three sugarcane industries in Santa Cruz; substitution of rice husk for fuelwood in a small rice mill, including a workshop for 25 rice mill owners in Santa Cruz; semicontinuous oven for gypsum production; improved brick production in Cochambamba, with training of brick producers; and improved efficiency in the use/substitution of *yareta* bushes for the production of ulexite;
- Design and implementation of silvopastoral enclosures in three low-income communities of the *altiplano* (Jatun Mayu. Casa Grande, and Sagha Sagha) and one training center (CEITHAR at Huerta Mayu), for improved management of natural resources, including training of stakeholders and involvement of local NGOs and municipalities;

- Feasibility studies for the development of Liquefied Petroleum Gas (LPG) market in rural areas and for a biomass-based power generation project in Riberalta;
- Preparation of a national energy balance, including woodfuel and biomass consumption;
- Dissemination of NBP results through technical publications (*Energía y Desarrollo*) and reports, and workshops in Bolivia and Washington. Development of energy efficiency curriculum and training materials; and
- Transfer of NBP outputs through agreements with relevant stakeholders: VMEH for biomass sector policies; NGOs and energy services firms for beneficiary training and energy efficiency project portfolio development; National Chamber of Industry/ Centro de Promoción de Tecnologías Sostenibles (CNI/CPTS) for supervision of the Biomass Fund and promotion and information on energy efficiency projects; Ministerio de Agricultura, Ganadería y Desarrollo Rural (Ministry of Agriculture and Rural Development) (MAGDR) (through its Policy Unit for Natural Resource Management) for the silvopastoral enclosures component; FUNDA-PRO for the management of the Biomass Fund; Servicio de Asistencia Técnica, Programa de Apoyo al Desorrollo de la Pequeña y de la Pequeña y Microempresa, Ministerio de Economía (SAT) at the Ministry of Economy as possible financial support for energy efficiency portfolio development.

The impacts and benefits of these NBP outputs are shown in Annex 1, in terms of woodfuel savings, financial benefits for industries, areas under silvopastoral management, and training beneficiaries. Annex 1 also shows that there are reasonable prospects for sustainability and replicability of NBP results from NBP, in view of the financing mechanisms and institutional arrangements that were put in place. The Biomass Fund (at FundaPro) and associated commercial banks would provide cofinancing for biomass efficiency projects proposed by small industries. Projects would be designed by these industries or energy service firms, which could apply to mechanisms such as SAT for financing the cost of these studies. The CPTS at the National Chamber of Industry would validate projects, promote best practices and inform industries about energy efficiency potential.

NBP Activities in Rural Industries

Patterns of biomass use by rural industries. The NBP undertook studies in the rural industry sector to determine levels and patterns of consumption of biomass as an energy source, the efficiency of its use, the productive and commercial channels, the origin and forms of biomass supply, monetary volumes of biomass commercialization and use, and the incidence of biomass in production costs of rural industries. These studies were meant to identify priority sectors, projects and zones for NBP intervention. The studies were carried out in seven departments by a number of Bolivian consulting firms, who collected detailed

information through semistructured interviews with key staff in selected rural industries regarding production processes (timing, frequency, seasonal variations), inputs required, biomass consumption and supply sources, and production costs and volumes.

The studies identified a total of 3,722 rural industries in seven departments, in which biomass is the principal energy source. Most industries produce building materials (brick, gypsum, tile, lime), while the rest belongs to traditional industrial sectors (maize beer, pottery, rice, brandy, raw sugar, and so on.) Incomplete information was obtained on bread and charcoal-producing activities, due to the high degree of dispersion of these establishments. Biomass energy sources used in rural industries include firewood, sawdust, charcoal, dung, forest residues, bagasse and *yareta* – either alone or in combination with LPG, gasoline, diesel, electricity, and even used tires. With an estimated consumption of about 345,000 tons/year, firewood is the most widely used energy source in small rural industries, and sawdust for brick production is the second most used energy source (about 130,000 tons/ year). Industries requiring motion power use gasoline and diesel engines and electric motors.

The studies also determined the specific energy consumption per unit of product output by type of industry. This is a good indicator of the level of technological development of rural industries in each department. It was found that specific energy consumption for a given product varies widely between departments and within the same department. For example, whereas bricks produced in La Paz use 1.5 to 2.8 MJ/kg, bricks produced in Oruro use 2.2 to 6.2 MJ/kg.

The assessment of biomass consumption patterns in rural industries showed that transformation of biomass in energy is based on inefficient and often obsolete technologies. It was found that the cost of biomass used by the rural industry often represents a sizable share of total product costs. The NBP concluded that the design of biomass projects must then, necessarily aim at upgrading the technologies used by rural industries in order to improve their competitiveness.

The studies found that: (a) globally, Bolivian rural industries spend about 16 percent of the value of their annual sales in biomass – a percentage significantly higher than the average for the whole industry sector; (b) the incidence of biomass expenditure in total costs ranges from 2 percent in the case of bakeries up to 69 percent in the case of lime production in Chuquisaca; (c) the principal factors affecting biomass price are the distance between the industry and the biomass production area, and the local environmental regulations influencing the cost of biomass resources; (d) the purchase of biomass is a permanent concern for energy-intensive industries such as the production of gypsum, lime and bricks; (e) rural industries generate approximately 20,000 sources of nonagricultural employment; and (f) the two most negative environmental impacts caused by the use of biomass by the rural

industry sector are the intensive exploitation of forest species with high calorific power and the emission of pollutants into the atmosphere due to biomass combustion. Biomass use in rural industries would cause the deforestation of approximately 80,000 hectare(s) (ha) of woods and the emission of about half a million tons of CO_2 into the atmosphere every year.

Identification of targets for NBP intervention in the rural industry sector. Based on these studies and on interviews with owners of rural industries, key informants, municipal authorities and associations, the consultants proposed actions/projects to enhance energy efficiency, rationalize biomass consumption and reduce energy costs, the implementation of which would result in significant economic benefits and lower environmental impacts. These projects were evaluated against the following eligibility criteria for technical assistance and funding under NBP:

- Final users are mostly rural industries which exist nationwide and use biomass as main energy source;
- Projects focus on the reduction of energy costs through biomass efficient use or its substitution with a fuel with lower environmental impact;
- Industries are small- or medium-sized with limited capital;
- Projects concern activities with large number of small industries, in order to: i) increase potential impacts and replication prospects, and ii) improve the terms of negotiations of industrials with suppliers of the goods and services required for project execution; and
- Projects bring a technological change in the industry processes either in the use of biomass or in the productive process itself.

The following six pilot projects were then selected for support under NBP as the most adequate instruments toward NBP objectives:

- Substitution of firewood with bagasse in *chancaca* processing industries in Saipina, Santa Cruz (Annex 2);
- Substitution of firewood with rice husks in rice mills of Yapacaní, Santa Cruz (Annex 3);
- Development of biomass efficiency projects in rural industries of the Department of Cochabamba (Annex 4);
- Efficient biomass use in the gypsum industries in Pacajes, Department of La Paz (Annex 5);
- Efficient biomass use in the production of ulexite in Nor Lípez, Department of Potosí (Annex 6); and
- Efficient biomass use in brick-making in San Carlos, Department of Santa Cruz (Annex 7).

Results of NBP in rural industries. The achievement of NBP in the rural industry sector can be summarized as:

- Loans for about US$200,000 were made to rural industries through the Biomass Fund for projects with estimated savings of 9,590 tons/year of biomass, representing about US$60,000/year of savings which will contribute to improve the competitiveness of these small industries;
- A portfolio of projects worth another US$500,000 were identified for financing under the Biomass Fund, with estimated savings of 36,000 tons/year of biomass;
- The technical and financing mechanisms established under NBP have stimulated the interest of entities for the management, financing, and execution of projects for energy efficiency in the rural productive sector, including three Energy Services Companies (ESCOs), several Financial Institutions (FUNDA-PRO, ANED), and a technical entity (CNI/CPTS); and
- Municipal governments have participated in project execution as sponsors, limiting their role to the provision of legal security for private investments in the projects. For the execution of future projects, letters of understanding have been agreed upon between municipal governments and ESCOs and associations of producers.

The Biomass Fund

Financial barriers. Access to financing is one of the main barriers for the execution of projects in energy efficiency and Renewable Energies (REs). Financial Intermediaries (FIs) do not provide financing for this type of projects due a number of reasons, including: their lack of experience with this type of borrowers (small industries) and the financial risk they pose; the lack of familiarity with these projects; the high transaction costs due to the small size of projects and financing required; and the absence of a portfolio of projects. Conversely, there is limited borrowing demand from small industries for energy efficiency projects due to: insufficient information on technologies available (specially imported technologies which have not yet been validated or adapted in Bolivia) and potential savings from energy efficiency projects; lack of expert assistance for the design and evaluation of energy efficiency projects; availability of only short-term financing not in line with payback duration of these projects; and the demanding requests from FIs, for example, in terms of collaterals. The NBP focused on establishing technical and financial mechanisms to facilitate the implementation of biomass efficiency projects in small rural industries. Financial mechanisms should be sustainable to ensure replicability and, should, thus rely on existing financial actors and not distort financial sector practices.

Establishment of the Biomass Fund. Based on the above considerations, the Biomass Fund was conceived as a financial mechanism to facilitate access to credit by small industries and create conditions to ensure sustainability of biomass efficiency projects. The Biomass Fund would be administered by a second-tier financial institution. Resources from the Biomass Fund would be mobilized through eligible financial intermediaries to cofinance eligible

projects proposed by industries or ESCOs, and that would qualify as biomass efficiency projects. FUNDA-PRO was selected to administer the Biomass Fund. FUNDA-PRO is a private nonprofit organization that has been providing funds since 1992 for economic and productive activities that have difficulties in accessing the formal banking system. The Biomass Fund was established through an agreement signed between the World Bank and FUNDA-PRO on November 3, 2000. The Biomass Fund was endowed with US$800,000 from the Dutch Government and US$200,000 from FUNDA-PRO. In 2004, an additional US$200,000 were provided by DANIDA. The Biomass Fund agreement was subsequently amended on October 9, 2001, to allow the use of its funds to cofinance projects in nonbiomass-using enterprises or entities in the industry, commercial and services sectors, provided these projects result in improving energy efficiency and/or enhancing clean production in these enterprises.

FUNDA-PRO is responsible for verifying the eligibility of projects and financial intermediaries. CPTS of CNI is responsible for the provision of technical assistance to the Biomass Fund, the promotion of efficient technology in industries, the dissemination of information and best practices, and the training and technical assistance for ESCOs and financial intermediaries requesting such services. In order to promote the development of a portfolio of energy efficiency projects simultaneously in several departments, PNB provided technical assistance and training to four selected ESCOs: the *Centro de Tecnología Intermedia* (CEDETI), an NGO based in Santa Cruz; *ENERGETICA*, an energy consulting firm based in Cochabamba; *SISTEMATICA*, an energy consulting firm based in La Paz with operations in Oruro, Potosi and Tarija; and finally, Profesionales Asociados (*PA*), a consulting firm based in La Paz. At the end of NBP, the World Bank formally transferred its responsibility of supervising the Biomass Fund operations to CNI, through two agreements signed between the VMEH and CNI (June 2002) and CNI and FUNDA-PRO (August 2002).

Access to the Biomass Fund. Access to the Biomass Fund is ruled by the following basic principles:

- Industries using biomass as an energy source can apply for a loan through a financial intermediary to cofinance an energy efficiency project;
- ESCOs can also propose projects on behalf of industries, on the basis of energy audits carried in the entire universe of industries to develop a portfolio of projects;
- Financial intermediaries may grant loans to industries from their own resources or from the Biomass Fund, or from a combination of both. Financial intermediaries assess the credit capacity of the industries and establish loan terms for the proposed projects according to their usual financial practices. Financial intermediaries then submit qualifying projects to FUNDA-PRO for cofinancing under the Biomass Fund; and

- FUNDA-PRO evaluates and qualifies financial intermediaries interested to participate in the Biomass Fund. With support from the CPTS, FUNDA-PRO verifies that the projects are eligible for financing by the Biomass Fund, as per simple eligibility criteria.

Projects financed under the Biomass Fund. After 15 months of effective operation (March 2002), the Biomass Fund had approved 52 operations for a total amount of close to US$400,000 – mostly for the substitution of firewood with natural gas in gypsum production. FUNDA-PRO was also considering a portfolio of 99 projects (mostly for substitution of firewood with natural gas in a variety of industries) for a total amount of over US$500,000. This portfolio had been developed with support from two ESCOs (ENERGETICA and SISTEMATICA) on the basis of the screening of 236 projects amounting to about US$1.0 million. Two financial intermediaries, ANED and Fundación para Alternativas de Desarrollo (FADES), were evaluated by FUNDA-PRO and cleared for participation in the Biomass Fund.

Evaluation of the Biomass Fund. An evaluation of the activities and results of the Biomass Fund was conducted in April 2002 by a financial consultant, who reached the following main findings and recommendations:

- After its first 15 months of operation, the Biomass Fund has shown many strengths (including an adequate design with strong private sector involvement and Government of Bolivia [GoB] support; the involvement of efficient and motivated ESCOs; the participation of first- and second-tier, nonprofit FIs which allowed nationwide outreach at affordable transaction costs; and the development of a solid portfolio of projects in small rural industries) which proved the existence of profitable business opportunities in energy efficiency and a legitimate demand for funding them;
- The Biomass Fund program also faces threats, as a longer and deeper economic recession in Bolivia could have negative effects on rural product prices, rural industry financial position and demand for energy efficiency loans, which are factors that could harm the long-term sustainability of the Biomass Fund. The Biomass Fund also showed a number of weaknesses such as its dependency on ESCOs for project portfolio generation, limited interest from financial intermediaries (two out of 20 potential candidates), lack of technical assistance for financial intermediaries on energy project appraisal techniques and insufficient understanding of ESCOs about loan appraisal procedures by the financial intermediaries; and
- The evaluation concluded that despite unusually adverse conditions, and bearing in mind that the program operated for only a 15-month period, the Biomass Fund performed as expected. Nonetheless, it is yet too early to conclude whether the Fund will achieve its sustainability and replicability objectives. The evaluation recommended that the Biomass Fund be transformed into an Energy Efficiency Revolving Fund under the management of FUNDA-PRO; it should mobilize additional local private funding and include a working

capital credit facility for new or currently operating rural industries, as well as a communication and dissemination program to maximize information on energy efficiency business opportunities for rural entrepreneurs. Resolving the sustainability of ESCOs is critical in order to identify, develop and implement energy efficiency projects and ESCOs should continue receiving support and training from CPTS.

Activities in the Household Energy Sector

Biomass as energy source in the household sector. Biomass represents about one-third of the total energy consumption, especially for cooking in rural households. In disperse valleys, 91 percent of biomass consumption is firewood and, in the northern highlands, 53 percent is dung. Rural areas consume about 965,000 tons of firewood and 263,000 tons of dung per year. Rural households use one or more energy sources for cooking. This is reflected in the fact that about 70 percent of all households consume biomass and 38 percent consume LPG.

The self-supply of biomass makes the exploitation of forest resources for energy purposes unsustainable, causes gender inequity in the labor distribution and discourages the expansion of the commercial energy market. Women and children in rural households are in charge of biomass collection from woods and soil (85 percent of firewood and 98 percent of dung). That collection is a labor equivalent to about seven million days of work per year. Only 15 percent of firewood and 2 percent of dung are bought by the users from suppliers of firewood and dung. In addition to the deforestation caused by the intensive extraction of firewood, the burning of biomass has a negative impact on the health of rural families and the global environment.

Efficiency in the transformation of biomass into useful energy for cooking is remarkably low. It was found that the generation of 1 kg of oil equivalent of useful energy requires either the burning of 25 kg of firewood or 33 kg of dung, but only 1.41 kg of LPG. Although households using firewood and dung spend twice to thrice more per month than families using LPG, it is unlikely that LPG will replace biomass in most rural families, because of their low income and the difficulties in the supply of LPG.

Based on the above, NBP identified two energy efficiency measures in the rural household sector: (i) the distribution of stoves having efficient combustion of biomass, and (ii) the substitution of firewood by LPG in rural households.

Distribution of stoves in rural households. The NBP assessed the potential for promoting the fabrication and sale of improved woodstoves in the Southern valleys and highlands of Bolivia. There are several models of improved stoves, including the multipot adobe stove with chimney (Lorena stove-type), which significantly improves fuel efficiency (savings of between 25-50 percent) while mitigating health impacts. International experience shows that the sustainable penetration of improved woodstoves hinges on the availability of proven equipment and their acceptance by households, the sale of improved equipment at commercial prices by local artisans was able to provide necessary technical services and the perception by households of the financial and health benefits of improved stoves.

The NBP undertook surveys and field work to (i) assess fuelwood consumption and expenditure; (ii) evaluate the various experiences for distribution of improved stoves (including the Centro de Estudios Ecológicos y de Derarrollo CEEDI initiative); (iii) conduct interviews with artisans and household appliance retailers in rural markets; and (iv) conduct interviews with staff of rural health centers (hospitals and rural health posts).

Several issues were identified as prerequisites for or obstacles to the successful penetration of improved stoves: (i) the need to involve local artisans and suppliers of rural markets in the fabrication and distribution of efficient stoves through commercial channels; (ii) the absence of a standard design for improved woodstoves; (iii) the lack of perception by households of the health problems (mostly for women) caused by indoor use of firewood for cooking – with the resulting low priority allocated to stove purchase in household expenditure; (iv) the need to establish sustainable mechanisms for the promotion and dissemination of stoves; (v) the market distortions caused by various NGO and government distributions who distributed improved stoves for free on the grounds of their environmental benefits; and (vi) the very low purchasing power of rural families, who could not afford the investment and maintenance costs of improved stoves, and the lack of microcredit mechanism to address investment costs. In the end, attempts of NBP to establish alliances and consensus-building with rural agents, staff of the rural health system and NGOs, so as to minimize these distortions and obstacles, were unsuccessful and the activity was stopped in October 1999.

Promotion of LPG use in rural households. The NBP undertook a study on the promotion of LPG distribution for household use, by assessing the potential market for LPG in selected rural areas, the technical and economic feasibility of installing LPG bottling plants near the consumers, and the existing barriers to private investment in those plants. Detailed surveys were conducted in three rural areas with promising prospects for substitution of biomass with LPG: Río Beni, Gran Chiquitanía and the Mesothermal Valleys. Main results of the surveys are as follows:

- Final consumers in the three areas pay a price up to 40 percent higher than the official price at national level (b$21 per cylinder of 10 kg) for LPG, basically because of transportation costs;
- In all three areas, average expenditure for households using firewood only (obtained commercially) was found to be more than double the expenditure of households using LPG only; the savings would allow to recover investment costs for substitution (LPG stove and cylinder) in less than a year; and
- The consumption of LPG is more important if households are smaller, family members younger, if the head of the family migrates regularly, has a higher level of schooling, if the family has improved housing conditions and if economic welfare is high.

Several obstacles to further penetration of LPG as a cooking fuel in the three areas were identified:

- The cost of LPG cylinders is very high in parts of the rural areas, due to high transportation costs and access difficulties during the rainy season (for example, a threefold increase in price during the rainy season was reported in San Matías, Chiquitanía);
- LPG supply is not guaranteed during the entire year, as some roads are inaccessible especially during the rainy season; and
- Households that collect firewood from nearby areas have limited incentives to switch to LPG as they don't allocate value to time spent by women and children in collecting firewood.

To improve the penetration of LPG in rural areas, the study proposed to establish small rural LPG bottling plants to which LPG would be transported in cistern trucks from wholesale selling points. The initial investment cost of a rural bottling plant would be about US$200,000. A rapid financial assessment indicated that rural bottling plants would be viable as fully private businesses in the areas of Chiquitanía and Mesothermal Valleys, and with some municipal and financial support in the area of Beni.

Municipal governments in the three areas showed interest in the proposed rural bottling plants, because of their potential role in reducing environment impacts, supporting the local economy and improving household welfare. Local governments would award concessions to private operators for plant installation on municipal areas and might participate in cofinancing of investment costs (for example, through provision of land and existing buildings).

However, the study also identified a regulatory obstacle to the establishment of rural bottling plants, as the LPG retail price structure does not include a specific remuneration for the transportation of LPG from wholesale LPG installations to the proposed rural bottling plants. As regulations set up a maximum retail price and, in the absence of the above noted

remuneration, rural bottling plants would not be financially profitable thus making them unattractive for investment by private operators.

On conclusion of the study, NBP organized workshops with the communities and municipal authorities of Gran Chiquitanía, Río Beni and the Mesothermal Valleys to inform them of the results of the study. Subsequently, NBP consultants met with the Superintendency of Hydrocarbons and VMEH to discuss the regulatory obstacle. It was suggested to further review the price structure and specific norms which would make the operation of rural LPG bottling plants financially viable.

Power generation with biomass. The NBP reviewed the viability of biomass-based power generation in the city of Riberalta (Department of Beni), as a case study of alternatives to reduce the cost of diesel generation in isolated power systems in Bolivia. Riberalta meets a rapidly growing demand (10 percent a year) through an isolated power system which is administered by the *Cooperativa Eléctrica de Riberalta* (CER). The system has a nominal capacity of 6 MW and an available capacity of 4 MW – including a 3.25 MW diesel unit and a 0.75 MW thermal plant fueled with nutshells. Whereas the commercial price of diesel in Riberalta is as high as US$0.47/liter, CER has access to subsidized diesel fuel and pays only US$0.16/liter. However, CER's average electricity tariff (equivalent to US¢22/kilowatt-hour) is among the highest in the country. Peak demand in Riberalta would reach close to 6.5 MW by the year 2010, although demand growth could even be higher as electricity service coverage is less than 60 percent in the city of Riberalta, and there is no coverage in rural areas around the city.

A study was conducted by a joint venture of consulting firms (Consultores Galindo from Bolivia, and Biomass Technology Group, a Dutch consulting firm with a large experience in the use of biomass as energy source). The results of the study were presented to local government authorities, representatives of CER and other institutions of Riberalta. The study concluded that all conditions for a biomass-based power generating project to be viable are fulfilled in Riberalta:

- A sustainable and reliable source of biomass supply for the plant would come from the exploitation of secondary woods in early years of the project and forest plantations of about 2,000 ha afterwards;
- The first step to meet demand growth for about three years would consist of the installation of a 1.0 MW fixed grate, low efficiency, direct biomass combustion plant. The 1.0 MW biomass-fueled plant would require an investment of about US$2.0 million. It would be operated as a base load plant, and peak load would still have to be met with the diesel-based power generating unit;

- The biomass-fueled plant would generate electricity at a total cost in the range of US¢5.5 to 8.5/kWh, which is significantly lower than production cost for a diesel-fueled plant – estimated at over US¢15/kWh. Additional revenues might be obtained for the biomass plant from carbon credits linked to the reduction of CO_2 emissions;
- Regarding the institutional framework and normative, the study concluded that under the existing legal framework for the power sector, private investors could establish a biomass-fueled power generating plant as an Independent Power Producer (IPP), obtain a generation license and sell electricity to CER under a Power Purchase Agreement (PPA); and
- The study also found that other cities with good prospects for the replication of the project in the Department include Guayaramerín, Santa Ana del Yacuma and San Ignacio, where sufficient, sustainable supply of biomass for power generation would be feasible and a 1 MW plant would fit the demand. In other locations such as Magdalena, San Ramón, San Joaquín, Huacaraje, El Carmen, Cachuela Esperanza and Bella Vista, the economics of biomass plants smaller than 1 MW should be further analyzed.

Sustainable supply of biomass: Silvopastoral enclosures

Conceptual framework. As the rural household sector is the main consumer of biomass in Bolivia, and significant substitution of biomass is improbable in the short term in rural areas, the NBP designed activities aimed at improving the sustainable supply of biomass in rural communities. Social management of resources under common property or collective exploitation is based on the fact that peasant communities in the Andean region are the owners of the land and that they constitute a social and productive peasant unit. Due to the coexistence of unwritten laws and formal laws, peasant communities regulate the public behavior of their members, define their rights and obligations, as well as the modalities and scope of access to use and distribution of land, water and forest products.

The deterioration of productive conditions of the rural economy has weakened the social or regulatory control of access to biomass for energy purposes. The farming economy in Bolivia is going through a deep crisis of its productive systems, which is expressed, in turn, in the crisis in management of natural resources. The vicious circle caused by extension of the agricultural frontier, uncontrolled grazing, increasing livestock population and decreasing soil fertility also impacts negatively on the exploitation of forest resources for energy purposes.

The NBP designed an action plan to demonstrate the technical, social, and economic feasibility of management of forest/pasture (silvopastoral) resources as a means to guarantee the supply of fuel, the productivity of livestock cycles and the recovery of organic material in agricultural soils. All these aspects are all closely linked to the crisis of farming production systems, and therefore, to poverty levels in Bolivian rural areas. The action plan included: (a) identification of

potential intervention areas for forest/biomass resource management; (b) identification of communal, social, and legal bases for project design and execution; (c) design of a management plan which integrates the conceptual, methodological and operational principles of communal resources management; and (d) design of a training strategy to develop the capacity of farmers and agricultural technicians in community management of silvopastoral resources, including new technologies based on practical experience.

The Plan for Silvopastoral Enclosures focuses on the integrated and participatory management of cattle, forest and pasture systems in rural communities through intensive land use, reforestation in synergy with improved pasture and livestock rotation within grazing blocks protected with solar-powered electric fences. The use of new technologies makes possible the intensive use of land, improves the productivity of pastures and livestock, rehabilitates degraded land and ensures success of reforestation activities. Biomass production surplus will be used by the community for household and commercial energy purposes.

Strategically speaking, the plan had three main components: i) realization of demonstrative projects in three communities to validate the proposed technology and approach; ii) definition of a methodology to measure impacts of the plan; and iii) development of a training system for capacity-building and project replication.

Demonstration projects. Three rural communities and one training center were selected for the establishment of enclosures for silvopastoral management: (a) Casa Grande (Department of Chuquisaca) with an enclosure of 76 ha and 72 participating families; (b) Jatun Mayu (Department of Chuquisaca) with an enclosure of 136 ha and 20 participating families; (c) Sagha Sagha (Department of Cochabamba), with an enclosure of 96 ha and 65 participating families; (d) Huerta Mayu (Department of Chuquisaca), with an enclosure of 12 ha, installed at CEITHAR's student training center. Technical support for the four enclosures was provided through local NGO and NBP staff.

The four enclosures were equipped with electric fences, animal drinking points, water connections, infiltration ditches, hay storage areas and control posts. Electric fences initially faced operational difficulties (lower voltage than expected) which were subsequently solved; the NBP prepared a manual on design, construction, and maintenance of electric fences in mountainous areas. Native tree species and improved pasture were planted in the four enclosures.

Measuring impacts of the silvopastoral projects. The impact evaluation methodology designed by *Consultora SUR* included the: (i) definition of performance indicators (productivity of pasture, hay, tree species, firewood, increase in weight of animals, production of dung,

milk and other products) and establishment of a baseline in the four enclosures; (ii) measurement of improvements in the performance indicators in the four enclosures; (iii) comparison of enclosures with similar parcels still under the extensive land use and production system; and (iv) interviews with farmers (participants, nonparticipants, women, elders). *Consultora SUR* also reviewed the legal situation of the land owned by the enclosures (titles, deeds) and evaluated the existing communal norms for land access and use; as a result the consultant designed a strategy to enable each community to register its land ownership rights in the *Sistema de Catastro Rural* and the *Instituto Nacional de Reforma Agraria*. The results of the four impact evaluations were incorporated in the training materials prepared for the projects.

After two years of application, the silvopastoral management plans, based on intensive land use, have had significant economic impact on the three communities. The intensive forest exploitation system has almost fourfolded the household income in Jatun Mayu and Sagha Sagha and doubled the household income in Casa Grande (Table 1). The enclosure of Jatun Mayu has made profits which were distributed among the members of the community. Each community has deposits in local bank accounts (from NBP inputs and sale of livestock) which allow future operation of the enclosures. These accounts are administered under community control and decision-making mechanisms.

Table 1: Impact of the Silvopastoral Plans on Household Income

Community	*Estimated Annual Household Income (US$)*	
	Without Intensive Exploitation	*With Intensive Exploitation*
Casa Grande	119	239
Jatun Mayu	586	2,177
Sagha Sagha	165	730

Training system. Beyond the demonstration effect of the three enclosures which were established with limited-in-time support from NBP and technical assistance, the dissemination and replication of the new concept of silvopastoral management requires adequate capacity building of farmers and technicians at the community level. Thus, NBP entrusted the *Facilitadores de Educación Rural Integral Alternativa (Facilitators of Integrated Alternative Rural Education)* (FERIA) design and application of a curriculum called "Community Management of Silvopastoral Resources." FERIA is the official state training system of the Vice Ministry of Alternative Education, and has a network of 38 rural training centers for adult education. It is attached to the *Comisión Episcopal de Educación* (CEE) – Episcopal Commission for Education.

The training program designed under the NBP emphasizes the management of silvopastoral resources with a focus on the production of goods and services with substantial local value added. The program has three different curricula for training of facilitators and teachers of the FERIA network; farmers at the secondary education level; and farmers of the communities participating in NBP and communities interested in the project concept. Training materials are based on the experience and results of the four demonstration enclosures and include four modules. An educational video was also prepared. It analyzes the crisis of productive systems, issues, and technological alternatives and presents the experience and results of silvopastoral enclosures implemented under NBP. The first training modules were applied at CEITHAR, Centro de Educación Técnica, Humanística y Agropecuaria (CETHA) Tiraque and eight CETHA rural centers. CEITHAR and CETHA Tiraque have also conducted workshops in the three communities of the Silvopastoral Enclosures Plan.

The sustainability of the training system is likely because: (a) The curriculum is used by the Program *Desarrollo Comunitario Sostenible* (DECOS) in the *Centro Avelino Siñani* for the training of rural facilitators and teachers. The curricular activities of this center are accredited by the *Universidad Católica Boliviana* (UCB); (b) CEITHAR and CETHA Tiraque have scheduled six annual workshops for students of rural secondary schools; (c) The curriculum on Communal Management of Silvopastoral Resources will be used in 20 educational centers of the Andean network of FERIA; and (d) The CEE is committed to assist in the implementation of the training plan in the future.

Lessons Learned

Studies, projects, and instruments development during the four years of implementation of the NBP allow lessons to be drawn regarding the promotion of sustainable supply and efficient use of biomass resources in Bolivia, some of which are of broader application:

- Information and financial aspects are important barriers to investments by rural industries in the efficient use or substitution of biomass. The demonstration projects, technology transfer and training instruments, developed by NBP, addressed information barriers. Dedicated financial instruments, such as the Biomass Fund, can efficiently address funding requirements but should not distort commercial banking practices;
- The Biomass Fund will require additional resources for a significant scale-up of biomass efficiency investments, which is required to obtain a noticeable reduction in biomass consumption and the associated environment benefits;
- The local acceptance and application of new technologies to increase efficiency in productive processes is a *sine qua non* condition for creating local value-added industry competitiveness and consolidation of the rural market and employment;

- Rural industrials and producers are very much interested in accessing new and efficient technologies. They clearly understand that their survival in the economic system depends heavily on their level of efficiency. The industries' perception of financial benefits from biomass efficiency projects is a key element in their decision to invest in these projects;
- The application of management principles in the production and rational use of biomass resources induces economic benefits for rural producers and industries;
- The NBP has identified institutions and actors who could continue and replicate the approach and results of NBP. Local entities, as well as ESCOs, should play a central role in that respect;
- The level of technological development of rural areas is closely related to educational and training policies and programs. There is a need to work on two fronts: conduct capacity-building activities in rural communities through local training entities; and strengthen university curricula on biomass resource management and technologies, to train professionals able to deal with the productive and environmental issues in rural areas; and
- There is still an important barrier to the implementation of a large-scale biomass program which, however, will take time to be removed: many local actors are still convinced that the state should be a provider of subsidized goods and services, while others are aware that market distortions, introduced by subsidies, work against the possibility of establishing sustainable management and financing mechanisms for biomass efficiency.

1. Overview of the National Biomass Program

ESMAP Support to the Energy Sector in Bolivia

Over the past two decades, Energy Sector Management Assistance Program (ESMAP) has financed several projects to assist Bolivia in the development of its energy sector. The Bolivia Country Program Phase I[1] (1986-97) contributed to the design of a National Energy Plan the definition of policies and actions applicable to rural energy and energy efficiency and a significant structural reform of the energy sector. Consistent with structural changes in Bolivia's economic policy between 1994 and 1997, the state focused on the regulation and facilitation of energy sector activities and established a transparent legal and regulatory framework which contributed to achieving extensive private sector participation in the production, transport, and distribution of energy in the country. The Country Program Phase I also prepared a plan called NBP, aimed at enhancing the efficient use of biomass as an energy source, while improving the quality of life of the rural population. The NBP objectives were consistent with the overall objectives of the World Bank Country Assistance Strategy (CAS) in Bolivia regarding accelerated growth and development of private sector activities. An agreement subscribed in November 1997 between the Government of the Netherlands and the World Bank assigned the execution of The National Biomass Program (NBP) to ESMAP, with The Vice Ministry of Energy and Hydrocarbons (VMEH) as its counterpart in Bolivia.

Biomass as Energy Source in Rural Areas

In 2000, biomass energy (firewood, dung, charcoal and forestry and vegetal residues) represented about one-third of the total national energy consumption in Bolivia. Biomass consumption is concentrated in rural areas where more than 70 percent of the population uses it for cooking. It is mainly consumed in the form of firewood (about 965,000 tons per year) and

[1] *ESMAP Bolivia Country Program Phase I: Final Report on Operational Activities, August 2000.*

dung (about 263,000 tons per year) corresponding to about 78 percent of the total household consumption of energy (Table 1.1). Biomass accounts for approximately 90 percent of the total household energy consumption. Rural industries consume the equivalent of about 2,500,000 tons of firewood, almost entirely supplied through commercial channels. The efficiency of biomass use by rural industries is very low, often due to low technological development.

Table 1.1: Structure of Rural Household Energy Consumption (percent)

Per Use		*Per Source*	
Cooking Food	89	Firewood	63
Lighting	5	Dung	15
Water Heating	4	LPG	13
Others	2	Kerosene	3
		Electricity	2
		Others	4

Source: VMEH, 2000.

The principal problems faced by biomass on the supply-side are the low level of production of firewood – especially in the Bolivian highlands (*Altiplano*) and Inter Andean Valleys – and the lack of regulations on access, control, and exploitation of forestry resources for energy purposes. Thus, the supply of biomass in those regions is unsustainable. On the demand-side, the principal problem is the inefficient use of biomass.

Many rural industries require large quantities of biomass, and sometimes lack access to commercial energy sources other than biomass. The annual biomass demand of the estimated 4,000 rural industries in Bolivia would be about 2,500,000 tons of firewood. The economic impact of these establishments is important, both in terms of value added to the local economy and nonagricultural sources of rural employment.

Objectives of the National Biomass Program

The NBP was designed to meet broad objectives, which included contributing to:

(a) Reducing negative environmental impacts of inefficient and unsustainable use of biomass as an energy source; (b) improving the quality of life of the rural population; and (c) increasing economic and social benefits derived from efficient production and use of biomass as an energy source.

These objectives were to be achieved by implementing demonstration projects for efficient use of biomass or biomass substitution in rural industries, establishing financing mechanisms to facilitate implementation of biomass efficiency projects by small-scale rural industries, promoting the efficient use or substitution of fuelwood in the household sector, implementing demonstration projects to improve the supply of biomass in rural areas, promoting biomass-based power generation, strengthening the capacity of public and private stakeholders in the biomass energy sector and establishing biomass energy in the policy agenda of central and local authorities.

Institutional Set-up of NBP

Despite the clear environment impacts of biomass production and use in Bolivia, Unidad de Medio Ambiente (Environmental Unit) (UMA) located within VMEH exclusively focused on Environment Impact Assessment (EIA) of hydrocarbon sector activities (exploration and production, transport and distribution). Thus, NBP was placed under VMEH's Directorate of Energy and Hydrocarbons. Its execution was performed by a national coordinator (local consultant) and local and international consultants (individuals and firms), under the supervision of a the World Bank team (including a task manager, an energy specialist and an administrative assistant). The local and the World Bank teams maintained close coordination with the Directorate of Energy and Hydrocarbons. The NBP also developed partnerships and collaboration with local authorities and Non Governmental Organizations (NGOs).

Program Cost and Financing

The Netherlands financed the NBP with a grant equivalent to US$2.66 million. The actual cost of NBP was US$2.51 million. The remaining amount of US$0.14 million was canceled when the grant was closed on June 30, 2002. Main budget items included consultants and training (US$1.2 million) and the Biomass Fund (US$0.8 million). The World Bank staff expenses amounted to US$0.29 million (time and travel), that is, about 11 percent of the total expenses (Annex 12 for a detailed budget).

Mid-term Review of the Program

A mid-term review of the program conducted in September/October 2000 found that progress toward achieving the objectives was less than 50 percent, primarily due to the program's complex implementation arrangements. This was the consequence of the extremely long time spent by the local team in the interactions to build constituencies with institutions, users and suppliers of biomass involved in NBP, compounded with the heavy

burden on the World Bank and Bolivia teams posed by the administration of a large number of consultancy contracts. The mid-term review recommended the extension of the duration of the project and a reduction in the number of activities originally included in NBP to those which could be completed before the revised project closing date.

The Dutch Government agreed to the extension of NBP until June 30, 2002. Activities were refocused on: (i) the establishment of the Biomass Fund together with the identification of a portfolio of projects to be financed from this Fund; (ii) the finalization of biomass efficiency pilot projects in rice, sugar, gypsum, brick and ulexite industries; (iii) the finalization of the three pilot silvopastoral enclosures; and (iv) the documentation of project results and their transfer to project beneficiaries and stakeholders. NBP activities in the household sector and in biomass-based power generation were folded out due to unpromising perspectives.

Results and Impacts of NBP

The NBP achieved significant results in line with its objectives. These results are detailed in the following chapters and can be summarized as follows:

- Establishment of the US$1 million Biomass Fund at FUNDA-PRO – a second-tier financial organization promotes lending to small industries; a portfolio of 236 biomass efficiency projects totaling US$1.1 million was developed at the prefeasibility level with NBP support, and financing of US$0.5 million for the first 99 projects was approved in 2002 by a first-tier financial institution (ANED); financial appraisal of projects and proponent industries was conducted by ANED, while the CPTS at the CNI verified the eligibility and quality of proposed projects from the biomass efficiency perspective. In 2002, the scope of the Biomass Fund was expanded to cover all types of energy efficiency projects or clean production projects in the industry, commercial and services sectors. In 2004, the Biomass Fund received supplementary financing of US$200,000 from the Danish Cooperation;
- The conclusion of several pilot projects in rural industries with good prospects for biomass efficiency, including: substitution of bagasse for fuelwood in three sugarcane industries in Santa Cruz; substitution of rice husk for fuelwood in a small rice mill, including a workshop for 25 rice mill owners in Santa Cruz; semicontinuous oven for gypsum production; improved brick production in Cochambamba, with training of brick producers; improved efficiency in the use/substitution of *yareta* bushes for the production of ulexite;
- Design and implementation of silvopastoral enclosures in three low-income communities of the *altiplano* (Jatun Mayu, Casa Grande, and Sagha Sagha) and one training center (CEITHAR at Huerta Mayu), for improved management of natural resources, including training of stakeholders and involvement of local NGOs and municipalities;

- Feasibility studies for the development of a LPG market in rural areas and for a biomass-based power generation project in Riberalta;
- The preparation of a National Energy Balance, including woodfuel and biomass consumption;
- The dissemination of NBP results through technical publications (*Energía y Desarrollo*) and reports, and workshops in Bolivia and Washington, and the development of an energy efficiency curriculum and training materials; and
- The transfer of NBP outputs through agreements with relevant stakeholders: VMEH for biomass sector policies; NGOs and energy services firms for beneficiary training and energy efficiency project portfolio development; CNI/CPTS for supervision of the Biomass Fund and promotion and information on energy efficiency projects; Ministerio de Agricultura, Ganadería y Desarrollo Rural (Ministry of Agriculture and Rural Development) (MAGDR) (through its Policy Unit for Natural Resource Management) for the silvopastoral enclosures component; FUNDA-PRO for the management of the Biomass Fund; SAT at the Ministry of Economy as possible financial support for energy efficiency portfolio development.

The impacts and benefits of the above NBP outputs are shown in Annex 1, in terms of woodfuel savings, financial benefits for industries, areas under silvopastoral management and training beneficiaries. Annex 1 also shows that there are reasonable prospects for sustainability and replicability of the NBP results from NBP, in view of the financing mechanisms and institutional arrangements which were put in place. The Biomass Fund (at FUNDA-PRO) and associated commercial banks would provide cofinancing for biomass efficiency projects proposed by small industries. Projects would be designed by these industries or energy service firms, which could apply to mechanisms such as SAT for financing the cost of these studies. The CPTS at the National Chamber of Industry would validate projects, promote best practices and inform industries about energy efficiency potential.

2. NBP Activities in Rural Industries

Studies on Biomass Use in Rural Industries

At the start of NBP, little was known about consumption of biomass by rural industries and biomass supply channels. The NBP thus undertook studies in the rural industry sector to determine levels and patterns of consumption of biomass as an energy source, the efficiency of its use, the productive and commercial channels, the origin and forms of biomass supply, monetary volumes of biomass commercialization and use, and the incidence of biomass in production costs of rural industries. These studies were meant to identify priority sectors, projects, and zones for NBP intervention.

The studies were carried out in seven departments by a number of Bolivian consulting firms: PROMETA in Tarija, ENERGÉTICA in Cochabamba, CEDETI in Santa Cruz, CIAC in Potosí, SISTEMÁTICA in La Paz, Asociación Sucrense de Ecología (ASE) in Chuquisaca and PA ENERGÍA in Oruro. Using existing studies and assessments of small rural industries, the consultants selected the universe of industries to be covered by the NBP studies, on the basis of the importance of their production in the local and regional economy, the geographical concentration of the industries, the number of production units, the production capacity and the type of technology used. The consultants, then, collected detailed primary information through semistructured interviews with key staff in selected rural industries regarding production processes (timing, frequency, seasonal variations), inputs required, biomass consumption and supply sources and production costs and volumes.

Patterns of Biomass Use by Rural Industries

The studies identified a total of 3,722 rural industries in seven departments, in which biomass is the principal energy source. These were classified into 17 industrial subsectors, as shown in Table 2.1. Most industries produce building materials, but some belong to traditional industrial sectors. Incomplete information was obtained on bread and charcoal-producing activities due to the high degree of dispersion of these establishments.

Table 2.1: Rural Industries using Biomass as Energy Source

Sector	*Number of Identified Establishments, per Sector and Department*							
	La Paz	*Cochabamba*	*Santa Cruz*	*Chuquisaca*	*Potosí*	*Tarija*	*Oruro*	*Total*
Bricks	174	530	544	229	67	77	111	1,732
Gypsum	338	150		1	22	22	48	581
Chicha (Maize Beer)		477						477
Pottery					352		3	355
Rice			97					97
Chancaca (Raw Sugar)			41			48		89
Singani (Brandy)				6		62		68
Cane Brandy				4		60		64
Tiles					59			59
Pisco (Brandy)				50				50
Silverwork					50			50
Bread		Not Identified				32		32
Lime		7		10	12		3	32
Salt					12			12
Ulexite					12			12
Charcoal			Not Identified					
Muña Oil							1	1
Total	**512**	**1,164**	**682**	**300**	**586**	**301**	**166**	**3,711**

Biomass energy sources used in rural industries include firewood, sawdust, charcoal, dung, forest residues, bagasse and *yareta* – either alone or in combination with LPG, gasoline, diesel, electricity and even used tires. Firewood is the most widely used energy source in small rural industries. Dung and used tires are mainly used in the highlands. *Yareta* is consumed in large quantities by the ulexite industry, with a more serious environmental impact on the extremely fragile *yareta* ecosystem than what the consumption of firewood by the brick industry in Santa Cruz has on forest resources. Industries requiring motion power use gasoline and diesel engines and electric motors. Table 2.2 shows estimates of annual consumption of different types of biomass by sector of rural industries.

Table 2.2: Estimated Consumption of Biomass by Type of Rural Industry (tons/year)*

Sector	*Firewood*	*Sawdust*	*Dung*	*Vegetal Residues*	*Charcoal*
Bricks	124,632	127,027	2,496	0	42
Charcoal	76,091	0	0	0	0
Ulexite	59,520	0	0	0	0
Gypsum	30,508	1,075	8,562	0	0
Rice	18,263	0	0	0	0
Chicha (Maize Beer)	13,782	0	0	0	0
Chancaca (Raw Sugar)	10,862	0	0	699	0
Bread	8,008	0	0	0	0
Lime	1,610	0	1,050	0	0
Salt	602	0	0	0	0
Pisco (Brandy)	190	0	0	0	0
Cane Brandy	150	0	0	0	0
Muña Oil	82	0	7	0	0
Singani (Brandy)	50	0	0	0	0
Pottery	0	1,199	13	0	0
Tiles	0	0	1,069	0	0
Silverwork	0	0	0	0	27
Total	**344,350**	**129,301**	**13,197**	**699**	**69**

**The studies identified different measurement units used in the collection and marketing of biomass: tarea, andén, camionada (truckload), bolsa (bag), burro, gavilla, champa and quintal (46 kg). These measurement units were checked for conversion to kilogram/ton.*

The studies also determined the specific energy consumption per unit of product output by type of industry. This is a good indicator of the level of technological development of rural industries in each department (Table 2.3). It was found that specific energy consumption for a given product varies widely between departments and within the same department. For example, whereas bricks produced in La Paz use 1.5 to 2.8 MJ/kg, bricks produced in Oruro use 2.2 to 6.2 MJ/kg.

Table 2.3: Specific Energy Consumption in Rural Industries*

Sector	*Unit*	*Number of Identified Establishments, per Sector and Department*						
		La Paz	*Cochabamba*	*Santa Cruz*	*Chuquisaca*	*Potosí*	*Tarija*	*Oruro*
Bricks	kg	1.5-2.8	2.9-3.4	2.3-3.7	1.6-4.8	1.1-3.0	1.6-2.9	2.16-6.24
Gypsum	kg	1.2-2.1	2.9-3.3		2.2	1.3-3.1	0.8-1.6	1.16-2.87
Chicha (Maize Beer)	lt	5.5-14.7						
Pottery	kg					5.1-7.7		9.92
Rice	kg			0.5-2.8				
Chancaca (Honey)	kg			22.7-25.1			11.7-27.8	
Singani	lt				9.51		41.2-57.8	
Cane Brandy	lt				18.3		25.6-61.4	
Tiles	kg					1.12		
Pisco (Brandy)	kg				32.1			
Silverwork	kg					98.1-836.4		
Bread	kg			4.63-9.13			10.0-50.2	
Lime	kg		4.6-6.7		5.3	7.5-7.7		8.91-19.28
Salt	kg					0.6-0.9		
Ulexite	kg					8.8-8.9		
Coal	kg				Not Identified			
Muña Oil	lt							3,039

**Calculation of the specific energy consumption was based on the calorific power of biomass and other fuels used in the National Survey of Energy Consumption in the Bolivian rural area ESMAP/the World Bank – INE and determined in Magazine No. 72 of the National Academy of Science "Calorific Power of 51 timber species in Bolivia."*

The assessment of biomass consumption patterns in rural industries showed that transformation of biomass in energy is based on inefficient and often obsolete technologies. It was found that the cost of biomass used by the rural industry often represents a sizable share of the total product costs. The NBP concluded that the design of biomass projects must, then, necessarily aim at upgrading the technologies used by rural industries in order to improve their competitiveness.

The studies found that: (a) globally, Bolivian rural industries spend about 16 percent of the value of their annual sales in biomass – a percentage significantly higher than the average for the whole industry sector; (b) the incidence of biomass expenditure in total costs ranges from 2 percent in the case of bakeries up to 69 percent in the case of lime production in Chuquisaca; (c) the principal factors affecting biomass price are the distance between the industry and the biomass production area (transportation cost) and the local environmental regulations influencing the cost of biomass resources; (d) the purchase of biomass is a permanent concern for energy-intensive industries such as the production of gypsum, lime and bricks; (e) rural industries generate approximately 20,000 sources of nonagricultural employment; and (f) the two most negative environmental impacts caused by the use of biomass by the rural industry sector are the intensive exploitation of forest species with high calorific power and the emission of pollutants into the atmosphere due to biomass combustion. Biomass use in rural industries would cause the deforestation of approximately 80,000 ha of woods and the emission of about half a million tons of CO_2 into the atmosphere every year.

Identification of Targets for NBP Intervention in Rural Industries

Based on these studies and on interviews with owners of rural industries, key informants, municipal authorities and associations, the consultants proposed actions to enhance energy efficiency, rationalize biomass consumption and reduce energy costs, the implementation of which would result in significant economic benefits and lower environmental impacts. In sum, the proposed actions seek to establish a national framework enabling a competitive, nondistorted development of sustainable biomass management projects. The projects and/or activities proposed by the consultants also took into consideration both the requests made by rural producers in seven departments, as well as the likeness of their implementation and replication, and included the following:

Department of La Paz:

- Study on fiscal incentives (environmental subsidy) for stucco producers;
- Pilot project to increase energy efficiency and capacity of stucco ovens of the *Asociación de Estuqueros de Cantones de Caquiaviri* (Association of Stucco Producers of Cantons of Caquiaviri);
- Economic feasibility study on the sustainable supply of firewood in charcoal-producing zones; and
- Enhancing the involvement of members of the *Asociación de Cerámica Roja* (Association of Red Ceramics) interested in the substitution of biomass by natural gas.

Department of Potosí:

- Design of an efficient oven for salt drying; and
- Design of an efficient oven for ulexite production.

Department of Chuquisaca:

- Dissemination of an improved oven for artisan brick production; and
- Energy efficiency projects in the lime sector.

Department of Cochabamba:

- Development of an institutional framework to enable the removal of financial, technical and institutional barriers for the expansion of the natural gas network.

Department of Tarija:

- Substitution of firewood with natural gas for brick production in Villa Bush;
- Substitution of firewood with LPG for the production of *singani* in the Central Valley of Tarija and dissemination of this technology;
- Training and dissemination of improved techniques for brick production; and
- Use of bagasse in *chancaca* production.

Department of Oruro:

- Design and implementation of a semicontinuous oven for gypsum production in the area of Chuquicambi;
- Training on best practices for brick production and technical assistance to brick producers; and
- Development of an improved process to produce lime in Challapata.

Department of Santa Cruz:

- Increased efficiency of stoves used for the production of *chancaca*;
- Electricity efficiency project in rice mills;
- Improved design of ovens in urban bakeries;
- Training on best practices for brick production and technical assistance to brick producers;
- Resettlement of charcoal producers close to forested areas under management schemes;
- Substitution of firewood with natural gas or cane bagasse in the production of *chancaca*;
- Substitution of firewood with rice husks in rice mills;
- Conversion to natural gas in three areas with high concentration of brick-making;
- Control of forested areas and fuelwood transport by municipal governments;
- Pilot application for an institutional and legal framework for the regulation of fuelwood production by municipal governments; and
- Implementation by Cooperativa Rural de Electrificación de Santa Cruz (CRE) of a seasonal electricity tariff regime for rice mills.

Selected Biomass Efficiency Projects

Based on this menu of proposed projects, the following six pilot projects were selected as the most adequate instruments toward the NBP objectives:

- Substitution of firewood with bagasse in *chancaca*-processing industries in Saipina, Santa Cruz (Annex 2);
- Substitution of firewood with rice husks in rice mills of Yapacaní, Santa Cruz (Annex 3);
- Development of biomass efficiency projects in rural industries of the Department of Cochabamba (Annex 4);
- Efficient biomass use in the gypsum industries in Pacajes, Department of La Paz (Annex 5);
- Efficient biomass use in the production of ulexite in Nor Lípez, Department of Potosí (Annex 6); and
- Efficient biomass use in brick-making in San Carlos, Department of Santa Cruz (Annex 7).

These projects met several of the following eligibility criteria for technical assistance and funding under the NBP:

- Final users are mostly rural industries which exist nationwide and use biomass as main energy source.
- Projects focus on the reduction of energy costs through efficient use of biomass or its substitution with a fuel with lower environmental impact;
- Industries are small- or medium-sized with limited capital;
- Projects concern activities with large number of small industries, in order to: (i) increase potential impacts and replication prospects; and (ii) improve the terms of negotiations of industrials with suppliers of the goods and services required for project execution; and
- Projects bring a technological change in the industry processes either in the use of biomass or in the productive process itself.

Enhancing NBP Impacts

Technological development and competitiveness of small rural industries are low because of the weakness of local channels to value add. Although the need for a technological leap in rural industries was widely recognized, the projects have to, nonetheless, overcome a series of barriers which hamper their implementation. The main barriers are the constraints posed by the market environment where the biomass projects will be inserted and the difficult access of producers to the financing needed to implement these projects. The effectiveness of the selected projects would be enhanced by strengthening the mechanisms of decentralized public administration and improving the economic, social and environmental impact of private investments in areas with rural industries.

Strengthening the mechanisms of decentralized public administration. The strengthening of public administration at the local level would guarantee a clear definition of roles played by stakeholders, ensure links with national norms and policies and enable the definition of long-term plans. Hence, local or international private investors would operate in a framework of legal security and sound political environment. The intervention of a private actor (consultant or NGO) would help articulate local requests of technical assistance, mobilize funds and build up consensus among the stakeholders involved in productive channels. This actor would also help strengthen the mechanisms for decentralized public administration by: (i) advising on the clarification or identification of tasks of local governments; (ii) incorporating the private sector as an important local actor who accepts the legitimacy of the decentralized or local public administration; and (iii) enhancing consensus-building among local private and public actors.

Improving the economic, social and environmental impacts of private investments in rural industries. Initiatives should also be supported toward: (i) improving income redistribution for the benefit of local jurisdictions where investments are made; (ii) encouraging competitiveness of companies through technical assistance for increased energy efficiency in production processes; (iii) improving opportunities for local population to access production channels with value added; and (iv) incorporating the productive sector within the local environmental monitoring structure.

Results of NBP in Rural Industries

The achievement of NBP in the rural industry sector can be summarized as:

- Loans for about US$200,000 were made to rural industries through the Biomass Fund for projects with estimated savings of 9,590 tons/year of biomass, representing about US$60,000/year of savings which will contribute to improve the competitiveness of these small industries;
- A portfolio of projects worth another US$500,000 were identified for financing under the Biomass Fund, with estimated savings of 36,000 tons/year of biomass;
- The technical and financing mechanisms established under NBP have stimulated the emergence of entities for the management, financing, and execution of projects for energy efficiency in the rural productive sector. Three ESCOs have strengthened their capacity in biomass efficiency projects and are active in rural areas. Thus, technical assistance is considered a rural development service and part of its cost is financed by the producers themselves. Also, the financial organizations working in rural credit are becoming interested in funding energy efficiency projects; and
- Municipal governments have participated in project execution as sponsors, limiting their role to the provision of legal security for private investments in the projects. For the execution of future projects, letters of understanding have been agreed upon between municipal governments and ESCOs and associations of producers.

3. Project Financing: The Biomass Fund

Financing Barriers for Biomass Efficiency Projects in Small Industries

A study carried out under ESMAP financing in 1996 identified access to financing as one of the main barriers for the execution of projects in energy efficiency and Renewable Energies (REs). FIs do not provide financing for this type of projects due to a number of reasons, including: their lack of experience with this type of borrowers (small industries) and the financial risk they pose; the lack of familiarity with these projects; the high transaction costs due to the small size of the projects and financing required; and the absence of a portfolio of projects. Conversely, there is limited borrowing demand from small industries for energy efficiency projects due to: insufficient information on technologies available (specially imported technologies that have not yet been validated or adapted in Bolivia) and potential savings from energy efficiency projects; lack of expert assistance for the design and evaluation of energy efficiency projects; availability of only short-term financing not in line with payback duration of these projects; and the demanding requests from FIs, for example, in terms of collaterals.

The NBP studies confirmed these financing barriers in Bolivia and the absence of mechanisms to finance investment by small rural industries for increasing their productivity and competitiveness. Given the large number and variety of rural industries (over 4,000 establishments), the NBP focused on establishing technical and financial mechanisms to facilitate the implementation of biomass efficiency projects in small rural industries. Financial mechanisms should be sustainable to ensure replicability and should thus rely on existing financial actors and not distort financial sector practices.

Establishment of the Biomass Fund

Based on these considerations, the Biomass Fund was conceived as a financial mechanism to facilitate access to credit by small industries and create conditions to ensure sustainability of biomass efficiency projects. The Biomass Fund would be administered by a second-tier

financial institution. Resources from the Biomass Fund would be mobilized through eligible financial intermediaries to cofinance eligible projects proposed by industries or ESCOs and that would qualify as biomass efficiency projects.

The selection of the financial institution to administer the Biomass Fund was based on a thorough process of comparison of several candidate financial institutions, on the basis of a report prepared by an independent consultant. The selected institution, FUNDA-PRO, is a private nonprofit organization which has been providing funding since 1992 for economic and productive activities that have difficulties in accessing the formal banking system. Since its foundation, FUNDA-PRO has worked efficiently as a second-tier institution and has received funds from several sources, including the United States Agency for International Development (USAID).

A contract to establish the Biomass Fund was signed between the the World Bank (on behalf of ESMAP) and FUNDA-PRO (as the Biomass Fund administrator) on November 3, 2000. The Biomass Fund was endowed with US$800,000 from the Dutch Government and US$200,000 from FUNDA-PRO. In 2004, an additional US$200,000 were provided by DANIDA. The Biomass Fund agreement was amended on October 9, 2001, to allow the use of its funds to cofinance projects in nonbiomass-using enterprises or entities in the industry, commercial and services sectors, provided these projects result in improving energy efficiency and/or enhancing clean production in these enterprises.

The Biomass Fund is steered by a Technical Committee including: (i) the CNI, through CPTS; (ii) the ESMAP Team in La Paz; (iii) the World Bank; (iv) other contributors to the Biomass Fund; (v) the National Directorate of Energy; and (vi) FUNDA-PRO. The technical committee seeks the mobilization of funds for the Biomass Fund and assists FUNDA-PRO in the resolution of problems derived from the implementation of projects financed by the Biomass Fund. In 2001, the technical committee held two formal sessions.

FUNDA-PRO is the administrator of the Biomass Fund, in accordance with conditions established in the agreement subscribed with the World Bank. It is responsible for verifying the eligibility of projects and financial intermediaries. The CPTS of the CNI is responsible for the provision of technical assistance to the Biomass Fund, the promotion of efficient technology in industries, the dissemination of information and best practices and the training and technical assistance for ESCOs and financial intermediaries requesting such services.

In order to promote the development of a portfolio of energy efficiency projects simultaneously in several departments, the PNB provided technical assistance and training to four selected ESCOs: CEDETI, an NGO based in Santa Cruz, which focused its activities

on substitution of fuelwood with bagasse or rice husk in *chancaca* and rice industries; *ENERGETICA*, an energy consulting firm based in Cochabamba, which concentrated its efforts on biomass substitution with natural gas in the gypsum industry; *SISTEMATICA*, an energy consulting firm based in La Paz with operations in Oruro, Potosi and Tarija; and, finally, *PA*, a consulting firm based in La Paz, which, however, did not get involved in the Biomass Fund program.

At the end of NBP, the World Bank transferred, formally, its responsibility of supervising the Biomass Fund operations to CNI, through two agreements signed between VMEH and CNI (June 2002) and CNI and FUNDA-PRO (August 2002).

Access to the Biomass Fund

Access to the Biomass Fund is ruled by the following basic principles (more details in Annex 8):

- Industries using biomass as an energy source can apply for a loan through a financial intermediary for an energy efficiency project. The industry has to finance at least 5 percent of the total project cost;
- ESCOs can also propose projects on behalf of industries, on the basis of energy audits carried in the entire universe of industries to develop a portfolio of projects;
- Financial intermediaries may grant loans to industries from their own resources or from the Biomass Fund, or from a combination of both. This gives access to the Biomass Fund to private banks, financial NGOs, private financial funds, credit unions and other financial institutions – provided that they meet the Biomass Fund eligibility requirements. Financial intermediaries must assess the credit capacity of the industries and establish loan terms for the proposed projects according to their usual financial practices. Financial intermediaries, then, submit qualifying projects to FUNDA-PRO for cofinancing under the Biomass Fund;
- FUNDA-PRO evaluates and qualifies financial intermediaries interested in participating in the Biomass Fund. With support from CPTS, FUNDA-PRO verifies that the projects are eligible for financing by the Biomass Fund, subject to compliance with the following criteria: (i) energy efficiency project; (ii) project cost lower than US$100,000; (iii) cofinancing by the industry of at least 5 percent of the investment; and (iv) the Net Present Value (NPV) of the project cash flow is positive at a discount rate acceptable to financial intermediaries; and
- In the case of projects involving the introduction of new or untested technologies in Bolivia, FUNDA-PRO can entirely finance project costs, for a cumulated amount of less than 10 percent of the Biomass Fund resources.

Projects Financed under the Biomass Fund

After 15 months of effective operation, the Biomass Fund had approved 52 operations for a total amount of close to US$400,000 and was considering a portfolio of 99 projects for a total amount of over US$500,000. Two financial intermediaries, ANED and FADES, were evaluated by FUNDA-PRO and cleared for participation in the Biomass Fund.

Approved operations. As of March 2002, 52 operations representing a total amount of US$389,000 were prepared by the industries in collaboration with the ESCO Energética, approved by the financial intermediary, ANED, and submitted to FUNDA-PRO for financing. Of these, 44 projects were for the substitution of firewood with natural gas in gypsum production, five for the substitution of firewood with rice husk, and three for substitution of firewood with bagasse (Table 3.1).

Table 3.1: Biomass Fund – Approved Operations

Project	*Industry*	*Number*	*ESCO*	*Department*	*BF Loan (US$)*
Substitution of firewood with natural gas	Gypsum Production	44	Energética	Cochabamba (Suticollo)	250,000
Substitution of firewood with rice husk	Rice Production	5	Energética	Santa Cruz (Yupacani)	85,000
Substitution of firewood with bagasse	Raw Sugar (*chancaca*) Production	3	Energética	Santa Cruz (Saipina)	54,000
Total		***52***			**389,000**

Source: FUNDA-PRO.

Pending applications. Additionally, the ESCOs ENERGETICA and SISTEMATICA screened 236 projects amounting to about US$1.0 million and selected 99 totaling US$511,115 as potential candidates for the Biomass Fund. These projects were to substitute firewood with natural gas in 20 cases, firewood and LPG with natural gas in 50 cases, dung and sawdust with natural gas in 10 cases, LPG with natural gas in four cases, *yareta* with natural gas in one case, and improve the efficiency of firewood use in 14 cases (Table 3.2 and Annex 9). In April 2002, these 99 projects were presented by ENERGETICA (74 projects) and SISTEMATICA (25 projects) to ANED for financing under the Biomass Fund.

Table 3.2: Biomass Fund – Projects Presented for Financing

Project	*Industry*	*Number*	*ESCO*	*Department*	*BF Credit (US$)*
Substitution of firewood with natural gas	Brick Production	10	Energética	Cochabamba	61,022
Substitution of firewood and LPG with natural gas	Bakeries	10	Energética	Cochabamba	36,045
Substitution of firewood and LPG with natural gas	Corn Production	10	Energética	Cochabamba	37,590
Substitution of firewood and LPG with natural gas	Chicha Production	30	Energética	Cochabamba	136,120
Substitution of firewood with natural gas	Gypsum Production	10	Energética	Cochabamba	18,690
Substitution of LPG with natural gas	Small Dairy, Ice, Chicken and Poultry Industries	4	Energética	Cochabamba	101,464
Substitution of yareta with natural gas	Ulexite Production	1	Sistemática	Potosí	59,000
Substitution of dung and sawdust with natural gas	Brick Production	10	Sistemática	Oruro	23,970
Efficiency improvement in firewood use	Gypsum Production	14	Sistemática	Tarija	36,850
Total		**99**			**510,751**

Source: FUNDA-PRO.

Evaluation of the Biomass Fund

An evaluation of the activities and results of the Biomass Fund was conducted in April 2002 by a financial consultant, who prepared a report with the following main findings and recommendations:

- The Biomass Fund operated for only 15 months and developed its activities within a particularly adverse economic and business environment. Based on the available information, the evaluation found evidence of remarkable strengths and positive short-term impacts in several areas. Nevertheless, the Biomass Fund is also facing serious weaknesses and threats;

- During its implementation, the Biomass Fund has shown the following strengths: adequate design; allowing strong private sector involvement and Government of Bolivia (GoB) support; identification of real funding demand from industries; leveraging international cooperation and local private funding; involvement of efficient and motivated ESCOs; participation of first- and second-tier, nonprofit FIs allowed nationwide outreach at affordable transaction costs;
- The positive impacts attributable to the Biomass Fund performance are: energy efficiency projects are opening the way to a new approach to rural development, investment, job creation and poverty alleviation in rural Bolivia; the Biomass Fund experience proves the existence of profitable business opportunities in energy efficiency and a legitimate demand for funding them; a new, previously nonexisting market for rural technical services has been developing in rural Bolivia. All these positive results should be preserved and enhanced;
- Nevertheless, the Biomass Fund program also faces serious threats, as a longer and deeper economic recession in Bolivia could have negative effects on: aggregate demand, rural product prices, biomass fuel prices, Internal Rate of Returns (IRRs), demand for additional energy efficiency loans and higher levels of portfolio at risk and arrears; all these factors could harm the long-term sustainability of the Biomass Fund;
- The implementation of the Biomass Fund program also showed a number of weaknesses and shortfalls such as its high dependency on ESCOs for demand generation and disbursement pressure; an initially inadequate coordination between ESCOs and financial intermediaries; limited interest from the financial intermediaries, as out of 20 potential financial intermediaries currently operating with FUNDA-PRO, two were willing to participate in the program and only one actually provided loans (ANED); lack of technical assistance for financial intermediaries on energy project appraisal techniques and insufficient understanding by ESCOs about credit appraisal by the financial intermediaries;
- The evaluation concluded the following: despite unusually adverse conditions and bearing in mind that the Biomass Fund program operated for only a 15-month period, the Biomass Fund performed as expected. Nonetheless, it is yet too early to conclude whether it has achieved – or will achieve – its mid-term objectives, since no loan repayment experiences have yet occurred, no lasting environmental impacts have been verified nor long-term improvements in technological and/or productive changes observed. Even though it is still too early to fully assess the Biomass Fund poverty mitigation impact, the relatively modest levels of rural investment financed with Biomass Fund resources, led to the creation of new, stable and better remunerated jobs; these outcomes are strong indicators that the Biomass Fund program has generated positive impacts in rural poverty alleviation; and
- The evaluation recommended that the Biomass Fund be transformed into an Energy Efficiency Revolving Fund (EERV), under the management of FUNDA-PRO; it should mobilize additional local private funding and include a working capital credit facility for new or currently operating rural industries, as well as a communication and dissemination program to maximize information on energy efficiency business opportunities for rural entrepreneurs. Resolving the sustainability of the ESCOs is critical in order to identify, develop and implement energy efficiency projects and ESCOs should continue receiving support and training from the CPTS.

4. Activities in the Rural Household Sector

Biomass as Energy Source in the Rural Household Sector

Biomass represents about one-third of the total energy consumption in Bolivia, mainly for cooking in rural households. The type of biomass used for cooking depends on the geographical location of consumers: in the valleys, 91 percent of the consumption comes from firewood, while in the northern highlands dung is used in 53 percent of the households. Some rural households use several energy sources for cooking: while 70 percent of the total households consume biomass, 38 percent of the total households use LPG. In 2000, rural areas' consumption was estimated at about 965,000 tons of firewood and 263,000 tons of dung per year. Only 15 percent of firewood and 2 percent of dung were purchased by households, the rest was collected by women and children in rural households – because of their low opportunity cost in the rural household economy. Collection of household fuels is estimated to represent the equivalent of about seven million days of work per year. The self-supply of biomass makes the exploitation of forest resources for energy purposes unsustainable, causes gender inequity and discourages the expansion of the commercial energy market. In addition to the deforestation caused by the intensive extraction of firewood, the combustion of biomass fuels inside the households has a negative impact on the health of rural families.

Efficiency in the transformation of biomass into useful energy for cooking is very low. It is estimated that the generation of 1 kg of oil equivalent of useful energy for cooking with equipment used in Bolivia requires about 25 kg of firewood or 33 kg of dung, but only 1.4 kg of LPG. At market prices in 2000, households buying firewood or dung for cooking purposes were spending two to three times more than families using LPG. However, firewood substitution with LPG in those households faces the issue of availability of LPG in rural areas. For households which collect biomass without direct monetary cost, substitution with LPG faces the issue of financial affordability.

Based on this review, NBP focused on two energy efficiency measures in the rural household sector: (a) the promotion of improved woodstoves; and (b) the assessment of obstacles to LPG distribution in rural areas. On the supply-side, NBP reviewed the use of biomass for power generation in Riberalta, and also developed a comprehensive approach to natural resource management in low-income communities of the Andean highlands (Chapter 5).

Promotion of Improved Woodstoves in Rural Households

The NBP assessed the potential for promoting the fabrication and sales of improved woodstoves in the Southern valleys and highlands of Bolivia. There are several models of improved stoves, including the multipot adobe stove with chimney (Lorena stove-type), which significantly improves fuel efficiency (savings of between 25 and 50 percent) while mitigating health impacts. International experience shows that the sustainable penetration of improved woodstoves hinges on the availability of proven equipment and their acceptance by households, the sale of improved equipment at commercial prices by local artisans able to provide necessary technical services and the perception by households of the financial and health benefits of improved stoves.

Isolated attempts had been made for the distribution of improved woodstoves without much success, mainly because of household affordability issues. However, the NGO CEEDI introduced at least 4,000 improved stoves in the province of Aroma (Department of La Paz). The NBP, thus, decided to review the conditions for successful replication of this experience.

The NBP undertook surveys and fieldwork in the highlands and valleys of the Southern part of the country to: (i) assess fuelwood consumption and expenditure; (ii) evaluate the various experiences for distribution of improved stoves; (iii) conduct interviews with artisans and household appliance retailers in rural markets; and (iv) conduct interviews with staff of rural health centers (hospitals and rural health posts).

Several issues were identified as prerequisites for or obstacles to the successful penetration of improved stoves: (i) the need to involve local artisans and suppliers of rural markets in the fabrication and distribution of efficient stoves through commercial channels; (ii) the absence of a standard design for improved woodstoves; (iii) the lack of perception by households of the health problems (mostly for women) caused by indoor use of firewood for cooking – with the resulting low priority allocated to stove purchase in household expenditure; (iv) the need to establish sustainable mechanisms for the promotion and dissemination of stoves; (v) the market distortions caused by various NGO and government distributions

who distributed improved stoves for free on the grounds of their environmental benefits; and (vi) the very low purchasing power of rural families, who could not afford the investment and maintenance costs of improved stoves, and the lack of microcredit mechanism to address investment costs. In the end, attempts of NBP to establish alliances and consensus-building with rural agents, staff of the rural health system and NGOs, so as to minimize the above distortions and obstacles, were unsuccessful and the activity was stopped in October 1999.

LPG Distribution in Rural Areas

Work conducted during the preparation of NBP indicated that about 38 percent of Bolivian rural households use LPG for cooking and consume about 50,000 tons of LPG per year, representing sales of about US$17 million, while households which purchase biomass fuels (firewood, dung) spend up to twice the amount spent by households using LPG.

The NBP undertook a study on the promotion of LPG distribution for household use, by assessing the potential market for LPG in selected rural areas, the technical and economic feasibility of installing LPG bottling plants near the consumers and the existing barriers to private investment in those plants (Annex 10). Detailed surveys were conducted in rural areas with promising prospects for substitution of biomass with LPG. Three areas were selected after field visits: Río Beni, Gran Chiquitanía and the Mesothermal Valleys. A household survey was conducted in 300 families in each area. The main results of the survey are summarized below:

- Final consumers in the three areas pay for LPG a price of up to 40 percent higher than the official price at national level (b$21 per cylinder of 10 kg), basically because of transportation costs;
- In terms of fuel use, in the three areas there is a similar and relatively even distribution of households which use firewood, LPG or both (about one-third each group);
- Gross energy consumption is much higher for households using only wood in contrast to those that use only LPG (six times more in the areas of Beni and Chiquitanía, and four times more in the area of Mesothermal Valleys);
- In terms of useful energy (that is, after accounting for efficiency of energy equipment), the average energy consumption of households which use a combination of firewood and LPG, is significantly higher than that of households using either LPG or firewood alone.
- In all three areas, the average expenditure for households using only firewood (obtained commercially) was found to be more than double the expenditure of households using LPG only; the savings would allow to recover investment costs for substitution (LPG stove and cylinder) in less than a year;

- The consumption of LPG is more important if households are smaller, younger, if the head of the family migrates regularly, has a higher level of schooling, if the family has improved housing conditions and if economic welfare is high; and
- Total estimated firewood consumption in the three areas amount to about 62,000 tons/year.

The study identified several obstacles to further penetration of LPG as a cooking fuel in the three areas:

- The cost of LPG cylinders is very high in parts of the rural areas due to high transportation costs and access difficulties during the rainy season (for example, a threefold increase in price during the rainy season was reported in San Matías, Chiquitanía);
- LPG supply is not guaranteed during the entire year, as some roads are inaccessible especially during the rainy season; and
- Households which collect firewood from nearby areas have limited incentives to switch to LPG as they don't allocate value to time spent by women and children in firewood collection.

To improve the penetration of LPG in rural areas, the study proposed to establish small rural bottling plants to which LPG would be transported in cistern trucks with a capacity of 10 tons from wholesale selling points. LPG would then be distributed by truck to retail points for sales to consumers. This system would also generate local economic benefits. Locations were identified for the proposed rural plants, at intermediate points between wholesale plants and demand centers. Investments required for a rural bottling plant would include two LPG cylinder-filling stations (balances), a 10-ton cistern truck, a storage tank with a capacity of 30 tons, civil works and complementary equipment. Cylinder-filling stations would be added over time to follow demand growth. Initial investment cost would be about US$200,000.

Municipal governments in the three areas showed interest in the proposed rural bottling plants, because of their potential role in reducing environment impacts, supporting the local economy and improving household welfare. Local governments would award concessions to private operators for plant installation on municipal areas and might participate in cofinancing of investment costs (for example, through provision of land and existing buildings).

The study assessed the profitability of the proposed rural LPG bottling plants under current and potential LPG demand in the three areas, with or without municipal and financial support. It concluded that rural bottling plants would be viable as a fully private business in the

areas of Chiquitanía and Mesothermal Valleys, and with some municipal and financial support in the area of Beni.

However, the study also identified a regulatory obstacle to the establishment of rural bottling plants, as the LPG retail price structure does not include a specific remuneration for the transportation of LPG from wholesale LPG installations to the proposed rural bottling plants. As regulations set up a maximum retail price and, in the absence of the above, noted remuneration, rural bottling plants would not be financially profitable thus making them unattractive for investment by private operators.

On conclusion of the study, NBP organized workshops with the communities and municipal authorities of Gran Chiquitanía, Río Beni, and the Mesothermal Valleys to inform them on the results of the study. Subsequently, NBP consultants met with the Superintendency of Hydrocarbons and VMEH to discuss this regulatory obstacle. It was suggested to further review the price structure and specific norms which would make the operation of rural LPG bottling plants financially viable.

Power Generation with Biomass

Background. At the request of VMEH, NBP reviewed the viability of biomass-based power generation in the city of Riberalta (Department of Beni), as a case study of alternatives to reduce the cost of diesel generation in isolated power systems in Bolivia. Located in the northeast of the country, the city of Riberalta meets a rapidly growing demand through an isolated power system which is administered by CER. The system has a nominal capacity of 6 MW and an available capacity of 4 MW – including a 3.25 MW diesel unit and a 0.75 MW thermal plant fueled with nutshells. Whereas the commercial price of diesel in Riberalta is as high as US$0.47/liter, CER has access to subsidized diesel fuel and pays only US$0.16/liter. However, CER's average electricity tariff (equivalent to US¢22/kWh) is among the highest in the country.

Annual demand growth rate in Riberalta is about 10 percent, and it is estimated that peak demand would reach close to 6.5 MW by the year 2010. Demand growth could even be higher as electricity service coverage is less than 60 percent in the city of Riberalta and there is no coverage in rural areas around the city.

Prospects for biomass-based power generation in Riberalta. A study was conducted by a joint venture of consulting firms (Consultores Galindo, from Bolivia, and Biomass Technology Group, a Dutch consulting firm with large experience in the use of biomass as

energy source). Aspects reviewed by the study included: estimation of power demand; type and source of available biomass; investment and Operations and Maintenance (O&M) costs of a biomass-fueled power generating plant; economics of the power plant compared to a diesel generating unit; electricity tariff structure and diesel subsidy; the institutional and regulatory framework which would enable private investment in a biomass-fueled power generating plant; and the prospects for project replication in other rural areas.

The results of the study were presented to local government authorities, representatives of CER and other institutions of Riberalta in two workshops, one held in La Paz, and another in Riberalta. The study concluded that all conditions for a biomass-based power generating project to be viable are fulfilled in Riberalta. Main conclusions are the following:

- A sustainable and reliable source of biomass supply for the plant would come from the exploitation of secondary woods in early years of the project and forest plantations of about 2,000 ha afterwards. The use of nutshells and sawdust was discarded because local industries use that type of biomass for self-consumption. Also, the collection of forest residues carried by rivers surrounding Riberalta was discarded as unpractical;
- The first step to meet demand growth for about three years would consist of the installation of a 1.0 MW fixed grate, low efficiency, direct biomass combustion plant. This plant would complement the existing nutshell-based power plant. The 1.0 MW biomass-fueled plant would require an investment of about US$2.0 million. It would be operated as a base load plant, and peak load would still have to be met with the diesel-based power generating unit;
- The biomass-fueled plant would generate electricity at a total cost in the range of US¢5.5 to 8.5/kWh, which is significantly lower than that of a production cost for a diesel-fueled plant – estimated at over US¢15/kWh. Additional revenues might be obtained for the biomass plant from carbon credits linked to the reduction of CO_2 emissions;
- Regarding the institutional framework and normative, the study concluded that under the existing legal framework for the power sector, private investors could establish a biomass-fueled power generating plant as an IPP, obtain a generation license and sell electricity to CER under a PPA; and
- The study also found that other cities with good prospects for the replication of the project in the Department include Guayaramerín, Santa Ana del Yacuma, and San Ignacio where sufficient, sustainable supply of biomass for power generation would be feasible and a 1 MW plant would fit the demand. In other locations such as Magdalena, San Ramón, San Joaquín, Huacaraje, El Carmen, Cachuela Esperanza, and Bella Vista, the economics of biomass plants smaller than 1 MW should be further analyzed.

5. Sustainable Biomass Supply: Silvopastoral Enclosures

Conceptual Framework

As the rural household sector is the main consumer of biomass in Bolivia, and significant substitution of biomass is improbable in the short term in rural areas, NBP included the design of activities to improve the sustainable supply of biomass for rural households. The sustainable supply of biomass for energy purposes necessarily involves concepts related to territorial management of resources. In this sense, there is an incipient understanding of the social, economic, cultural, and normative factors which influence the consumption of biomass as an energy source. This lack of knowledge has made it difficult to design energy policies ensuring long-term sustainable supply of biomass and has led to an absence of state policies on biomass.

Another problem is the absence of information on technological alternatives and, particularly, on systems which would enable the conversion of the present forest resource exploitation practices for energy production into supply channels which are sustainable in the long term. As long as biomass for energy purposes, especially in the household sector, is not related to a market reference, it is improbable that returns on investments in reforestation aimed at fuel supply will justify the development of a market.

Social management of resources under common property or collective exploitation is based on the fact that peasant communities in the Andean region are the owners of the land and that they constitute a social and productive peasant unit. Due to the coexistence of unwritten laws and formal laws, peasant communities regulate the public behavior of their members, define their rights and obligations, as well as the modalities and scope of access to use and distribution of land, water and forest products. Nevertheless, this control is not fully exercised in all fields. Evidence shows that in spite of thorough social control on crop land and pasture land, the access to and use of biomass, especially the biomass used for energy purposes, is not subject to said control.

The initial assumption of NBP was that processes of deterioration of productive conditions of farmers have given rise to dynamics which override social control or the regulatory system for access to biomass for energy purposes (for household, and mainly commercial, consumption). The farming economy in Bolivia is going through a deep crisis of its productive systems, which is expressed in turn in the crisis in management of natural resources. The vicious circle caused by extension of the agricultural frontier, uncontrolled grazing, increasing livestock population and decreasing soil fertility is closely linked to the exploitation of forest resources (mainly shrubs) for energy purposes.

In order to achieve the objective of creating conditions for the establishment of sustainable channels (commercial and noncommercial) for biomass supply for energy purposes in the mediumterm, NBP based its work on the following premises:

- Experiences worldwide have shown the difficulty of establishing reforestation for energy purposes which is economically feasible or socially mobilizing;
- The exploitation of forest resources for energy purposes can be sustainable if this exploitation is integrated in the rationale of use of woodlands for agriculture, pasture cycles, manure production and, in general, within an objective of rational use of resources by the communities;
- Extensive use of woodlands for energy purposes and grazing is one of the main causes of the crisis in rural productive systems;
- The establishment of sustainable channels for the exploitation of forest resources hinges on the farmers' recognition of the financial returns of this exploitation; and
- As long as the legal rights of agents regarding access to and exploitation of forest resources are not clear, there will be insufficient incentives for investments in reforestation.

Design of an Action Plan

These premises were used to design an action plan to demonstrate the technical, social, and economic feasibility of management of forest/pasture (silvopastoral) resources as a means to guarantee the supply of fuel, the productivity of livestock cycles and the recovery of organic material in agricultural soils. All these aspects are all closely linked to the crisis of farming production systems and, therefore, to poverty levels in Bolivian rural areas.

Some of the relevant characteristics of this type of management of forest resources are:

- The application of existing laws on sustainable use and management of resources, taking account of the deterioration of productive systems and the scope of the social control exercised by communities on land and forest resources;

- The proposed technological alternatives enable to increase intensity in land use, improve the productivity of pasture areas and livestock, rehabilitate degraded land, improve chances of success in reforestation activities and increase biomass production; and
- The legal rights of agents who intervene in forest resource management are clear and undisputed in the intervened areas, and there is a favorable institutional framework, so as to allow and provide incentives for investments in resource management.

Under the above conceptual definitions, NBP proceeded to:

- Identify potential intervention areas for forest/biomass resource management;
- Identify communal, social, and legal bases for project design and execution;
- Design a plan which integrates the conceptual, methodological, and operational principles of communal resources management; and
- Design a training strategy to develop the capacity of farmers and agriculture technicians in community management of silvopastoral resources, including new technologies based on practical experience.

Starting in 1999, NBP developed an action plan, called the Plan for Silvopastoral Enclosures in Bolivia, which was based on the following principles:

- Sustainable channels for the supply of biomass for energy will only be feasible if integrated management of silvopastoral areas is attractive and profitable for communities;
- Achieving profitable management of silvopastoral areas by the communities requires breaking the vicious circle resulting from the crisis of productive systems; the plan thus changed the exploitation pattern from extensive to intensive;
- The crisis of productive systems in the Andean areas of Bolivia is not a recent phenomenon, it is a process that has been going on for years. Hence, changes in the patterns of use of silvopastoral areas will be gradual and will not have an immediate impact;
- The introduction of the principles, concepts, and techniques of a new way of exploitation of silvopastoral areas in communities should be incorporated in the existing system for farmer training and extension services;
- The development of silvopastoral management practices at community level requires increasing decision-making capacities of communities in that respect; and
- The plan should encourage a participatory process which involves communities, municipal governments, funding agencies, and national authorities.

The Plan for Silvopastoral Enclosures focuses on the recovery of interaction between cattle, forest, and pasture systems in rural communities, by means of a technological leap in silvopastoral production, in which forest species used for firewood and timber interact with

improved forage areas and animals under intensive integrated management. Thus, reforested areas can be managed within pasture areas, where animals are fed through rotation in grazing blocks protected with solar-powered electric fences. The use of new technologies will make possible the intensive use of land, improve the productivity of pastures and livestock, rehabilitate degraded land and ensure success of reforestation activities. Biomass production surplus will be used by the community for household and commercial energy purposes.

Strategically speaking, the proposal was organized in three areas: (i) realization of demonstrative projects in three communities to validate the proposed technology and approach; (ii) definition of a methodology to measure impacts of the plan; and (iii) development of a training system for capacity building and project replication.

Demonstration Projects

Ten communities were identified and evaluated under a participatory process, leading to the selection of three communities and one training center for the establishment of enclosures for silvopastoral management:

- Enclosure of Casagrande, in the community of Casa Grande, Municipality of Mojocoya in the Department of Chuquisaca. The community comprises 75 families, 72 of which participated in the project. The 76 ha enclosure included cattle management (up to 19 animals at one point). Technical support was recruited with NGO CEIBO;
- Enclosure of Jatun Mayu, in the community of Jatun Mayu, Municipality of Icla in the Department of Chuquisaca. Twenty out of the 160 families of the community participated in the management of the 136 has enclosure, in which cattle (19 heads) and 56 llamas are managed. In the beginning, this community was supported by NGO PROAGRO. Later, the enclosure was directly managed by the community, with technical advice from NBP field technicians;
- Enclosure of Sagha Sagha, in the community of Urubumba, Municipality of Vacas in the Department of Cochabamba. Sixty-five of the 115 families of the community participated in management of the 96 has enclosure, in which 86 sheep were managed. This community benefited from technical support recruited by NBP with NGO CESAT; and
- Enclosure of Huerta Mayu, in the community of Villa Serrano, Department of Chuquisaca. This enclosure of 12 ha(s) is installed at CEITHAR's student training center.

The four enclosures were equipped with electric fences, animal drinking points, water connections, infiltration ditches, hay storage areas and control posts. Electric fences initially faced operational difficulties (lower voltage than expected) which were subsequently solved;

the NBP prepared a manual on design, construction, and maintenance of electric fences in mountainous areas. Native tree species and improved pasture were planted in the four enclosures.

Measuring Impacts of the Silvopastoral Projects

An impact evaluation methodology was designed with support from *Consultora SUR*, which had supported NBP in the initial design of the silvopastoral. The methodology included the: (i) definition of performance indicators (productivity of pasture, hay, tree species, firewood, increase in weight of animals, production of dung, milk and other products) and establishment of a baseline in the four enclosures; (ii) measurement of improvements in the performance indicators in the four enclosures; (iii) comparison of enclosures with similar parcels still under the extensive land use and production system; and (iv) interviews with farmers (participants, nonparticipants, women, elders). Furthermore, *Consultora SUR* reviewed the legal situation of the land owned by the enclosures (titles, deeds) and evaluated the existing communal norms for land access and use; as a result the consultant designed a strategy to enable each community to register its land ownership rights in the *Sistema de Catastro Rural* and the *Instituto Nacional de Reforma Agraria*. The results of the four impact evaluations were incorporated in the training materials prepared for the projects.

After two years of application, the silvopastoral management plans based on intensive land use have had significant economic impact on the three communities. The intensive forest exploitation system has almost fourfolded the household income in Jatun Mayu and Sagha Sagha and doubled the household income in Casa Grande (Table 5.1). The enclosure of Jatun Mayu has made profits which were distributed among the members of the community. Each community has deposits in local bank accounts (from NBP inputs and sale of livestock) which allow future operation of the enclosures. These accounts are administered under community control and decision-making mechanisms.

Table 5.1: Impact of the Silvopastoral Plans on Household Income

Community	*Estimated Annual Household Income (US$)*	
	Without Intensive Exploitation	*With Intensive Exploitation*
Casa Grande	119	239
Jatun Mayu	586	2,177
Sagha Sagha	165	730

Training System

Beyond the demonstration effect of the three enclosures which were established with limited-in-time support from NBP and technical assistance, the dissemination and replication of the new concept of silvopastoral management requires adequate capacity-building of farmers and technicians at community level. Thus, NBP entrusted the FERIA program the design and application of a curriculum called "Community Management of Silvopastoral Resources." FERIA is the official state training system of the Vice Ministry of Alternative Education, and has a network of 38 rural training centers for adult education. It is attached to the *Comisión Episcopal de Educación* (Episcopal Commission for Education).

Scope of the training program. The training program designed under the NBP emphasizes the management of silvopastoral resources with focus on the production of goods and services with substantial local value added. The program has three different curricula for training of: (i) facilitators and teachers of FERIA network; (ii) farmers at secondary education level; and (iii) farmers of the communities participating in the NBP and communities interested in the project concept. Training materials are based on the experience and results of the four demonstration enclosures and include four modules:

- *Module 1*: Communal organization and participatory decision-making. Analysis of the organizational structure and decision-making mechanisms of communities. Legal aspects related to management of silvopastoral resources. Analysis of the communal norms governing the daily life of communities;
- *Module 2*: Participatory communal planning. Theory, processes, approaches, and methodologies in planning community participation;
- *Module 3*: Issues and potential of silvopastoral resources. Comparison and evaluation of production systems (extensive versus intensive systems). Techniques and methodology for the identification and evaluation of silvopastoral resources. Protection of renewable resources; and
- *Module 4*: Management of a silvopastoral production system. Climate and environmental factors affecting natural resources. Vegetal and animal resources under a different management approach.

An educational video (22 minutes' duration) was also prepared. It analyzes the crisis of productive systems, issues, and technological alternatives and presents the experience and results of silvopastoral enclosures implemented under NBP.

The first training modules were applied at CEITHAR (275 hours of training), CETHA Tiraque (72 hours), and eight CETHA rural centers (104 hours). CEITHAR and CETHA Tiraque have

also conducted workshops totaling 114 hours in the three communities of the Silvopastoral Enclosures Plan.

Sustainability of the training system. In January 2002, CEE completed an evaluation of prospects for the transfer and future delivery of the training program on silvopastoral management. The sustainability of the training system is likely because:

- The curriculum is used by the Program DECOS in the *Centro Avelino Siñani* for the training of rural facilitators and teachers. The curricular activities of this center are accredited by the UCB;
- CEITHAR and CETHA Tiraque have scheduled six annual workshops for students of rural secondary schools;
- The curriculum on Communal Management of Silvopastoral Resources will be used in 20 educational centers of the Andean network of FERIA; and
- CEE is committed to assist in the implementation of the training plan in the future.

6. Lessons Learned

The studies, projects and instruments development during the four years of implementation of NBP allow lessons to be drawn regarding the promotion of sustainable supply and efficient use of biomass resources in Bolivia, some of which are of broader application:

- Information and financial aspects are important barriers to investments by rural industries in the efficient use or substitution of biomass. The demonstration projects, technology transfer, and training instruments developed by NBP addressed information barriers. Dedicated financial instruments, such as the Biomass Fund, can efficiently address funding requirements but should not distort commercial banking practices;
- The Biomass Fund will require additional resources for a significant scale-up of biomass efficiency investments, which is required to obtain a noticeable reduction in biomass consumption and the associated environmental benefits;
- The local acceptance and application of new technologies to increase efficiency in productive processes is a *sine qua non* condition for creating local value-added, industry competitiveness, and consolidation of the rural market and employment;
- Rural industrials and producers are very much interested in accessing new and efficient technologies. They clearly understand that their survival in the economic system depends heavily on their level of efficiency. The industries' perception of financial benefits from biomass efficiency projects is a key element in their decision to invest in these projects;
- The application of management principles in the production and rational use of biomass resources induces economic benefits for rural producers and industries;
- The NBP has identified institutions and actors which could continue and replicate the approach and results of NBP. Local entities, as well as ESCOs, should play a central role in this respect;
- The level of technological development of rural areas is closely related to educational and training policies and programs. There is a need to work on two fronts: (a) conduct capacity-building activities in rural communities through local training entities; and (b) strengthen university curricula on biomass resource management and technologies to train professionals able to deal with the productive and environmental issues in rural areas; and

- There is still an important barrier to the implementation of a large-scale biomass program which, however, will take time to be removed: many local actors are still convinced that the State should be a provider of subsidized goods and services, while others are aware that market distortions introduced by subsidies work against the possibility of establishing sustainable management and financing mechanisms for biomass efficiency.

Annex 1

Impacts and Sustainability: National Biomass Program

Table A1.1: Impacts and Sustainability – National Biomass Program

Activity	*Main Product*	*Sustainability Strategy*	*Replicability Prospects*	*Product Benefits*
Demonstration Projects in Rural Industries				
Chancaca	Three industries have substituted 70 percent of their firewood consumption with bagasse	These projects' sustainability is linked to the implementation of energy efficiency support mechanisms: The Biomass Fund will provide cofinancing for the projects	A project portfolio for another 17 industries has been developed	Firewood savings of 384 ton/year in the Three industries with NBP projects potential savings of firewood of 5,400 ton/year in 20 industries, equivalent to 150 ha(s) of forest saved from deforestation Potential savings of US$200,000/year in 20 industries
Rice	Three industries have substituted 100 percent of their firewood consumption with rice husk for the drying process	CPTS will certify the eligibility of the projects and promote energy efficiency best practices The (CNI) took over the task of overseeing the operation of the Biomass Fund through the BF Technical Committee	A project portfolio for 15 industries in the Province of Ichilo has been developed in the Department of Santa Cruz there is a total of 97 rice mills.	Savings of firewood of 500 ton/year in the three industries with NBP projects, representing US$11,000/year Potential savings of firewood of 3,700 ton/year in 21 industries, representing financial saving of US$80.000/ year and 49 ha(s)/year saved from deforestation
Gypsum in Cochabamba	Thirty-five industries have substituted 100 percent of their firewood consumption with natural gas.	SAT can make resources available for energy efficiency services and project design	In the Department of (Cochabamba) there are 150 gypsum industries.	Sales of NG to industries are over US$80,000/year Saving of firewood of 4,000 ton/year Financial savings of US$100,000/year in 35 industries. 35 ha(s)/year saved from deforestation
Bricks in Santa Cruz	Methodology for efficient brick production tests carried out in 30 furnaces in the community of San Carlos	ESCOs develop the portfolio of projects and, through the Vice Ministry of Popular Participation, work with municipal authorities to get energy efficiency incorporated in the local policy agenda	In the Department of (Santa Cruz there are over than 500 brick industries using firewood. There are about 1,700 brick industries in the country	Economic saving in San Carlos of US$1,300/ year Potential saving of firewood of 2,800 ton/year with the first 30 participating furnaces
Industries of the Highlands (Altiplano)	Preparation of a portfolio of projects for:16 gypsum industries, under a semiindustrial partnership production Twelve ulexite furnaces to substitute *yareta* with commercial fuels Eight brick industries to substitute firewood with natural gas		In the highlands there, are about 300 gypsum establishments with similar production characteristics. In South Potosí, there are four ulexite plants and six sulfur plants, each one with several furnaces	The first semicontinuous furnace in Pacajes will save 270 ton/year of firewood Fuel substitution in the first ulexite plant implies a minimum saving of 2,000 ton/year of *yareta* Impacts in sulfur industries were not quantified

Activity	*Main Product*	*Sustainability Strategy*	*Replicability Prospects*	*Product Benefits*
Rural LPG	Market assessment in three potential rural areas for LPG distribution Recommendations on legal and regulatory incentives for private investment in LPG distribution	Actual development of the rural LPG market hinges on regulatory changes by VMEH and the Superintendency of Hydrocarbons, in particular regarding price regulation to recognize the cost of transport from LPG storage to rural bottling plants	The NBP has preidentified five potential zones for rural LPG distribution.	Household saving of US$55-164/year by substitution of firewood with LGP Expected sale of 1,300 10 kg cylinders of LGP/day during the first year of implementation (in the three zones which were surveyed) 27 percent of firewood consumption is displaced, equivalent to 25,000 ton/year of firewood
Silvopastoral Enclosures Program	Four forest and pasture enclosures were implemented in three low-income communities and one training center, covering a total of 320 ha(s) Eighteen ha(s) of forests were planted Twenty-three ha(s) of forests are under management Twenty-nine ha(s) of pastures were improved Intensive rotation of animals Community system of manure collection Community system of firewood collection Establishment of system to measure productivity and project impact	It is expected that information and dissemination activities on this NBP program which were conducted toward sector ministries such as VMAGDR or MDSMA would result in follow-up work on silvopastoral enclosures by the operational organizations of these ministries (for example, PROBONA, ATICA, and so on, and so forth).	The program can be replicated in Bolivia's Andean region ecosystems	The 125 families in the three community projects have improved their income as a result of the improved productivity of pastures in the enclosures The silvopastoral enclosure established at CEITHAR gives 100 students the opportunity to study this management system every year The project provides a sustainable community system for the provision of firewood The project might be a viable alternative to the crisis of productive systems in Bolivia's highlands.
		Support Mechanisms		
Biomass Fund	As of April 2002, FUNDA-PRO has committed US$400,000 and was processing another US$500,000 for biomass efficiency projects in small rural industries	FUNDA-PRO has evidenced strong commitment to the administration and development of the Biomass Fund Orientation Committee is in place for Biomass Fund supervision and technical support Two financial intermediaries (ANED and FADES) are participating the Biomass Fund scheme The Biomass Fund has extended its coverage of Energy Efficiency and Clean Production projects	The Biomass Fund has been established as a revolving fund Loan repayment risk is taken by financial intermediaries FUNDA-PRO is strongly committed to proper administration of the Biomass Fund	As noted above for each industry sector, in terms of biomass savings, financial savings, and avoided deforestation

Activity	*Main Product*	*Sustainability Strategy*	*Replicability Prospects*	*Product Benefits*
Technical Assistance Service	SAT to incorporate into its eligibility criteria for support to projects in small enterprises, the services provided in energy efficiency and clean production for enterprise development	Projects prepared by ESCOs should follow SAT criteria, so as to be eligible for SAT support	Access to support from SAT should boost the development of a large portfolio of energy efficiency projects by competing ESCOs	
Sustainable Technology Promotion Centre (CPTS)	CPTS has been established as a mechanism for technical support to the Biomass Fund, in terms of project validation, best practice dissemination and ESCOs training/strengthening	CPTS is expected to continue its role, namely, the Biomass Fund, as CPTS is receiving donor supportfor energy efficiency related work	CPTS participation should result in project portfolio development, through its information/ dissemination activities and support to ESCOS	
Training System for community management of forest and pasture resources	A curriculum for community management of forest and pasture resources has been designed, directed to teachers, technical agents, farmers and agriculture students Pilot experiences of application of this curriculum were conducted in three rural centers of alternative education (CETHA's). The curriculum was transferred to the DECOS program and FERIA network.	Continued application of the curriculum in the CETHAs/ CEITHAR and the DECOS program and Feria network in Bolivia Fellowship financing for farmer students should be pursued through the FONCRESOL mechanism	Training could be replicated through (i) the application of the curriculum through the FERIA network in the Andean region; and (ii) inclusion of the curriculum into the Program of Sustainable Community Development from the Vice Ministry of Alternative Education CEE	The curriculum was applied in 3 CETHA centers with a total of over 300 students in the last year of high school

Annex 2

Substitution of Firewood with Bagasse in *Chancaca* Industries

Background and Issues

Chancaca producers are located in the Municipality of Saipina of the Department of Santa Cruz. There are approximately 80 sugarcane processing units (mills), only 45 of which are presently operating. The production of about 300 ha(s) of sugarcane is one of the principal economic activities of the zone, and involves about 95 small farmers.

Chancaca-processing is a traditional industrial activity in the zone and requires about 390 direct nonagricultural jobs. There are mills with different capacities – the smallest ones produce approximately 10 ton/year, the biggest ones about 300 ton/year. Total annual production of the 45 industries, currently in operation, amounts to approximately 4,500 tons of *chancaca*. This production represents sales of about US$1.3 million/year.

Chancaca is obtained by evaporating the juice of sugar cane and crystallizing the honey obtained in traditional mud ovens. Production efficiency is between 8 percent and 14 percent, that is, between 80 and 140 kg of *chancaca* are obtained from one ton of sugar cane. The traditional production system is discontinuous, in batches of 800 to 1,600 liters of cane juice, depending on the plant's capacity.

During evaporation, significant quantities of firewood are used: every kg of *chancaca* requires between 1.6 and 2.8 kg of firewood. During the crystallization of honey, about 2 kg of bagasse is used per kg of product. This means that 62 percent of the energy demand is covered by firewood, 37 percent by bagasse and 1 percent by diesel for the motors of the mills. Efficiency in the transformation of thermal energy is low, because of intermittency of the process. The energy diagnosis which was carried out in the *chancaca* industries showed that their energy efficiency is only about 20 percent.

Firewood represents approximately 41 percent of the total production cost, mainly due to the low efficiency of the ovens and the high cost of firewood in the area (US$30 to US$35/ton). Firewood is transported from the lower area of the department, at a distance of 300 km from Saipina. On the other hand, only about 56 percent of bagasse produced is used in the mills. In some cases, bagasse is used as soil nutrient. Surveys in 20 *chancaca* industries showed an estimated consumption of firewood of about 8,000 tons a year.

The traditional market for *chancaca* elaborated in the area of Saipina is the department of Cochabamba, where it is used as a raw material for the elaboration of chicha (maize beer). Only a small part of *chancaca* is commercialized in Santa Cruz for different traditional household purposes.

Competitiveness of the *chancaca* industries is at risk: the lack of technological innovation, increasing firewood prices, inefficient production process and limited diversification of products and markets has resulted in the closing of various *chancaca* industries in the zone, thus causing unemployment.

Alternatives to Address Efficiency Issues

Different alternatives were analyzed to solve the above described issues. The two main options to increase efficiency are: i) substitution of firewood with natural gas; and ii) substitution of firewood with bagasse.

The analysis of the substitution of firewood with natural gas was based on the study of three substitution projects which had been developed with support from gas distribution companies, and reached the following conclusions:

- The incorporation of almost 40 industries would require a total investment of about US$750,000, and there was no financing mechanism available;
- Many industries were too far away from existing gas distribution network; only 15 industries were at a reasonable distance – and investment required for fuel substitution was significant;
- Natural gas consumption for a medium-sized industry would mean an annual expense of about US$2,000 – quite significant compare to product sales; and
- Fuel substitution was not associated to technological change in the *chancaca* traditional production process.

On the other hand, there were various industries in Costa Rica similar to the ones in Bolivia, which had been subject to a technological leap by means of incorporation of a semicontinuous oven in the production, which used bagasse as the energy source. The NBB recruited the consulting firm which had been involved in these projects in Costa Rica Biomass Technology Group (BTG), the Netherlands, to assess the feasibility of transfer of the Costa Rican technology to the mills in Saipina, and to develop a comparison with the alternative of firewood to gas substitution.

The conclusions of this assessment are summarized below:

- The investment in each industry would be similar to the investment required for substitution to natural gas;

- Industries would not need to move their installations and all would have access to the project;
- Expenditure in firewood in each industry would not exceed US$1,500 a year; and
- Each producer would benefit from improved quality of production as a result of better sanitary conditions in plants, which would open up the possibility to access new markets with clean products.

Based on the above assessment, an agreement was reached during a meeting with producers, CEDETI, BTG, and NBP local staff, to go ahead with a project to use bagasse in a semicontinuous oven and the CEDETI – Intermediate Technology Center was recruited to develop the detailed design of the project. Beforehand, two producers and one CEDETI technician traveled to Costa Rica to evaluate the feasibility of adapting the technology to Bolivian industries. CEDETI completed the project design in March 1999.

The Project

The principal objective defined for the project was: "to increase energy efficiency and competitiveness of the *chancaca*-producing industries by means of the introduction of a semicontinuous oven which reduces the consumption of firewood, decreases production costs and improves quality of the products."

The project had the following specific objectives:

- An increase of fuel efficiency, from 23 percent to a minimum of 40 percent by means of the introduction of a semicontinuous oven. In terms of firewood consumption, the target was to reduce up to 70 percent of firewood consumption in a traditional plant;
- Access of producers to the formal financial system (under market terms) for the financing of investment in technology upgrade; and
- Annual substitution of a total quantity of 5,600 tons of firewood with bagasse in 21 industries in the zone of Saipina.

Additional benefits were expected to include:

- The reduction of labor necessary in the mills;
- Improved working conditions for operators;
- Reduction of processing times and improvement of the quality of the product; and
- New products and opening of new markets.

In physical terms, every project consisted of the construction of a new *chancaca*-processing plant including the following components:

- Improvements in the milling system, to avoid contamination of sugarcane juice by residues of lubrication oil;
- Tiled tanks for sedimentation and cleaning of the sugarcane juice;
- A semicontinuous oven that uses the same energy source for juice evaporation and honey crystallization;
- A shed for the semicontinuous oven and areas for milling and packing the product; and
- Each plant represented an investment of US$22,000, financed by a financial intermediary (ANED) with resources from the Biomass Fund.

The project was executed with the following main steps and timetable:

- After creation of the Biomass Fund in October 2000, CEDETI approached the producers to agree on a portfolio of efficiency projects;
- Although local conditions (market and financial situation) had worsened since 1999, NBP's three pilot projects were prepared in agreement with producers and submitted to the Biomass Fund in April 2001;
- The projects were presented to the Biomass Fund by the financial intermediary ANED, which qualified for the Biomass Fund. The projects were based on an energy diagnosis of the three mills, a complete evaluation of the production cycle and a financial analysis.
- All conditions for producers to receive the first disbursement from the Biomass Fund were satisfied in August 2001. In the meantime, CEDETI prepared for project execution;
- The branch office of BTG in Costa Rica was hired to provide the technology, CEDETI to supervise the works, coordinate the process and provide technical assistance to producers in production, energy, and financial aspects;
- With support from CEDETI, the three producers organized a technical committee and invited three construction companies to present bids for the construction of the three plants, based on tender documents prepared by CEDETI;
- After selection of the construction, works started under the supervision of CEDETI and oversight of BTG. Works were concluded in January 2002;
- The technical committee continued to operate after project completion for decision-making on different topics which involved the three producers (request for additional financing, review of conformity with the technology, search for new markets for the new product, and so on, and so forth);
- A workshop sponsored by the Municipal Government of Saipina was organized at the end of January 2002 to present the first plant in operation, with participation of about 20 *chancaca* producers, as well as municipal authorities and the project service providers,

that is, CEDETI as the technical assistance provider, ANED as the funding agency and the construction company which had built the first three plants;

- Between March and April 2002, BTG and CEDETI conducted additional training on operation of the new plant, aimed at maximizing productivity of the plant, optimizing the use of bagasse and firewood and developing new products. Each day concluded with a meeting of technical assistants, producers, and plant operators to evaluate results and plan the following steps to achieve the objective. Various topics related to new markets, quality of the products and new packing modalities were also discussed during these meetings; and
- Finally, in conformity with rules of the Biomass Fund, CEDETI and the technical committee set up the three producers selected and hired a consulting firm to verify the effectiveness of the new technology; the consultant report indicated that the new plant complied with energy consumption targets for both firewood and bagasse, and had achieved a productivity improvement of 72 percent. With these indicators, CEDETI is making a new evaluation of the project's profitability.

Results

At the end of NBP activities, the situation was as follows:

- Three new industries have started to operate, one of which has fully appropriated the technology;
- CEDETI has prepared five new projects which have been evaluated by ANED, for a total demand of US$125,000 from the Biomass Fund;
- ANED has presented requests to the Biomass Fund for two of these projects, whereas the other three still have to meet some requirements related to solvency of the producers;
- There is a construction firm which has the knowledge and capacity required to replicate the technology;
- CEDETI, as an ESCO, can provide technical assistance to the producers, and has the required capacity to manage and transfer the technology;
- Producers have already taken initiatives to elaborate new products and look for new markets; and
- There are good prospects for achieving the target of an annual substitution of 2,100 tons of firewood with bagasse in eight industries in the zone of Saipina.

Annex 3

Substitution of Firewood with Rice Husks in Rice Mills of Santa Cruz

Background

In the provinces of Ichilo, Sara, Santiesteban, and Ibáñez of the Department of Santa Cruz, there are approximately 100 industries which process rice (drying and peeling), with an annual estimated production of 160,000 tons. This represents about 65 percent of the total national production of rice, estimated at 215,000 tons/year. Rice production involves small producers in colonization areas, who own between four and 75 cultivated ha(s), as well as large producers with 1,000 ha(s) in average.

The NBP focused its activities in the province of Ichilo, where there are 40 rice mills which consume approximately 5,000 tons of firewood and 3,000 megawatt hour (MWh) of electric power a year.

Immediately after the harvest, producers deliver grains to rice mills. Humidity of the incoming rice is about 22 percent. The totality of the rice is dried, 85 percent is peeled and 15 percent is "polished." The 15 percent which is not peeled is returned to producers for their own consumption.

The measurement unit used for rice production is the *fanega*, equivalent to 184 kg of wet rice. After peeling, each *fanega* of rice results in 40 kg of husk (residues). These residues have become a serious environmental problem in the zone. As these residues are not used, they are piled up and burnt without control or thrown into the rivers or woods. The paradox is that while production costs of industries are affected because they use firewood, the price of which has gone up in these last years, they throw away large quantities of biomass residues which contain sufficient energy to substitute firewood.

On average, the cost of energy represents 11 percent of the total production cost in rice mills. The thermal energy provided by firewood represents 85 percent of the total energy consumption, although its cost accounts for only 19 percent of the total energy cost of the mill. Electricity is the complementary energy source (15 percent) and it accounts for 81 percent of the energy costs.

The methodology used to design the project has been similar to the one used for other NBP pilot projects in rural industries. After carrying out an energy audit in a representative industry, the consulting firm BTG was entrusted with the review of technological alternatives for rational use of biomass.

In 1998, in a workshop organized by CEDETI with participation of (i) several rice producers; (ii) BTG; (iii) the energy auditor (PA Energía); and (iv) the NBP local staff, the central aspects of a possible project were discussed.

The workshop analyzed three different alternatives:

- Perspectives regarding the efficient use of firewood to dry rice were not encouraging, as it was detected that efficiency levels of both combustion and heat transfer in existing driers were at acceptable levels and that it would be difficult to introduce efficiency improvements;
- Treatment of rice husks to produce briquettes was technically feasible but not attractive in economic terms. The energy auditor had analyzed briquette production costs in a rice drying plant, and found that briquettes could not compete with firewood; and
- The most attractive alternative was presented by BTG, which made reference to several rice mills in Costa Rica which use rice husk for rice drying through direct combustion in specially designed ovens. As these ovens had an installed maximum capacity of only 380 Kilowatt (kW), a new design was required to address energy needs of rice mills in Bolivia (600 kW in average).

Moreover, the energy auditor reviewed the mills' efficiency in electricity use and identified technological alternatives to reduce the consumption of electricity of these industries.

Based on the above information and after an agreement was reached with relevant actors, NBP entrusted CEDETI with the detailed design of a project. In addition, one rice producer and one technician from CEDETI traveled to Costa Rica to evaluate, from their perspective, the feasibility of adapting the technology used in Costa Rica to Bolivian industries. CEDETI completed the project design in March 1999.

The Project

The principal objective of the project was "to increase efficiency in the use of thermal energy and overall energy management in rice processing industries."

The specific objectives of the project were as follows:

- Construct a pilot installation in a selected rice mill, including a rice husk combustion oven with a capacity of 600 kW, to substitute 100 percent of the firewood used in this mill;

- After validation of the new technology, replicate the pilot project in 20 rice mills;
- Facilitate access of rice producers to the formal financial system; and
- Achieve the annual substitution of an estimated 3,700 tons of firewood by rice residues in 21 industries in the province of Ichilo and the mitigation of local environmental impacts caused by inadequate treatment of rice husks.

The project consisted of:

- Design and construction of a 600 kW rice husk direct combustion oven in Bolivia;
- Connection of the oven to driers in the mills, without affecting the existing firewood combustion system;
- Installation of a fan, to ensure air circulation from the oven to the driers; and
- Installation of a conveying belt to feed rice husks into the oven.

Actual execution of the project started only in August 2000, in view of delays in the establishment of the Biomass Fund as a financial mechanism for the projects. Execution was as follows:

- In June 2000, the branch office of BTG in Costa Rica was hired to provide the oven technology and CEDETI was hired for supervision of project execution;
- A new rice mill was selected for the pilot project as the initially selected producer has desisted to participate in the project due to the above noted delays;
- In December 2000, BTG selected the company to build the oven in Bolivia. The technical design was finalized and construction started;
- At the end of March 2001, the first tests were carried out on the oven. Tests were not successful, because of the following problems: (i) insufficient air circulation in the oven; (ii) incomplete heat exchange; and (iii) inefficient and incomplete combustion of residues. As a result, the oven did not reach its design capacity and rice drying was not satisfactory;
- BTG then focused on (i) solving the above-noted problems; and (ii) training Bolivian technicians and operators in the mills on technical aspects and operation of the oven. At the end of December 2001, the oven capacity was increased to 450 kW, as air circulation in the oven had been improved, and the oven was ready for rice drying tests;
- However, due to floods in the region, the rice mills could not collect sufficient rice for the drying tests and, with help from CEDETI, raw rice had to be brought from another region to carry out drying tests in May 2002;
- During the tests, the oven capacity reached 460 kW, which was sufficient to dry a full load of raw rice (90 tons). The process took 14 hours, whereas drying with firewood takes between 18 and 20 hours to process the same load;

- After validation of the technology, CEDETI organized two demonstration workshops in the mill, with the presence of producers of other mills, representatives of the Municipal Government of Yapacaní and a local (FI); and
- As a result of these two workshops, CEDETI received requests for technical assistance from sick industries interested in the new technology.

Results

In spite of implementation difficulties, the project achieved several of its objectives, which are as follows:

- The pilot project built in one rice mill demonstrated the feasibility of the proposed technology. Although actual profitability of the project was not fully evaluated, it is worth noting that: (i) total substitution of firewood is possible in the rice mills; (ii) the oven design and quality was accepted by the producers; and (iii) further improvements in the oven performance are possible, which would further improve the project profitability for the industries;
- A local mechanical workshop has acquired the knowledge and capacity to replicate the improved oven technology;
- CEDETI, as an ESCO, is now able to provide technical assistance to rice producers for technology transfer and management;
- As a result of training and information activities conducted around the pilot project, CEDETI has received requests for technical assistance from six industries, which could lead to request for funding from the Biomass Fund; and
- There are reasonable prospects for the annual substitution of 2,100 tons of firewood by rice husks in seven industries in the area of Yapacaní.

Annex 4

Development of a Portfolio of Biomass Efficiency Projects in Rural Industries of the Department of Cochabamba

Background

Surveys on biomass consumption in small rural industries which were conducted under the NBP in the Department of Cochabamba in 1998 (Table A4.1).

Table A4.1: Estimated Firewood Consumption of Rural Industries in the Department of Cochabamba

Estimated Firewood Consumption (tons/year)				
Industry-type/Size	*Chicha*	*Brick-making*	*Gypsum*	*Lime*
Large	851	2,854	3,263	0
Medium-sized	0	29,379	10,712	245
Small	12,932	3,230	10,198	0
Total	13,783	35,463	24,173	245
Share (percent)	19	48	33	
Total Estimated Firewood Consumption: 73,664 tons/year				

The gypsum industry was thus selected to design and execute a demonstration project within the NBP, on the basis of the following criteria: (i) level of organization of producers; (ii) geographical concentration of producers; and (iii) existence of efficiency barriers that could be solved by the project.

In the localities of Suticollo and Montenegro, located at a distance of 35 km from the city of Cochabamba, in the province of Quillacollo, there are more than 100 rural industries that produce gypsum as a basic construction material. Although part of these industries have access to natural gas, most industries are still using firewood obtained from forested areas in the Lower Valleys of the Department of Cochabamba.

A typical gypsum industry normally requires only basic assets for production which are as follows: (i) an adequate area for storage of stones; (ii) one or two ovens for dehydration; and (iii) an electric mill or a mechanical mill (pulley powered by a truck) for grinding the stones.

Most of the ovens used in these industries have a similar design: cylindrical ovens with a capacity of about 28 m^3 (volume), which can hold on an average 19,540 kg of stones which can produce 16,400 kg of gypsum, that is, about 820 bags of 209 kg each.

The basic process consists of manual loading of the stones into the oven, dehydration using firewood for combustion, unloading, grinding, and packing in paper bags of 20 kg.

The energy efficiency of the process prospects for improvements were assessed through an energy audit. It was found that losses due to process intermittency, radiation, conduction, and convection amounted to 79 percent of the total energy from firewood combustion. In case of natural gas use, losses amounted to 65 percent only.

One of the most important results of the audit showed that the cost of fuel represented 31.5 percent of production costs in case of firewood use, and 10.4 percent in the case of natural gas use.

The principal technological problems of gypsum producers related to low efficiency of the process and poor quality of the final product due to: (i) the poor quality of combustion; (ii) excessive temperatures; (iii) irregular heat distribution; and (iv) excessive size of stones loaded into the oven; and (v) intermittency of the process.

A total of 103 industries were identified in the project area, 75 of which were without access to natural gas. Despite the technical and economic benefits of using natural gas for the production of gypsum, there were physical, financial and information barriers to the use of this fuel in all industries. Some industries were too dispersed or too far away from the existing gas distribution grid, making financially unviable the extension of the grid by the gas distribution company. Most industries faced difficulties in obtaining the financing for the investment required for switching from firewood to natural gas, as well as the costs of connection to the natural gas distribution grid. Producers were not knowledgeable about the technology based on natural gas use and feared government intervention in their business on the grounds of environment impact of their industry. The gas distribution company considered the producers as high-risk consumers.

In this context, in 1999, a meeting was held in Cochabamba, with participation of: (i) several gypsum producers of Suticollo and Montenegro; (ii) the ESCO Energética; (iii) BTG; (iv) the VMEH; (v) EMCOGAS, the gas distribution company; (vi) some financial institutions; and (vii) NBP staff.

As a result of this meeting, a project concept was prepared, with the following objectives:

- Reducing the consumption of biomass in gypsum industries in Suticollo and Montenegro, through substitution with natural gas, with positive economic and environmental impacts;
- Resolving institutional barriers to facilitate access of gypsum industries to the natural gas distribution grid;
- Making available a financial mechanism to cofinance investments by the gypsum industries to substitute firewood with natural gas;
- Strengthening technical assistance capacity to support gypsum producers; and
- Achieving a critical mass of substitution projects in a sufficient number of industries in the area, so as to allow the distribution company to consider extending the natural gas distribution grid.

Out of the 75 industries without access to natural gas in the area, 48 industries were identified, for which substitution was making financial sense and who were willing to borrow for the associated investment.

To connect these 48 industries to its distribution grid, EMCOGAS would have to install 3,209 meters of secondary pipes, eight derivations from the principal gas pipeline, six road crossings, 164 m^2 of paving and 19 connections to secondary lines. The investment in substitution equipment to be made by each producer amounted to between US$3,550 and US$9,500. Total investment by producers would amount to US$247,800. Assuming availability of credit at 13 percent annual rate, the IRR of substitution projects was 44 percent over 20 years, with an average period of return on the investment of 4.6 years. The expected substitution of firewood in the 48 industries would be a total of 5,590 tons annually.

The project approach was as follows:

Financial: Although the financial mechanism of the NBP had not been established, the *Banco Nacional de Bolivia, Banco Unión* and the NGO ANED were interested in granting credits to the gypsum producers.

Technical Assistance: The ESCO ENERGÉTICA had to develop technological and financial management capacities to support the producers in the design and operation of the individual projects, the preparation of credit requests and helping achieve connection to the natural gas grid.

Institutional: ENERGÉTICA would become a competent promoter of substitution projects, with capacity recognized by all stakeholders. At the same time, the NBP developed coordination with: (i) the Municipality of Sipe Sipe, for facilitation of the project tasks; and (ii) the Prefecture of the Department of Cochabamba, for monitoring the resulting impacts of the project and approving the environmental licenses required for project development.

Actual execution of the project started only in September 2001, due to delays in the establishment of the financial mechanism for the projects (Biomass Fund). Execution of the project can be summarized as follows:

- After creation of the Biomass Fund in October 2000, ENERGÉTICA was entrusted with a new effort to mobilize interest of producers in participating in the project;
- Although local conditions had changed, in April 2001, a new portfolio was formulated with 44 projects, including for each project/industry: an energy audit, a complete evaluation of the production cycle, an assessment of guarantees/collaterals and a financial evaluation;
- ENERGÉTICA, in representation of producers, identified seven financial institutions (banks, cooperatives, financial NGOs) which might provide first-tier lending under the Biomass Fund;
- In the end, the 44 projects were presented to the Biomass Fund by ANED, a financial NGO with extensive experience in rural microcredit for production;
- All conditions required for producers to access the Biomass Fund were satisfied in September 2001. Previously, EMCOGAS and ANED had subscribed a cooperation agreement which contemplated the inclusion of natural gas installations in the industries as part of the credit guarantee;
- EMCOGAS committed to cofinance connection costs, with a contribution of 3,000 meters of natural gas secondary pipelines; and
- Due to financial difficulties faced by gypsum producers (economic crisis leading to slowdown of the construction industry and a fall of gypsum market prices by about 35 percent in 2001), in October 2001 the goals of the project were reduced from 44 to 30 natural gas connections. As of April 2002, eight connection projects had been concluded and 10 additional projects had been approved for financing under the Biomass Fund and were awaiting execution.

In October 2001, ENERGÉTICA started developing a portfolio of projects in rural industries in the Department of Cochabamba under the same principles and methodology as had been used for gypsum industries. The portfolio includes the following projects in 174 industries:

- Substitution of firewood and LPG with natural gas in 63 chicha breweries;
- Substitution of firewood and LPG by natural gas in 23 bakeries;
- Substitution of firewood with natural gas in 46 brick-making industries;
- Substitution of firewood with natural gas in 14 rice and wheat mills;
- Substitution of diesel motors by electric motors in 23 gypsum industries;
- Substitution of LPG by natural gas in one ice industry in Quillacollo;
- Substitution of LPG by natural gas in one chicken industry;
- Substitution of LPG by natural gas in one chicken slaughterhouse; and
- Substitution of LPG by natural gas in one agroindustry (dehydrated fruits for export).

Close to 50 percent of the project portfolio has been submitted to the Biomass Fund by ANED. EMCOGAS had made the same cofinancing commitment for connection costs as in the case of gypsum projects. Producers have committed to finance 50 percent of the costs of technical assistance and ENERGÉTICA has approached several national institutions (SAT and PROSAT) for funding the rest of the cost of technical assistance.

Results

Several of the project objectives have been achieved:

- Lessening of barriers identified at the beginning of the project resulting in the execution of investments for firewood substitution in the first eight industries;
- The ESCO ENERGETICA has consolidated its role and capacity as project promoter and technical assistance provider;
- ANED has developed a new market niche for the rural microfinance market; and
- There are good prospects for the execution of a total of 18 substitution projects which would represent total savings of 2,280 tons of firewood each year.

Annex 5

Efficient Biomass Use in Gypsum Industries in the Highlands

Background

The studies carried out by NBP in 1998 to collect information on biomass consumption in rural industries showed that there are 338 gypsum industries in the highlands of the Department of La Paz, with an approximate annual consumption of 30,000 tons of firewood and 10,000 tons of dung, with negative environmental impacts. Energy efficiency of these industries is very low, not exceeding 20 percent.

A workshop was organized in 1998, in the gypsum-processing area of Estación Pando, Municipality of Corocoro, Province of Pacajes in the Department of La Paz, to analyze difficulties faced by family-scale gypsum producers, as the quality and market prices of their products (called "Pando" stucco[2]) were decreasing. Participants in that workshop, included: (i) stucco producers; (ii) the consulting firms BTG, Sistemática Consultores and PA Energía; and (iii) NBP staff. As a result of the workshop, a working relationship was established between Sistemática Consultores and the stucco producers of Estación Pando, to facilitate the collection of information by means of interviews and energy diagnosis of gypsum producers.

It was found that only minimal improvements could be achieved in traditional ovens used by gypsum producers, which did not justify the associated investments. Thus, two alternatives were considered to increase production efficiency: (i) relocate gypsum processing in an industrial plant to be located in the city of Viacha, with easy and cheap access to natural gas, which would enable efficient burning of gypsum in a continuous large-scale rotating oven; and (ii) design and implement a semicontinuous oven for artisan producers, to improve efficiency and product quality. Under the first alternative, there would be limited value-added for gypsum producers in Estación Pando, as raw material would be processed out of which area; also, it was likely that artisan gypsum production would persist, with continued environmental impacts and financial difficulties for the producers. The second alternative was thus pursued under the NBP.

The design of a semicontinuous oven implied a technological leap in stucco processing, aimed at lowering energy costs and improving quality of the product, so as to have access to better markets at higher prices. The oven design was based on the following considerations and principles to obtain high quality stucco: (i) using a heat recovery system similar to that of continuous ovens; (ii) design of the combustion chamber to facilitate treatment of gypsum

[2] *Stucco is a semihydrated gypsum.*

at a controlled temperature, (iii) lowering the size of particles to a minimum; (iv) achieving an energy efficiency of about 50 percent; and, finally; (v) taking into account the restrictions faced by artisan producers: lack of access to electricity and natural gas, limited availability of labor, and so on.

The oven was designed for a production capacity of 1 ton/hour which would allow total production of over 6,000 tons/year. Investment cost would amount to US$29,000. The financial analysis was carried out on the basis of an average price of b$2.9/fanega of stucco (35 kg), that is, about US$14.5/ton. With average profits of US$ 4.5/ton of stucco, the projected IRR would be 24 percent (with borrowing at 15 percent for investment costs).

The oven could accommodate the average processing needs of eight producers (about 50 tons a month). However, only four families showed interest in participating in the project and were willing to supply raw materials for processing in the oven. As this level of production load would not be sufficient to ensure financial viability of the operation, the project in Estación Pando was suspended.

In October 2001, the NBP recruited Sistematica to develop a portfolio of projects for gypsum industries in other departments. In March 2002, the financial intermediary ANED presented for financing under the Biomass Fund, several projects of semicontinuous gypsum ovens for two groups of producers in the Departments of Tarija and La Paz. In Tarija, the projects involve artisan producers, as in Estación Pando. Conversely, producers of the community of Huayco export their products to Paraguay, with higher quality requirements and better price than the local market.

In addition, in April 2002, Sistemática completed the construction of semicontinuous oven in the facilities of a company which exploits and processes nonmetallic minerals in Sucre.

Annex 6

Rational Biomass Use in the Production of Ulexite

Background

Surveys of biomass consumption which were conducted in rural industries in 1999 with support from the consulting firm, Sistematica, allowed to identify the production of ulexite as an important economic activity in the region of Potosi, though with significant impacts on degradation of local biomass resources due to the intensive use of yareta[3] as an energy source for the production process.

Ulexite[4] is a complex mineral that is directly deposited in arid regions from the evaporation of water in intermittent lakes. In Bolivia it is found in the region of salt lakes southwest of Potosí, where its exploitation has been growing over the last decade. Ulexite is exported mainly to Brazil, and to other countries through Chile. There are more than 30 companies which produce chemicals in Brazil, which require ulexite as raw material for the elaboration of products for agriculture, glass industry, enamel industry and others.

The treatment of ulexite in exploitation areas is based on significant consumption of *yareta* as a fuel through an inefficient process. The 12 industrial establishments in the region of Río Grande, near the Uyuni salt lake, which were surveyed under the NBP, process about 8,000 tons of ulexite in rustic ovens and consume an annual quantity of approximately 6,000 tons of *yareta*. Although the calorific power of *yareta* is rather low (3,516 kilocalorie(s) kcal/kg), its advantage resides in its low combustion, in addition to low cost. *Yareta* is exploited by the so called "*yareteros,*" inhabitants of communities in the province of Nor Lípez, who uproot the plant, let it dry and then take it to ulexite-processing plants. The NBP did not gather information on *yareta* consumption in ulexite industries in other regions in Bolivia, nor did it estimate *yareta* consumption in the sulfur industry or as a household fuel.

The production and processing of ulexite include the following steps:

Ulexite is extracted with manual tools (except for some companies which use machinery), from clay soils on the banks of salt lakes in the southwest of Potosí. Large blocks of ulexite are piled up on the production site to lower its humidity, during at least one week. This facilitates transportation of the ulexite to the treatment plant.

[3] Yareta (azorella compacta) *is a very slow-growing plant of the moss-type, large in size and with a bright intense green color, which is found in Bolivia's* puna *(highlands).*
[4] *Hydrated sodium calcium borate hydroxide, otherwise known as the "TV stone."*

Further solar drying on platforms at the plant reduces humidity from 40 percent to about 10-12 percent. The resulting concentration in boron oxide ($B2O^3$) increases from about 22 to 30 percent.

Ulexite is then dehydrated in ovens to reach a 40 percent concentration in $B2O^3$, as required by the market in Brazil. Ovens reach a temperature of 200ºC and consumes on an average about 7 kg of *yareta* per kg of processed ulexite.

NBP Activities

As opposed to other demonstration projects under NBP, the social environment in this area – *Río Grande* – was not favorable to consensus-building between the key stakeholders, including: (i) small ulexite producers associated in a rural cooperative in Río Grande; (ii) a private company processing ulexite mineral – with nonlocal owners, employees from the community and poor relationship with the cooperative; (iii) union leaders of the community in open confrontation with the company; (iv) the Municipal government not involved in the process, though worried about environmental degradation; (v) environmental organizations which criticized the company; and (vi) leaders of civil society of the city of Uyuni, generally with ideological opposition to private companies.

For these reasons, instead of trying to achieve consensus between stakeholders, NBP focused on providing them with information on options to improve efficiency in the ulexite production process as well as on the stock and patterns of use of the *yareta*, as a first step toward consensus-building on these issues, to contribute to improving the social environment in the area. The consulting firm, Sistematica, was entrusted with two studies: (i) a review of options to improve efficiency in ulexite-processing, including substitution options; and (ii) an inventory of *yareta* resources in the region, prospects for sustained production of *yareta* and options for alternative uses of *yareta* with lower environmental impact.

The first study reviewed the following aspects: the dehydration process in oven and its relation to product quality; the incidence of $B2O^3$ concentration levels on the market price of ulexite; and the prospects of export markets for other boron products than ulexite (for example, probertite – that is, calcinated ulexite). The study's findings are summarized below:

- The $B2O^3$ concentration (40-43 percent) of ulexite exported to the Brazilian market can be achieved by simply washing the mineral (lixiviation) and drying it at low temperatures, that is, without the need for product dehydration as currently performed. Ulexite purity through this process would reach 98 percent;

- Ulexite dehydration curves were established for different temperatures and duration of the dehydration process. These allowed to define a new modality for dehydration of ulexite – in a profitable and environmentally sustainable fashion; and
- The new process would include the lixiviation of ulexite by producers on production site, achieving an increase in $B2O^3$ concentration by 3 percent which would represent an additional financial benefit of about US$15/ton of product. The ulexite would then be dehydrated to a high $B2O^3$ concentration (50 percent) in LPG- or natural gas-fueled ovens which efficiency (50 percent) is about double that of *yareta*-fueled ovens; additional benefits through this process would represent another US$40/ton.

However, the substitution of *yareta* with LPG or natural gas would have a negative impact on local families involved in *yareta* exploitation activities in the province of Nor Lípez, and adequate mitigation measures should be designed and implemented for these families.

The second study conducted an inventory of the stock and growth of *yareta* resources in the province of Nor Lípez and assessed the prospects for sustainability of the current pattern of *yareta* use in the province. The main findings of the study are summarized below:

- The estimated stock of *yareta* in the province of Nor Lípez would be about 100,000 tons of biomass, in medium-sized and large plants (diameter over 35 cm) which could be exploited;
- There would be about 1.6 million *yareta* plants smaller than 35 cm compared to about 13,000 plants with diameter over 35 cm. This would point to an average growth in plant diameter of only 1.4 mm/year. Thus, plants like the ones often used in ulexite plants would be over 1,000-year-old; and
- The annual growth of the stock of exploitable *yareta* was estimated at about, 1000 tons. This compares to an estimated annual consumption of 10,000 tons for the ulexite industry (60 percent) and other small industries plus the household sector (40 percent). Thus, if current consumption patterns continued, the estimated stock of *yareta* in the province of Nor Lípez could be completely depleted in a little more than a decade. This confirms that clearly *yareta* cannot be considered a renewable biomass resource, contrary to other forms of biomass.

The study also reviewed the potential for production of *yareta*-based essential oils, through different tests. Although production of these products is technically feasible, competitiveness would be very low because of production costs.

Results

The results of the studies were discussed with stakeholders, in particular with the above mentioned private company and with small producers. Although these dissemination activities did not result in requests to the Biomass Fund for financing of *yareta* efficiency projects, the private company took action on its own and made several investments to improve its production process, including: (i) incorporation of product lixiviation as part of the process; (ii) installation of a new LPG-fueled plant for ulexite dehydration; and (iii) construction of a solar predrying system, though with limited success. It is expected that the company will achieve substitution of most of its *yareta* consumption.

As a result of NBP support through Sistematica, a project for improved production of ulexite in a company (Company Circuata) operating in the south of Potosí, in the community of Apacheta, near the Chilean border, was presented to ANED and then to the Biomass Fund in March 2002. ANED submitted an ulexite pellets production project to the Biomass Fund. The project includes: (i) the production of a new type of product (ulexite pellets) for exports and the national market, which maximizes local value-added; and (ii) the total substitution of *yareta* by geothermal energy and LPG in the process of ulexite dehydration.

The NBP also allowed the ESCO ENERGETICA to consolidate its role and capacity as project promoter and technical assistance provider on energy efficiency projects in ulexite industries

Annex 7

Efficient Biomass Use in Brick-making Industries

Background

Studies conducted under the NBP to estimate biomass consumption by rural industries in seven departments (La Paz, Cochabamba, Santa Cruz, Chuquisaca, Potosí, Tarija and Oruro) indicated that there are about 1,800 brick- and tile-making establishments in these departments, with an estimated annual consumption of approximately 125,000 tons of firewood and 127,000 tons of sawdust. Santa Cruz concentrates about two or three of biomass consumption by brick-making industries. The NBP undertook the review of options to increase energy efficiency in the brick-making industry in view of its significant use of biomass.

A workshop was organized in May 1998 with the participation of the NBP local staff and consulting companies (CEDETI, BTG, and PA Energía) to review the brick-making industry context and the options for improving energy efficiency in this industry. The main conclusions of the workshop were the following:

- Substitution of firewood with natural gas: Some producers in Cochabamba and Tarija have already switched to natural gas. Most others are too far from the natural gas grid, although in many cases natural gas would be competitive compared to firewood use. Switching to natural gas won't be feasible for about 1,600 producers;
- Use of gasified rice husks: this technology would be limited to Yungas (La Paz) and Ichilo (Santa Cruz), where rice husks are available;
- Increased efficiency in biomass use: Significant improvements are possible in most brick-making industries without substantial changes in the production system;
- The comparative analysis of biomass consumption patterns and production techniques indicates that brick makers with high capacity ovens (between 18,000 and 40,000 units per batch) have an energy consumption under 2 MJ/kg, while brick makers with medium-size ovens (between 7,000 and 18,000 units per batch) consume between 2 and 3 MJ/kg. Small industries (less than 7,000 units per batch) have an average consumption higher than 3 MJ/kg. Producers in the area of San Carlos (Department of Santa Cruz) are more efficient than producers in other departments; and
- Brick makers with lower energy consumptions often incorporate sawdust in the clay used for brick production, in a proportion which is limited by brick resistance and price aspects (sawdust in excess causes excessive porosity in the bricks, and sawdust prices are higher than firewood's).

The NBP selected the Municipality of San Carlos, province of Ichilo, Department of Santa Cruz, to develop a demonstration project with 30 small artisan brick producers in that area – most of them experienced producers coming from other regions. The 34 ovens used by these producers were found to have an average efficiency of about 44 percent.

The Project

The objective of the project was to achieve a specific energy consumption of less than 2.0 MJ/kg, leading to reduction in production costs. The project would incorporate normalized patterns in clay preparation, oven design and construction and burning techniques for artisan brick production, to increase energy and economic efficiency. The project would hinge on promotion actions by municipal authorities and local development actors, and on dissemination, information and capacity-building actions with support from the NBP and consulting companies. The project was expected to be disseminated and replicated in other departments.

The NBP recruited the consulting firm CEDETI to conduct filed tests to measure oven efficiency and recommend better practices in terms of clay preparation, oven design and oven operation as well as to prepare training materials and conduct several training events.

Results

On conclusion of the project, the following results had been achieved:

- Preparation of an energy efficiency manual for the brick production and elaboration of audiovisual training materials;
- Training of workers from the cooperative of brick producers in San Carlos, who can now act in turn as trainers, in association with CEDETI, to extend the delivery of technical assistance services for improving energy efficiency in brick-making ovens in other areas and departments;
- Definition of a replication strategy, including the following aspects:
  - Promotion would be ensured by municipal governments and development institutions, by means of workshops to discuss energy and financial issues in brick-making and to present the energy efficiency manual;
  - CEDETI and its team of trainers would provide technical assistance services on efficient brick-production for producers in the Department of Santa Cruz and other departments, through course and workshops with the objective of identifying and training additional trainers. These services would be financed by municipal governments or development institutions interested in addressing the severe environmental impacts of brick production;
  - The target for dissemination and replication of the energy efficiency technological package would be over 1,300 brick-makers, to be achieved in a period of five years (260 brick makers a year). The expected impact achieved in biomass cost reduction for each brick-maker would be about US$68/year in the case of an oven of 25,000 units per batch with 10 batches/year; and
  - Reaching that target would result in an estimated reduction of biomass consumption by about 60,000 tons of biomass, equivalent to avoiding deforestation of about 9,000 ha/year.

Annex 8

The Biomass Fund

Background

The NBP is financed by the Netherlands and implemented by ESMAP through a consultant team based in Bolivia and in coordination with the VMEH. The NBP includes the execution of projects and technical assistance for the rational use and substitution of biomass, with the objectives of reducing the negative impacts of biomass use on the environment and increasing the profitability of small industries (generally located in rural areas) and their positive impacts on the local economy.

Several projects have been identified which would be commercially viable and should have an environmentally positive impact, because they diminish contamination and deforestation. The main barriers which impede the execution of these projects are the lack of affordable financial mechanisms specialized in such projects and the lack of information of industries on opportunities in biomass efficiency. The latter barrier is being addressed through specific technical assistance activities also financed under NBP which will help with the identification and design of relevant projects and the dissemination of corresponding technologies. Regarding the first barrier, there is a need to improve the conditions of and access to credit by small industries; this should be done through financial intermediaries in order to minimize distortions in small commercial markets. ESMAP, through NBP, and other donors would provide limited funds for bringing down the cost of credit or increasing loan maturity for a first group of projects to be implemented in several types of industries (rice mills, gypsum industry, small sugar industries, and others to be defined). It is expected that these projects will increase the level of confidence and interest of both financial intermediaries and industries for biomass efficiency projects, which would be fully financed by financial intermediaries.

The intermediation of NBP funds for the first generation of small projects will be done through a second-tier FI. Based on a consultancy which reviewed the market for this type of financing in Bolivia, FUNDA-PRO was selected for managing the Biomass Fund. FUNDA-PRO is a private nonprofit foundation which provides financing for projects with social and economic benefits. Their objective is to support and strengthen the private sector by facilitating the decentralization and expansion of credit in favor of social segments and regions which face difficulties in accessing credit. Since its foundation in 1992, FUNDA-PRO has worked efficiently as a second-tier FI, and has received funds from different institutions like the Agency of International Cooperation of USAID.

Technical assistance for identifying and structuring biomass efficiency projects will be provided by local consulting companies supported by NBP (Energy Services Organizations, ESOs) and through CPTS. The CPTS, was created in 1998, by means of an agreement between CNI and VMEH. The purpose of CPTS is to provide technical support to projects

which reduce contamination and increase energy efficiency. The CPTS is financed by USAID, Denmark and NBP. The Biomass Fund is consistent with a national initiative for cleaner industrial production (PROLIMP) which is promoted by the CNI. It is foreseen that PROLIMP will be developed under similar principles as the Biomass Fund. The possible participation of FUNDA-PRO in PROLIMP would be reviewed in due time with CNI and donors contributing to PROLIMP.

Eligibility of Biomass Projects

Project which will be eligible for funding from the Biomass Fund should have the following characteristics, except as otherwise agreed with the International Development Association (IDA):

- Industries using biomass as their main energy source;
- Total cost of less than US$100,000 per project;
- Aimed at reducing unit consumption of biomass (relative to production) with reduced negative impacts on the environment;
- Co-financing by industries of at least 5 percent of project costs; and
- Positive NPV of the project's estimated cash flow at a discount rate acceptable to the financial intermediaries.

The first projects to be funded will be the ones already identified by NBP:

- Substitution of firewood by bagasse in the production of "*chancaca*" in small sugar industries in Santa Cruz. For this project, ESCO CEDETI and the technology providing consultant BTG have already been contracted by ESMAP as part of the NBP;
- Substitution of firewood by rice residues in rice industries in Santa Cruz. For this project, ESCO CEDETI and the technology providing consultant BTG have already been contracted by ESMAP as part of NBP; and
- Substitution of firewood by natural gas in small gypsum industries in Cochabamba. For this project, ESCO ENERGÉTICA has already been contracted by ESMAP as part of NBP.

Agents

The following agents will participate in the execution of the projects:

- Industries. These are industries which use biomass as their main energy source. The client is the beneficiary of a biomass project;

- ESCOs. They are in charge of identifying and developing the biomass projects, to propose them to the financial intermediary and to facilitate their execution;
- Financial intermediaries: The financial intermediaries lend funds to industries, using their own resources and those originating from the Biomass Fund. They can be a private bank, a NGO, a private financial fund, a savings and loan cooperative or any other type of financial intermediary accepted by FUNDA-PRO and IDA;
- FUNDA-PRO will act as a second-tier FI and administrator of the Biomass Fund, according to the conditions set forth in the agreement entered into with IDA; and
- CPTS in CNI. CPTS will provide technical assistance to the Biomass Fund by promoting the introduction of efficient technologies in industries, providing information on energy efficiency best practices and experiences for industries as well as advice and training for ESCOs and advising FUNDA-PRO and financial intermediaries on the technical soundness of projects proposed by industries for financing from the Biomass Fund.

Roles of agents

The agents will have the following roles:

The ESCOs will:

- Identify candidate industries and eligible biomass projects;
- Help prepare the request for financing from the financial intermediary;
- Identify potential financial intermediary for each project; and
- Provide the new technology, or subcontract all necessary works to provide the new technology, or assist the industries to select, contract, and supervise the providers of the new technology.

The industry will:

- Contract the ESCO to provide technical assistance and/or all works needed to implement the new technology/project;
- In case of separate contracts, also contract the technology providers; and
- Borrow funds from a financial intermediary for no more than 95 percent of the total project costs.

The financial intermediary will:

- Review and evaluate projects proposed by industries and approve those projects which qualify for lending.

CPTS will:

- Provide information, advice and training to ESCOs and industries; and
- Advise FUNDA-PRO and financial intermediaries on the technical soundness of projects proposed by industries for financing from the Biomass Fund.

FUNDA-PRO will:

- Manage the Biomass Fund;
- Evaluate projects which were prepared by the industries in collaboration with ESCOs and proposed to the financial intermediaries in order to decide on the eligibility of these projects for financing from the Biomass Fund; and
- Until December 31, 2001, the services of ESCOs and CPTS will be financed by ESMAP under NBP. Thereafter, it is expected that the industries would finance the services of ESCOs and the financial intermediaries and FUNDA-PRO would finance the services of CPTS, as needed.

Eligible financial intermediaries

The following are the general eligibility criteria for the financial intermediaries who will be ascertained by FUNDA-PRO, and reviewed by IDA, the first time FUNDA-PRO enters into a contract with a financial intermediary and every six months thereafter:

- Adequate profitability, capital and portfolio quality as confirmed by audited financial statements;
- Acceptable levels of loan collections;
- Appropriate capacity, either internal or contracted, to carry out subproject appraisal;
- Capacity to mobilize financial resources; and
- Appropriate prudential policies, administrative structure, and business procedures.

If standard eligibility criteria currently used by FUNDA-PRO for assessing its financial intermediaries are found to be acceptable to IDA, the above mentioned review by IDA will only take place on an ex post basis.

Initial financing

The Biomass Fund will start its operation with a total amount of US$1,000,000, to be financed as follows:

- US$800,000 from the funds of the Dutch Government for NBP; and
- US$200,000 from FUNDA-PRO's own funds (not to be used for pilot projects mentioned below).

Additional financial contributions

The Biomass Fund can receive other financial contributions, up to 20 percent of the total amount of overall project portfolio financed by FUNDA-PRO with these and other resources. Additional contributions to the Biomass Fund beyond this threshold will have to be reviewed and agreed upon by FUNDA-PRO. All financial contributions to the Biomass Fund will be administered in the same way as stipulated in this project brief. Each new contributor can define the type of project or industry which it wishes to finance, in agreement with FUNDA-PRO.

Additional revenues

The Biomass Fund will also count with the following revenues, to be accounted for separately from financial contributions and deposited in a separate account:

- Revenues from lending net interest (equal to lending interest minus FUNDA-PRO's 2 percent commission, minus taxes) charged to the borrowers on the resources from the Biomass Fund (excluding FUNDA-PRO's own resources); and
- Revenues from borrowing interests earned by FUNDA-PRO on undisbursed funds in the Biomass Fund (excluding FUNDA-PRO's own resources and after deduction of FUNDA-PRO's service fee of 1.5 percent, minus taxes).

As of January 1, 2002, FUNDA-PRO will use these revenues to support the development and evaluation of project portfolio, and/or to provide financing for new projects under the Biomass Fund.

Lending conditions from financial intermediaries to industries

The financial intermediary will evaluate the potential borrowers according to its practices and procedures and will decide which of the applicants can or cannot be subject of credit.

The financial intermediary will participate in two ways in the credit to the final borrower:

- Using their own resources, on which it will charge a positive interest rate (the market rate);
- Intermediating the resources of the Biomass Fund, for which it will receive a spread.
  – The interest rate charged to the final borrower will be calculated in the following way:

$$t_{final} = t_P \Pi_P + sp_P \Pi_N + t_N \Pi_N = t_P \Pi_P + (sp_P + t_N) * \Pi_N \quad (1)$$

where:

t_{final} is the interest rate paid by the final borrower

t_P, t_N are the interest rates paid to the financial intermediary (t_P) and the Biomass Fund (t_N) on their respective resources

sp_P is the spread paid to the financial intermediary for intermediation of the Biomass Fund resources

Π_P, Π_N are the financial contributions of the financial intermediary and of the Biomass Fund to the total loan

- The financial contributions are by definition such that
- $\Pi_P + \Pi_N = 1$ (2)
- The final interest rate at which the resources will be lent on to the final borrower must never be inferior to the maximum passive interest rate of the Bolivian banking system plus 1 percent point.

Negotiation between FUNDA-PRO and the financial intermediary

- FUNDA-PRO will evaluate, according to its own practices and procedures, whether a financial intermediary applying for funds qualifies or not to receive resources from the Biomass Fund;
- FUNDA-PRO will also verify whether the projects for which the financial intermediary seeks financing from the Biomass Fund fit the eligibility criteria as defined in this project brief;
- FUNDA-PRO will negotiate with the financial intermediary: (a) the share of its financial resources in the total loan to the final borrower; (b) the final interest rate to be paid by the borrowers; and (c) the spread to be paid on the resources of the Biomass Fund; and

- The financial intermediary will assume 100 percent of risk toward FUNDA-PRO for the funds from the Biomass Fund on-lent to the final borrowers.

Conditions to comply with between FUNDA-PRO and the contributors

- The interest rate to be paid to the Biomass Fund will be calculated in the following way

$$t_N = t_F \Pi_F + (t_{INT} + t_A) \Pi_A \quad (3)$$

where:
t_N is the interest rate to be paid on the resources of the Biomass Fund
t_F, t_A is the interest rates to be paid to FUNDA-PRO (t_F) and to other contributors (t_A) for their resources, respectively
t_{INT} is the interest rate to be paid to FUNDA-PRO for intermediation of financial resources other than from the NBP
Π_F ,Π_A are the financial contributions of FUNDA-PRO and other contributors to the Biomass Fund

- The contributions are by definition such that

$$\Pi_F + \Pi_A = 1 \quad (4)$$

with $$\Pi_A = \Sigma_{i=1}^{n} \Pi_{Ai} \quad (5)$$

and $$t_A = \Sigma_{i=1}^{n} (t_{Ai} * \Pi_{Ai}) \quad (6)$$

where A_i is contributor no. i and n it is the total number of contributors.

- Upon signature of the present agreement, the only contributors to the Biomass Fund are IDA and FUNDA-PRO, so that equations (3) and (4) become:

$$t_N = t_F \Pi_F + (t_{INT} + t_{BM}) \Pi_{BM} \quad (3)$$

with $$\Pi_F + \Pi_{BM} = 1 \quad (4)$$

where t_{BM} and Π_{BM} are the interest rate and the contribution of IDA in the Biomass Fund.

The interest rate which FUNDA-PRO gets paid for its resources (tF) will be similar to its opportunity cost, that is to say, similar to the effective interest rate of the national banking system for deposits on fixed term in foreign currency over more than 360 days, as published in the information letters of the *Superintendencia de Bancos y Entidades Financieras* (Superintendence for Finance Entities and Banks) (SBEF). The rate to be

paid to FUNDA-PRO for intermediation is 2 percent. The interest rate to be paid on the resources of other contributors (tA) must be superior to 0 percent.

FUNDA-PRO will assume, toward the Biomass Fund, 100 percent of the risk for the resources given to the financial intermediary.

In the case of other contributions to the Biomass Fund, FUNDA-PRO commits to analyze and confirm through its board the possibility of leveraging FUNDA-PRO's resources together with these additional contributions.

Pilot Projects for the Introduction of New Technologies

In some cases, the potential projects identified by ESCOs may be based on technologies which are not yet available or not known well enough in Bolivia or in the project region, so that no single industry wishes to borrow from a financial intermediary for an eligible project, although a significant number of potential beneficiaries are likely to commit to a loan in case the potential benefits of the new technology were demonstrated and proven. In these cases, FUNDA-PRO may decide, with IDA's approval – based on a mechanism to be established shortly after the signature of the Biomass Fund agreement, to finance on a conditional grant basis each first project of such a type to be carried out in Bolivia (pilot project). For a pilot project grant, the loan from FUNDA-PRO may reach up to 100 percent of the total project cost and this loan will be transformed into a grant if the project is not successful in financial and technical terms, as per criteria preestablished with ESMAP team. The total amount of such grants by FUNDA-PRO, including the remuneration of consultants to verify project performance, shall not exceed 10 percent of the total funds in the Biomass Fund. FUNDA-PRO will not use its own resources to finance pilot projects. Up to 10 percent of the Biomass Fund could continue to be used for financing pilot projects beyond December 31, 2002.

Technical guidance for the Biomass Fund

A technical committee will be established for providing guidance on the Biomass Fund. The committee will: (a) advise on issues arising in the implementation of projects financed under the Biomass Fund; and (b) contribute to the mobilization of additional funds mentioned under above paragraph 7 and advise on the projects which could be eligible for financing under these funds. The committee will include a representative of: (a) the *CNI*; (b) the ESMAP team in La Paz; (c) IDA; (d) other contributors to the Biomass Fund; (e) the National Directorate of Energy; and (f) FUNDA-PRO. The committee would meet on a quarterly basis and its meetings will be organized by the ESMAP team in La Paz. The committee will remain operational at least during the effectiveness of the agreement between FUNDA-PRO and IDA regarding the Biomass Fund.

Annex 9

Portfolio of Biomass Efficiency Projects Prepared for the Biomass Fund

Table A9.1: Portfolio of Biomass Efficiency Projects Prepared for the Biomass Fund

Sector	*No. of Industries*	*Investment costs (US$)*	*Industry Contribution (US$)*	*To be Requested from Biomass Fund (US$)*
Brick-making Industries (Cochabamba)	63	373,799	25,118	328,665
Bakeries	25	99,071	5,103	86,026
Maize Mills	14	57,076	5,022	47,606
Chicha Breweries	90	395,993	19,104	348,295
Rice Mills	25	49,613	2,385	44,382
Various Enterprises	4	106,759	5,200	96,264
Oven (Huayco)	1	32,410	4,610	15,000
Oven (Pando)	1	28,710	1,160	18,000
Brick-making Industries (Oruro)	7	52,915	8,080	17,715
Chancaca	5	104,353	24,364	79,989
Total	235	1,300,699	100,146	1,081,942

Annex 10

Substitution of Biomass Fuels with LPG in the Rural Household Sector

Work conducted during the preparation of NBP indicated that about 38 percent of Bolivian rural households use LPG for cooking and consume about 50,000 tons of LPG per year, representing sales of about US$17 million. This work also indicated that households which purchase biomass fuels (firewood, dung) spend up to twice the amounts spent by households using LPG.

The NBP undertook a study on the promotion of LPG distribution for household use, including detailed surveys in rural areas with promising prospects for substitution of biomass with LPG. Areas were selected on the basis of four main criteria: (i) high price of firewood in the area; (ii) high proportion of commercialized firewood in the area; (iii) distance from the area to the closest LPG bottling plant higher than 100 km; and (iv) seasonal variations in LPG retail prices in the area.

Five rural areas of the country were preselected and visited so as to validate existing information, and study the perception of mayors and users in those zones as regards to increased use of LPG, as well as to analyze their willingness to cooperate in the study and fieldwork. In the end, three areas were selected for the study:

- The Municipal Mancomunidad (Association) of Río Beni, which covers the following localities in the province of General José Ballivián: Rurrenabaque, Reyes, Santa Rosa; Yucumo and San Borja of the Department of Beni. Additionally, this area includes the locality of San Buenaventura, located in the province of Abel Iturralde of the Department of La Paz;
- The Municipal Mancomunidad of Gran Chiquitanía; located in the northeast of the Department of Santa Cruz; which covers the following localities in the province of Velasco: San Ignacio de Velasco, San Miguel, San Rafael, Santa Ana and Santa Rosa de la Roca; and
- The Municipal Mancomunidad of the Mesothermal Valleys; located in the west of the Department of Santa Cruz, which covers the following localities: Mairana, Los Negros, Pampa Grande and Mataral, located in the province of Florida; Vallegrande, in the province of Vallegrande and Comarapa, located in the province of Caballero.

In order to collect socioeconomic information and data on monthly household energy consumption patterns, 300 families were surveyed in each selected area. The main results of the survey are summarized below:

- Final consumers in the three areas pay higher prices for LPG than the official price at national level (b$21 per cylinder of 10 kg), basically because of transportation costs;

Table A10.1: Prices of LPG Cylinders of 10 kg

	Price Paid by Final User (Bs)		*Differential*
Locality	*Average Local Price*	*National Price*	*Percent*
Río Beni	30	21	43
Chiquitanía	31	21	48
Valles Mesotérmicos	23	21	10

- In terms of fuel use, in the three areas there is a similar and relatively even distribution of households which firewood, LPG or both.

Table A10.2: Firewood and LPG Use in Households in the Three Areas (Percent of Households)

Fuel Use	*Rio Beni*	*Chiquitanía*	*Valles Mesotérmicos*
Only Firewood	35	27	27
Only LPG	28	31	31
Both	37	42	42
Total	100	100	100

- Gross energy consumption is much higher for households using only wood than for those that use only LPG (six times more in the areas of Beni and Chiquitanía, and four times more in the area of Mesothermal Valleys);

Table A10.3: Average Gross Energy Consumption for Cooking

	Gross Energy Consumption (Kcal/Household/Day)		
Fuel Consumption by Type of Use	*Río Beni*	*Chiquitanía*	*Valles Mesotérmicos*
LPG (LPG-only Households)	8,403	9,462	8,314
LPG (LPG & Firewood Households)	7,693	7,942	6,604
Firewood (LPG & Firewood Households)	47,897	63,215	31,271
Firewood (Firewood-only Households)	52,960	58,947	35,781

- In terms of useful energy (that is, after accounting for efficiency of energy equipment), the average energy consumption of households which use a combination of firewood and LPG, is significantly higher that that of households using either LPG or firewood alone;

Table A10.4: Average Useful Energy Consumption for Cooking

	Useful Energy Consumption (Kcal/Household/Day)		
Type of use	*Río Beni*	*Chiquitanía*	*Valles Mesotérmicos*
LPG-only	4,874	5,488	4,822
Firewood-only	5,296	5,894	3,578
LPG and Firewood	8,894	11,015	7,289

Note: Cooking efficiency was considered to be 10 percent with firewood and 58 percent with LPG.

- In all three areas, average expenditure for households using only firewood (obtained commercially) was found to be more than double the expenditure of households using LPG only; the savings would allow to recover investment costs for substitution (LPG stove and cylinder) in less than a year;

Table A10.5: Average Household Expenditure for Cooking Fuels

	Cost per Household (US$/Month)		
Type of Use	*Río Beni*	*Chiquitanía*	*Mesothermal Valleys*
Firewood-only	21.9	24.4	12.3
LPG-only	10.5	11.4	8.0

Note: Based on average costs of fuels in the three areas. Exchange rate during the study: 6.25 Bs/US$.

Other findings from the surveys include the following:

- The consumption of LPG is more important if households are smaller, younger, if the head of the family migrates regularly, has a higher level of schooling, if the family has improved housing conditions and if economic welfare is high;
- Households purchase firewood according to weight, and firewood is cheaper than LPG on a weight basis but not on an energy equivalent basis (as noted above);
- LPG consumption is not widespread essentially due to limitations in access to this fuel; and
- The total estimated firewood consumption in the three areas amount to about 62,000 tons/year.

The supply and marketing of LPG cylinders in the three areas covered by the study vary depending on the following factors: (i) distance to LPG bottling plants; (ii) dispersion of population in each area; (iii) quality of access roads; and (iv) types of transportation used.

Table A10.6: Sources of LPG Supply in the Study Areas

Sources of LPG Supply	*Río Beni*	*Chiquitanía*	*Valles Mesotérmicos*
Nearest Bottling Plants	Senkata (City of El Alto-La Paz)	San José de Chiquitos (Prov. Chiquitos of the Department of Santa Cruz de la Sierra)	Palmasola and Flamagas(City of Santa Cruz de la Sierra)
Other Plants Serving the Region	Trinidad (Capital of the Department of Beni)	Palmasola and Flamagas (City of Santa Cruz)	

Besides LPG bottling plants serving the three areas, several small LPG distributing companies operate in these areas (some of them registered with the Superintendency of Hydrocarbons), as well as some occasional distributors.

Table A10.7: LPG Distribution in the Areas of the Study

	Río Beni	*Chiquitanía*	*Valles Mesotérmicos*
No. of Identified distributors	11	2	5
Distributors Registered in the Superintendency of Hydrocarbons	5	2	3
Estimated Number of Cylinders Sold Monthly	11,808	7,835	13,172
Occasional Distributors	Yes	Yes	Yes

The study identified several obstacles to further penetration of LPG as a cooking fuel in the three areas:

- The cost of LPG cylinders is very high in parts of the rural areas due to high transportation costs and access difficulties during the rainy season (for example, a three fold increase in price during the rainy season was reported in San Matías, Chiquitanía);

- LPG supply is not guaranteed during the entire year, as some roads are inaccessible especially during the rainy season; and
- Households which collect firewood from nearby areas have limited incentives to switch to LPG as they don't allocate value to time spent by women and children in firewood collection.

The study estimated the potential LPG market in the three areas as shown in the Table below.

Table A10.8: LPG Demand (Year 2000)

Type of Demand	*Río Beni*	*Chiquitanía*	*Valles Mesotérmicos*
Current Demand (Cylinders/Month)	12,960	11,190	16,290
Unsatisfied Demand (Cylinders/Month)	1,153	3,355	3,095
Unsatisfied/Current Demand (Percent)	9	30	19

To improve the penetration of LPG in rural areas, the study proposed to establish small rural bottling plants to which LPG would be transported in cistern trucks with a capacity of 10 tons from wholesale selling points. LPG would then be distributed by truck to retail points for sales to consumers. This system would also generate local economic benefits. Locations were identified for the proposed rural plants, at intermediate points between wholesale plants and demand centers, as follows:

- In Beni, the ideal location for the plant would be the population of Yucumo, at the junction of the roads from San Borja and Rurrenabaque;
- The plant for Chiquitanía could be located near the urban center of San Ignacio (57 percent of total demand in the area), but at a distance of 6 km from the urban center – in compliance with safety standards; and
- The locality of Mataral would be the ideal location for a plant for the Mesothermal Valleys, because of its proximity to potential demand.

Investments required for a rural bottling plant would include two LPG filling stations (balances), a 10-ton cistern truck, a storage tank with a capacity of 30 tons, civil works and complementary equipment. Filling stations would be added over time to follow demand growth. Initial investment cost would be about US$200,000.

Municipal governments in the three areas showed interest in the proposed rural bottling plants, because of their potential role in reducing environmental impacts, supporting the local economy and improving household welfare. Local governments would award concessions to private operators for plant installation on municipal areas and might participate in cofinancing of investment costs (for example, through provision of land and existing buildings).

The study assessed the profitability of the proposed rural bottling plants under current and potential LPG demand in the three areas, with or without municipal and financial support. As shown below, bottling plants would be viable as a fully private business in the areas of Chiquitanía and Mesothermal Valleys, and with some municipal and financial support in the area of Beni.

Table A10.9: Investments in Rural Bottling Plants – Internal Rate (percent)

Purely Private Investment			
	Demand		
Area	*Current*	*Potential (Low)*	*Potential (High)*
Río Beni	5	8	13
Chiquitanía	8	17	20
Valles Mesotérmicos	13	22	25
With Municipal Cofinancing and Preferential Lending			
	Demand		
Area	*Current*	*Potential (Low)*	*Potential (High)*
Río Beni	11	15	19
Chiquitanía	14	24	27
Valles Mesotérmicos	19	28	31

However, the study also identified a regulatory obstacle to the establishment of rural bottling plants, as LPG retail price structure does not include a specific remuneration for the transportation of LPG from wholesale LPG installations to the proposed rural bottling plants. As regulations set up a maximum retail price and, in the absence of the above, noted remuneration, rural bottling plants would not be financially profitable thus making them unattractive for investment by private operators.

On conclusion of the study, NBP organized workshops with the communities and municipal authorities of Gran Chiquitanía, Río Beni and the Mesothermal Valleys to inform them on the results of the study. Subsequently, NBP consultants met with the Superintendency of Hydrocarbons and the VMEH to discuss the above mentioned regulatory obstacle. It was suggested to further review the price structure and specific norms which would make financially viable the operation of rural LPG bottling plants.

Annex 11

Activities Conducted Under NBP

Table A11.1: Dissemination/Communication Activities

Study/Project	*Consultant*	*Total Cost of Contract (US$)*	*Output*
Preparation of articles on NBP projects in rural industries	Walter Canedo	5,827	Article 1: Energy Efficiency and Agro-industry: Project Proposal for Rice and *Chancaca* Industries Article 2: Final Use of Biomass in Rural Industry Article 3: A Technological Leap in Rural Industry: Substitution of Firewood with Natural Gas
Seminars and activities for documentation of NBP results and dissemination with stakeholders	CINER	23,767	Seminar Reports *Yareta* – A renewable resource? institutional report
Dissemination of NBP results with national authorities	José Baldivia	12,031	Documents on NBP results and meetings with national authorities
Communication activities for NBP exit strategy	Canaru Comunicación Integral	29,293	Implementation of communication activities
	Total	**US$70,918**	

Table A11.2: Activities in the Household Energy Sector

Study/Project	*Consultant*	*Total Cost of Contract (US$)*	*Output*
Identification of potential zones for the establishment of rural LPG bottling plants	Centro de Estudios & Proyectos (CEP)	49,319	Final reports for the LPG project, including: Economic assessment of the installation of LPG bottling plants Socioeconomic analysis of LPG consumers Legal and regulatory aspects
Preliminary assessment of power generation with biomass in Riberalta	Consultores Galindo Ltda	53,743	Final Report on power generation with biomass in Riberalta
	Total	**US$103,062**	

Table A11.3: Activities in the Rural Industry Sector

Study/Project	*Consultant*	*Total Cost of Contract (US$)*	*Output*
Assessment of biomass consumption in the Department of Chuquisaca	Asociación Sucrense de Ecología (ASE)	5,990	Estimates of biomass consumption in small rural industries in the Department of Chuquisaca
Assessment of biomass consumption in the Department of Tarija	PROMETA	7,810	Estimates of biomass consumption in small rural industries in the Department of Tarija
Assessment of biomass consumption in the Department of Potosí	CIAC	7,076	Estimates of biomass consumption in small rural industries in the Department of Potosí
Energy diagnosis in rural industries of Bolivia	PA& PARTNERS	9,009	Overall energy diagnosis in rural industries of Bolivia
Energy diagnosis in rural industries of Bolivia	Lioubov Hanna	3,736	Technical evaluation report
Development of pilot projects in rural industries in the Department of Cochabamba	ENERGÉTICA	12,300	Development of pilot projects in rural industries in the Department of Cochabamba
Development of pilot projects in rural industries of Bolivia	SEMTA	9,919	Support to local counterpart. La Paz
Design of pilot projects in rural industries in the Departments of La Paz, Chuquisaca, Potosí and Tarija	SISTEMATICA Consultores	14,053	Design of pilot project for rational energy use in small rural gypsum industries in the department of La Paz Advice to identify projects in the Departments of Chuquisaca, Potosí and Tarija
Development of pilot projects in rural industries in the Department of Santa Cruz	Centro de Tecnología Intermedia (CEDETI)	15,132	Energy efficiency in the artisan production of bricks Substitution of firewood with rice husk in rice mills Substitution of firewood with bagasse in *chancaca* production

Study/Project	*Consultant*	*Total Cost of Contract (US$)*	*Output*
Identification and design of projects in rural industries of the Bolivian highlands	Sistemática Consultores	71,352	Project design of a semi continuous gypsum oven Estimate of biomass consumption and identification of actions in small rural industries of Oruro Proposal on new design for ulexite processing Study on *yareta* consumption
Support to design and establishment of the Biomass Fund	Carmen Crespo	14,844	Final consultancy report, including: Evaluation of candidate institutions to administer the Biomass Fund Draft contract for the fund administrator
ESMAP financing of Biomass Fund		800,000	
Technical assistance for the implementation of projects in rural industries of Bolivia	Biomass Technology Group (BTG)	25,200	Evaluation of a multiple oven for the production of raw sugar
Design of energy efficiency projects for brick production in the Department of Santa Cruz	Centro de Tecnología Intermedia (CEDETI)	30,998	Final Report: Energy efficiency in the artisan production of bricks in the Department of Santa Cruz
Technical assistance for the implementation of energy efficiency projects in rural industries in the Department of Cochabamba	Energética	44,378	Final Report: Implementation of projects for the substitution of firewood with natural gas in gypsum industries in the Department of Cochabamba
Technical assistance for the implementation of energy efficiency projects in rural industries of the Department of Santa Cruz	Centro de Tecnología Intermedia (CEDETI)	68,706	Final report: Implementation of projects for the substitution of firewood with bagasse in the production of raw sugar (*chancaca*) and the substitution of firewood with rice husks in rice mills in the Department of Santa Cruz

Study/Project	*Consultant*	*Total Cost of Contract (US$)*	*Output*
Technical Assistance for the Implementation of Projects in Rural Industries of Bolivia	Biomass Technology Group (BTG)	87,435	Final Report: TA and provision of technology for the rice project Final Report: TA and provision of technology for the Chancaca project
Training of Industry Managers and Operators	Biomass Technology Group (BTG)	36,625	Training materials and reports on training sessions on combustion Systems for the rice project and the Chancaca project
Development of Projects in Rural Industries in the Department of Cochabamba	Energética	94,871	Identification of a portfolio of 74 projects in the Department of Cochabamba, for the Biomass Fund
Development of Projects in Rural Industries in the Highlands	Sistemática Consultores	79,029	Identification of a portfolio of 25 projects in the highlands, for the Biomass Fund
	Total	**US$1,438,467**	

Table A11.4: Activities on Silvopastoral Enclosures

Consultant	*Total Amount of Contract(US$)*	*Output*
Charles Venator	26,420	Report on visits to Tarija, Potosí, and Chuquisaca, manual for management of silvopastoral systems, Final report on silvopastoral systems (2000)
Ramiro Molina B	2,100	Report: Identification of foundations for the program for access to and exploitation of forest resources for energy purposes
Consultora SUR	24,524	Action plan for silvopastoral enclosures
Carlos Hidalgo	1,145	Final Report: Supervision of the implementation of the silvopastoral enclosure of Casa Grande
Néstor Zambrano	1,514	Final Report: Supervision of the implementation of the silvopastoral enclosure of Jatun Mayu
Saúl Rodríguez	1,549	Final Report: Supervision of the implementation of the silvopastoral enclosure of Sagha Sagha
F&D S.R.L.	63,448	Civil works for establishment of three enclosures
ARIMAR	13,297	Provision of materials for three enclosures
Columbia	19,666	Provision of materials for three enclosures
CESAT	37,650	Final reports – management plan for the silvopastoral enclosure of Sagha Sagha, year 2000 and year 2001
Fundación Ceibo	37,149	Final reports: Phase I and Phase II of the silvopastoral enclosure in the community of Casa Grande
PROAGRO	13,634	Final Report on silvopastoral enclosure of Jatun Mayu. March 2000 – March 2001
Renán Orellana	9,123	Manual on electric fences
Comisión Episcopal de Educación	44,260	Production of curriculum on communal management of silvopastoral resources. Production of training materials on (i) approaches and instruments for participatory planning and (ii) community and farmer organization and participatory decision-making for the management of silvopastoral enclosures
Consultora SUR	97,499	Reports on the silvopastoral enclosure projects: (i) definition of baseline (ii) assessment of legal and cultural aspects (iii) impact evaluation (iv) dissemination report
Total	**US$366,722**	

Annex 12

Sources and Applications of Funds (FY98 to FY02)

Table A12.1: Sources and Applications of Funds (FY98 to FY02)

Source of Funds		
Dutch Grant	2,660,394.00	
Application of Funds		
Consultants and Training		1,205,031.29
Biomass Fund		800,000.00
Local Team		
Fees		112,789.72
Travel costs		61,267.37
The World Bank Team		
Fees		119,935.05
Travel costs		169,079.66
Operational Expenses		22,268.60
Miscellaneous		29,130.60
Total Project Cost		2,519,502.29
Unused Funds		140,891.71
Total	2,660,394.00	2,660,394.00

List of Technical Reports

Region/Country	Activity/Report Title	Date	Number
	SUB-SAHARAN AFRICA (AFR)		
Africa	Power Trade in Nile Basin Initiative Phase II (CD Only): Part I: Minutes of the High-level Power Experts Meeting; and Part II: Minutes of the First Meeting of the Nile Basin Ministers Responsible for Electricity	04/05	067/05
	Introducing Low-cost Methods in Electricity Distribution Networks	10/06	104/06
Cameroon	Decentralized Rural Electrification Project in Cameroon	01/05	087/05
Chad	Revenue Management Seminar. Oslo, June 25-26, 2003. (CD Only)	06/05	075/05
Côte d'Ivoire	Workshop on Rural Energy and Sustainable Development, January 30-31, 2002. *(Atelier sur l'Energie en régions rurales et le Développement durable 30-31, janvier 2002)*	04/05	068/05
Ethiopia	Phase-Out of Leaded Gasoline in Oil Importing Countries of Sub-Saharan Africa: The Case of Ethiopia - Action Plan	12/03	038/03
	Sub-Saharan Petroleum Products Transportation Corridor: Analysis and Case Studies	03/03	033/03
	Phase-Out of Leaded Gasoline in Sub-Saharan Africa	04/02	028/02
	Energy and Poverty: How can Modern Energy Services Contribute to Poverty Reduction	03/03	032/03
East Africa	Sub-Regional Conference on the Phase-out Leaded Gasoline in East Africa. June 5-7, 2002	11/03	044/03
Ghana	Poverty and Social Impact Analysis of Electricity Tariffs	12/05	088/05
	Women Enterprise Study: Developing a Model for Mainstreaming Gender into Modern Energy Service Delivery	03/06	096/06
	Sector Reform and the Poor: Energy Use and Supply in Ghana	03/06	097/06
Kenya	Field Performance Evaluation of Amorphous Silicon (a-Si) Photovoltaic Systems in Kenya: Methods and Measurement in Support of a Sustainable Commercial Solar Energy Industry	08/00	005/00
	The Kenya Portable Battery Pack Experience: Test Marketing an Alternative for Low-Income Rural Household Electrification	12/01	05/01
Malawi	Rural Energy and Institutional Development	04/05	069/05
Mali	Phase-Out of Leaded Gasoline in Oil Importing Countries of Sub-Saharan Africa: The Case of Mali - Action Plan *(Elimination progressive de l'essence au plomb dans les pays importateurs de pétrole en Afrique subsaharienne Le cas du Mali — Mali Plan d'action)*	12/03	041/03
Mauritania	Phase-Out of Leaded Gasoline in Oil Importing Countries of Sub-Saharan Africa: The Case of Mauritania - Action Plan *(Elimination progressive de l'essence au plomb dans les pays importateurs de pétrole en Afrique subsaharienne Le cas de la Mauritanie – Plan d'action.)*	12/03	040/03

Region/Country	Activity/Report Title	Date	Number
Nigeria	Phase-Out of Leaded Gasoline in Nigeria	11/02	029/02
	Nigerian LP Gas Sector Improvement Study	03/04	056/04
	Taxation and State Participation in Nigeria's Oil and Gas Sector	08/04	057/04
Regional	Second Steering Committee: The Road Ahead. Clean Air Initiative In Sub-Saharan African Cities. Paris, March 13-14, 2003	12/03	045/03
	Lead Elimination from Gasoline in Sub-Saharan Africa. Sub-regional Conference of the West-Africa group. Dakar, Senegal March 26-27, 2002 *(Deuxième comité directeur : La route à suivre - L'initiative sur l'assainissement de l'air. Paris, le 13-14 mars 2003)*	12/03	046/03
	1998-2002 Progress Report. The World Bank Clean Air Initiative in Sub-Saharan African Cities. Working Paper #10 (Clean Air Initiative/ESMAP)	02/02	048/04
	Landfill Gas Capture Opportunity in Sub Saharan Africa	06/05	074/05
	The Evolution of Enterprise Reform in Africa: From State-owned Enterprises to Private Participation in Infrastructure-and Back?	11/05	084/05
Senegal	Regional Conference on the Phase-Out of Leaded Gasoline in Sub-Saharan Africa *(Elimination du plomb dans l'essence en Afrique subsaharienne Conference sous regionales du Groupe Afrique de l'Ouest Dakar, Sénégal. March 26-27, 2002.)*	03/02	022/02
	Alleviating Fuel Adulteration Practices in the Downstream Oil Sector in Senegal	12/03	046/03
	Maximisation des Retombées de l'Electricité en Zones Rurales, Application au Cas du Sénégal	09/05 03/07	079/05
South Africa	South Africa Workshop: People's Power Workshop.	12/04	064/04
Swaziland	Solar Electrification Program 2001 2010: Phase 1: 2001 2002 (Solar Energy in the Pilot Area)	12/01	019/01
Tanzania	Mini Hydropower Development Case Studies on the Malagarasi, Muhuwesi, and Kikuletwa Rivers Volumes I, II, and III	04/02	024/02
	Phase-Out of Leaded Gasoline in Oil Importing Countries of Sub-Saharan Africa: The Case of Tanzania - Action Plan	12/03	039/03
Uganda	Report on the Uganda Power Sector Reform and Regulation Strategy Workshop	08/00	004/00
	WEST AFRICA (AFR)		
Regional	Market Development	12/01	017/01
	EAST ASIA AND PACIFIC (EAP)		
Cambodia	Efficiency Improvement for Commercialization of the Power Sector	10/02	031/02
	TA For Capacity Building of the Electricity Authority	09/05	076/05
China	Assessing Markets for Renewable Energy in Rural Areas of Northwestern China	08/00	003/00
	Technology Assessment of Clean Coal Technologies for China Volume I-Electric Power Production	05/01	011/01
	Technology Assessment of Clean Coal Technologies for China Volume II-Environmental and Energy Efficiency Improvements for Non-power Uses of Coal	05/01	011/01
	Technology Assessment of Clean Coal Technologies for China Volume III-Environmental Compliance in the Energy Sector: Methodological Approach and Least-Cost Strategies	12/01	011/01
	Policy Advice on Implementation of Clean Coal Technology	09/06	104/06
	Scoping Study for Voluntary Green Electricity Schemes in Beijing and Shanghai	09/06	105/06
Papua New Guinea	Energy Sector and Rural Electrification Background Note	03/06	102/06
Philippines	Rural Electrification Regulation Framework. (CD Only)	10/05	080/05
Thailand	DSM in Thailand: A Case Study	10/00	008/00
	Development of a Regional Power Market in the Greater Mekong Sub-Region (GMS)	12/01	015/01

Region/Country	Activity/Report Title	Date	Number
Vietnam	Options for Renewable Energy in Vietnam	07/00	001/00
	Renewable Energy Action Plan	03/02	021/02
	Vietnam's Petroleum Sector: Technical Assistance for the Revision of the Existing Legal and Regulatory Framework	03/04	053/04
	Vietnam Policy Dialogue Seminar and New Mining Code	03/06	098/06
	SOUTH ASIA (SAS)		
Bangladesh	Workshop on Bangladesh Power Sector Reform	12/01	018/01
	Integrating Gender in Energy Provision: The Case of Bangladesh	04/04	054/04
	Opportunities for Women in Renewable Energy Technology Use In Bangladesh, Phase I	04/04	055/04
	EUROPE AND CENTRAL ASIA (ECA)		
Azerbaijan	Natural Gas Sector Re-structuring and Regulatory Reform	03/06	099/06
Macedonia	Elements of Energy and Environment Strategy in Macedonia	03/06	100/06
Poland	Poland (URE): Assistance for the Implementation of the New Tariff Regulatory System: Volume I, Economic Report, Volume II, Legal Report	03/06	101/06
Russia	Russia Pipeline Oil Spill Study	03/03	034/03
Uzbekistan	Energy Efficiency in Urban Water Utilities in Central Asia	10/05	082/05
	MIDDLE EASTERN AND NORTH AFRICA REGION (MENA)		
Turkey	Gas Sector Strategy	05/07	114/07
Regional	Roundtable on Opportunities and Challenges in the Water, Sanitation And Power Sectors in the Middle East and North Africa Region. Summary Proceedings, May 26-28, 2003. Beit Mary, Lebanon. (CD)	02/04	049/04
Morocco	Amélioration de d´Efficacité Energie: Environnement de la Zone Industrielle de Sidi Bernoussi, Casablanca	12/05	085/05
	LATIN AMERICA AND THE CARIBBEAN REGION (LCR)		
Brazil	Background Study for a National Rural Electrification Strategy: Aiming for Universal Access	03/05	066/05
	How do Peri-Urban Poor Meet their Energy Needs: A Case Study of Caju Shantytown, Rio de Janeiro	02/06	094/06
	Integration Strategy for the Southern Cone Gas Networks	05/07	113/07
Bolivia	Country Program Phase II: Rural Energy and Energy Efficiency Report on Operational Activities	05/05	072/05
	Bolivia: National Biomass Program. Report on Operational Activities	05/07	115/07
Chile	Desafíos de la Electrificación Rural	10/05	082/05
Colombia	Desarrollo Económico Reciente en Infraestructura: Balanceando las necesidades sociales y productivas de la infraestructura	03/07	325/05
Ecuador	Programa de Entrenamiento a Representantes de Nacionalidades Amazónicas en Temas Hidrocarburíferos	08/02	025/02
	Stimulating the Picohydropower Market for Low-Income Households in Ecuador	12/05	090/05
Guatemala	Evaluation of Improved Stove Programs: Final Report of Project Case Studies	12/04	060/04
Haiti	Strategy to Alleviate the Pressure of Fuel Demand on National Woodfuel Resources (English) *(Stratégie pour l'allègement de la Pression sur les Ressources Ligneuses Nationales par la Demande en Combustibles)*	04/07	112/07

Region/Country	Activity/Report Title	Date	Number
Honduras	Remote Energy Systems and Rural Connectivity: Technical Assistance to the Aldeas Solares Program of Honduras	12/05	092/05
Mexico	Energy Policies and the Mexican Economy	01/04	047/04
	Technical Assistance for Long-Term Program for Renewable Energy Development	02/06	093/06
Nicaragua	Aid-Memoir from the Rural Electrification Workshop (Spanish only)	03/03	030/04
	Sustainable Charcoal Production in the Chinandega Region	04/05	071/05
Perú	Extending the Use of Natural Gas to Inland Perú (Spanish/English)	04/06	103/06
	Solar-diesel Hybrid Options for the Peruvian Amazon Lessons Learned from Padre Cocha	04/07	111/07
Regional	Regional Electricity Markets Interconnections - Phase I Identification of Issues for the Development of Regional Power Markets in South America	12/01	016/01
	Regional Electricity Markets Interconnections - Phase II Proposals to Facilitate Increased Energy Exchanges in South America	04/02	016/01
	Population, Energy and Environment Program (PEA) Comparative Analysis on the Distribution of Oil Rents (English and Spanish)	02/02	020/02
	Estudio Comparativo sobre la Distribución de la Renta Petrolera Estudio de Casos: Bolivia, Colombia, Ecuador y Perú	03/02	023/02
	Latin American and Caribbean Refinery Sector Development Report - Volumes I and II	08/02	026/02
	The Population, Energy and Environmental Program (EAP) (English and Spanish)	08/02	027/02
	Bank Experience in Non-energy Projects with Rural Electrification Components: A Review of Integration Issues in LCR	02/04	052/04
	Supporting Gender and Sustainable Energy Initiatives in Central America	12/04	061/04
	Energy from Landfill Gas for the LCR Region: Best Practice and Social Issues (CD Only)	01/05	065/05
	Study on Investment and Private Sector Participation in Power Distribution in Latin America and the Caribbean Region	12/05	089/05
	Strengthening Energy Security in Uruguay	05/07	116/07
	GLOBAL		
	Impact of Power Sector Reform on the Poor: A Review of Issues and the Literature	07/00	002/00
	Best Practices for Sustainable Development of Micro Hydro Power in Developing Countries	08/00	006/00
	Mini-Grid Design Manual	09/00	007/00
	Photovoltaic Applications in Rural Areas of the Developing World	11/00	009/00
	Subsidies and Sustainable Rural Energy Services: Can we Create Incentives Without Distorting Markets?	12/00	010/00
	Sustainable Woodfuel Supplies from the Dry Tropical Woodlands	06/01	013/01
	Key Factors for Private Sector Investment in Power Distribution	08/01	014/01
	Cross-Border Oil and Gas Pipelines: Problems and Prospects	06/03	035/03
	Monitoring and Evaluation in Rural Electrification Projects: A Demand-Oriented Approach	07/03	037/03
	Household Energy Use in Developing Countries: A Multicountry Study	10/03	042/03
	Knowledge Exchange: Online Consultation and Project Profile from South Asia Practitioners Workshop. Colombo, Sri Lanka,	12/03	043/03

Region/Country	Activity/Report Title	Date	Number
	June 2-4, 2003		
	Energy & Environmental Health: A Literature Review and Recommendations	03/04	050/04
	Petroleum Revenue Management Workshop	03/04	051/04
	Operating Utility DSM Programs in a Restructuring Electricity Sector	12/05	058/04
	Evaluation of ESMAP Regional Power Trade Portfolio (TAG Report)	12/04	059/04
	Gender in Sustainable Energy Regional Workshop Series: Mesoamerican Network on Gender in Sustainable Energy (GENES) Winrock and ESMAP	12/04	062/04
	Women in Mining Voices for a Change Conference (CD Only)	12/04	063/04
	Renewable Energy Potential in Selected Countries: Volume I: North Africa, Central Europe, and the Former Soviet Union, Volume II: Latin America	04/05	070/05
	Renewable Energy Toolkit Needs Assessment	08/05	077/05
	Portable Solar Photovoltaic Lanterns: Performance and Certification Specification and Type Approval	08/05	078/05
	Crude Oil Prices Differentials and Differences in Oil Qualities: A Statistical Analysis	10/05	081/05
	Operating Utility DSM Programs in a Restructuring Electricity Sector	12/05	086/05
	Sector Reform and the Poor: Energy Use and Supply in Four Countries: Botswana, Ghana, Honduras and Senegal	03/06	095/06

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