Peru

Rural Electrification

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ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) is a special global technical assistance program run as part of the World Bank's Energy, Mining and Telecommunications Department. ESMAP provides advice to governments on sustainable energy development. Established with the support of UNDP and bilateral official donors in 1983, it focuses on the role of energy in the development process with the objective of contributing to poverty alleviation, improving living conditions and preserving the environment in developing countries and transition economies. ESMAP centers its interventions on three priority areas: sector reform and restructuring; access to modern energy for the poorest; and promotion of sustainable energy practices.

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ESMAP is governed by a Consultative Group (ESMAP CG) composed of representatives of the UNDP and World Bank, other donors, and development experts from regions benefiting from ESMAP's assistance. The ESMAP CG is chaired by a World Bank Vice President, and advised by a Technical Advisory Group (TAG) of four independent energy experts that reviews the Programme's strategic agenda, its work plan, and its achievements. ESMAP relies on a cadre of engineers, energy planners, and economists from the World Bank to conduct its activities under the guidance of the Manager of ESMAP, responsible for administering the Programme.

FUNDING

ESMAP is a cooperative effort supported over the years by the World Bank, the UNDP and other United Nations agencies, the European Union, the Organization of American States (OAS), the Latin American Energy Organization (OLADE), and public and private donors from countries including Australia, Belgium, Canada, Denmark, Germany, Finland, France, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland, the United Kingdom, and the United States of America.

FURTHER INFORMATION

An up-to-date listing of completed ESMAP projects is appended to this report. For further information, a copy of the ESMAP Annual Report, or copies of project reports, contact:

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Acronyms and Abbreviations

DEP	Dirección Ejecutiva de Proyectos (Directorate of Project Execution)
ESMAP	Energy Sector Management Assistance Programme
FAO	Food and Agriculture Organization (United Nations)
GoP	Government of Peru
IDB	Inter-American Development Bank
INDECOPI	Consumers' Protection Office
ITDG	Intermediate Technology Development Group
kW	Kilowatt
kWh	Kilowatt hours
LAC	Latin America and the Caribbean Region
MEM	Ministry of Energy and Mines
MHP	Micro Hydroelectric Plant (1 kilowatt to 100 kilowatts)
NGO	Nongovernmental Organization
O&M	Operations and Maintenance
OSINERG	Organization Supervising Electricity Companies
PHRD	Population and Human Resources Development
PV	Photo-voltaic
SUNAT	The Peruvian Tax Authority
UNDP	United Nations Development Programme
Wp	Watt peak

Currency Units

July 1996	PEN/US$: 2.45
January 1997	PEN/US$: 2.60
April 1999	PEN/US$: 3.36

Preface

This ESMAP study originated as part of an ESMAP country program, which was agreed with the Peruvian government and the World Bank's Latin America and the Caribbean (LAC) region, and financed by the Canadian government from 1995-1999. Since its beginnings in 1995, the fundamental objective of the ESMAP program in Peru has been twofold:
(a) To focus the government's attention on—and strengthen its capability to deal with—those key areas left outside of the privatization and reform process of the energy sector; and
(b) To explore the design, implementation, and supervision of alternative institutional delivery mechanisms in these new areas, three of which the program specifically targeted:

- The environmental impact of hydrocarbons development, particularly in the Amazon region where most of the reserves are located;
- The development of the energy service industry with emphasis on supporting energy end-users and on the potential for CO_2 mitigation; and
- Increasing energy access in decentralized rural areas in a sustainable fashion—which is the focus of this report.

It is expected that these demonstrations will facilitate, in time, the mainstreaming of the new approaches to energy efficiency, to environmental assessments, to indigenous participation—and improve energy access in the rural sector.

This report is based on the work of ITDG-Peru, the consultant for this activity, prepared under the responsibility of Teodoro Sanchez and with the participation of the members of ITDG's energy program—Alfonso Carrasco, Rafael Escobar, Saúl Ramírez, and Homero Miranda. The report summarizes the findings of the full ESMAP activity, task-managed by Michel del Buono and Anke Sofia Meyer while Salvador Rivera coordinated the ESMAP Peru Country Program. Many other individuals and organizations contributed to the work, including Jorg-Uwe Richter, LCSFP, Jesus Beoutis of MEM/DEP, and Paul Ragusa of CIDA. Their support is gratefully acknowledged.

Summary and Recommendations

Introduction

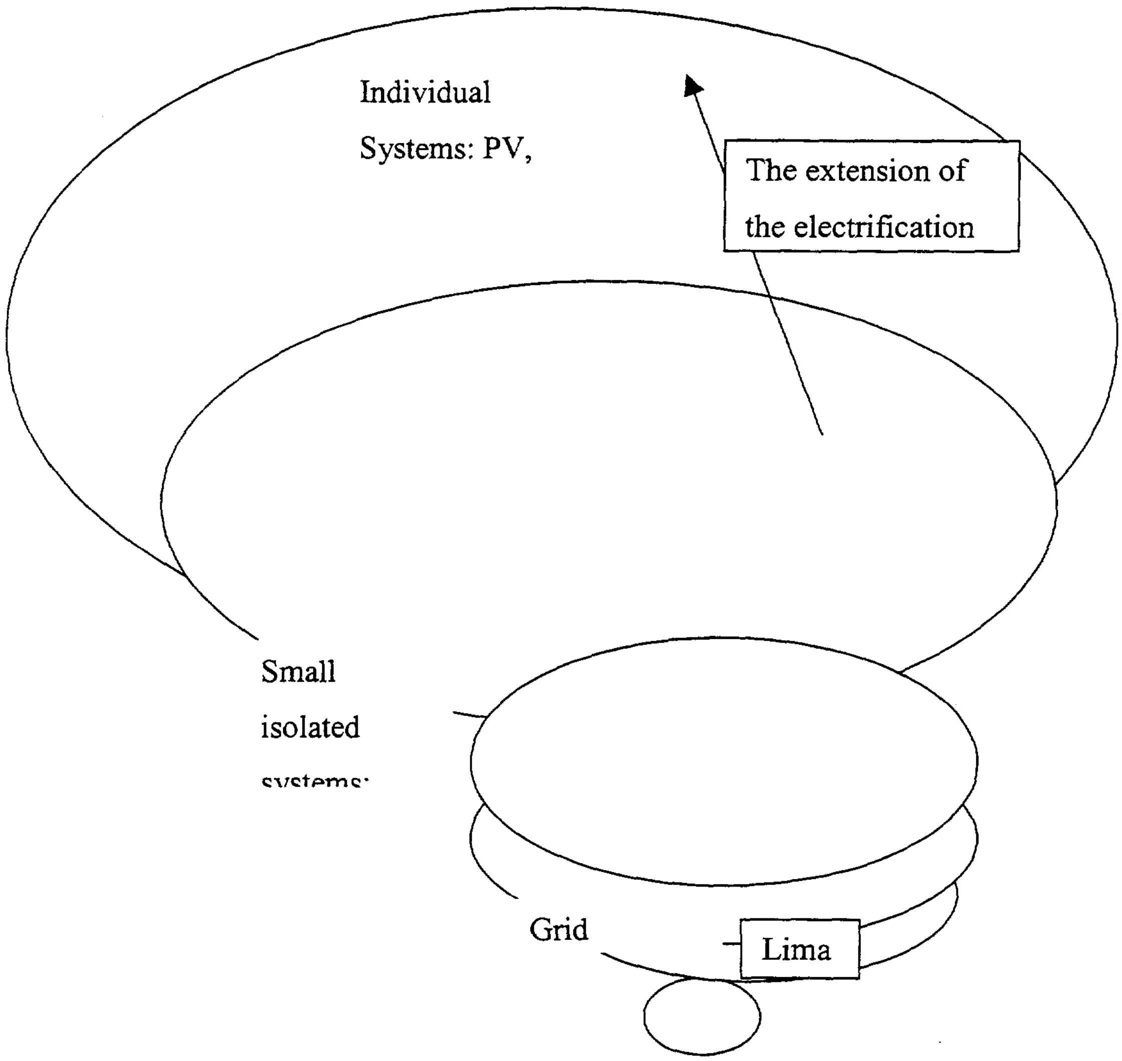
Peru, a large country with complex geographical features, covers 1.3 million km^2 and has a population of over 24 million people, 70 percent of whom live in urban areas and 30 percent in rural areas. The rural electrification coefficient as reported by the Ministry of Energy and Mines (MEM) increased from 5 percent in 1993 to 20 percent at the end of 1997. This is evidence of the great effort made in recent years to improve rural households' access to electricity. Nevertheless, much remains to be done since six million rural households still have no access. Moreover, the majority of these people live mainly in the highlands and to a lesser extent in the jungle, in areas that are so isolated that it is unlikely that the population there will gain access to the national grid anytime soon. In the coastal regions, by contrast, only a small percentage of the population lives in rural areas, and communities there that are not electrified at this point will be connected to the grid in the short or medium term.

The majority of the rural population in Peru will probably be electrified using small isolated power supply systems. However, many planners and strategists have their doubts about rural electrification based on this approach, mainly because such systems carry high costs and because so far they have shown few signs of being sustainable.

The National Electrification Plan of 1997–2000 calls for an increase of the national electrification rate from 65 to 75 percent by the end of the period, requiring investments of US$600–800 million. It is expected that most of the increase will come from grid extension, for which the electricity concessions law (D.L. 25844) provides a valid framework. Private sector concessionaires are expected to extend the grid "naturally" with committed resources and some cofinancing by the government. It is doubtful, though, judging by the results of many unsustainable experiments with government-supported schemes in the past, that this framework would be applicable to rural electrification beyond the grid through small isolated systems or individual systems.

International experience shows the need to structure different institutional models and corresponding financial delivery systems as one extends the electrification frontier (see figure 1). This holds in particular for the participation of regional and/or local organizations, not only in the construction of the systems but also in their operation and maintenance.

Figure 1: The Extension of the Electrification Frontier



Source: World Bank staff.

Rural Electrification in the Context of Social Development in Peru

The increase in electrification rates fits within the generally positive picture of social development in Peru during the last five years, in which poverty declined and a larger share of the population received better nutrition, better education, and access to safe drinking water—and was generally less poor. Progress was uneven, however: Urban areas benefited more than rural ones and in 1997 a higher percentage of all malnourished and poor people lived in rural areas in 1997 compared to 1994. Indigenous people are among the most vulnerable and likely to live under these conditions.

For example in 1996, of the 7.6 billion soles that were spent on social programs (education, health, basic infrastructure, and antipoverty programs), only 17 percent went to the poorest 20 percent of the population, whereas 21 percent went to the richest 20 percent. Urban areas received 70 percent of the social program funds. Table 1 provides a breakdown for five basic and social services. Provision of electricity is among those services with the largest bias toward urban populations.

Table 1: New Access to Basic and Social Services, 1994–97 (percentages)

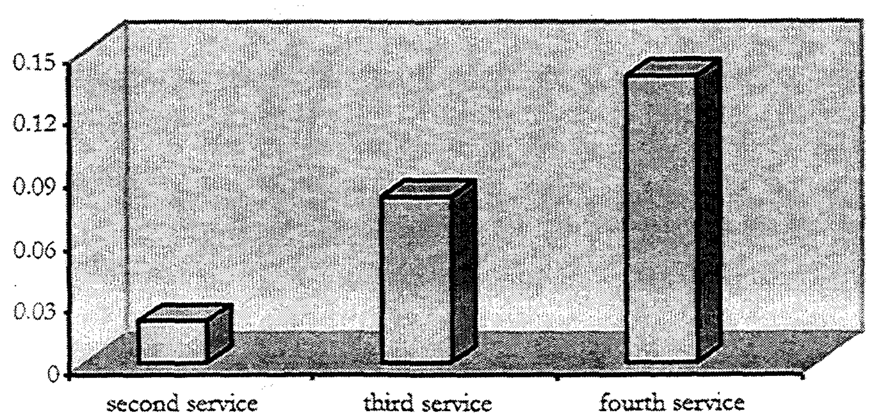
	Urban	*Rural*
Water	57	43
Electricity	72	28
Sanitation	78	22
Outpatient health care	74	26
Schooling	33	67

Source: World Bank, "Dialogue on Experiences and Challenges in the Struggle Against Poverty," workshop held in Ica, Peru, October 26–27, 1998.

Basic services are crucial to the progress of poor households. In general, sectoral interventions such as introducing or improving the water supply, roads, health care, education, or electrification are carried out in an isolated fashion—and as a consequence they have little impact on rural development. If policies and investments were coordinated more effectively across sectors, and if services were provided as a bundle, they could contribute more effectively to income growth. Figure 2 shows that the coordinated supply of infrastructure services adds considerably to per capita income growth.

Figure 2: Bundling Services - Increasing Returns

(increase in per capita growth rate, 1994-1997)



Source: Staff Estimates based on ENNIV (1994 and 1997).

These results suggest that rural electrification efforts need to be put into the context of rural development and that a strategy for rural electrification needs to be part of a strategy for rural services delivery and, more general, rural development. Successful rural electrification should not be measured by the number of kilowatts installed or kilometers of grid extended but by how the service improves the lives in rural households and how it generates income for individuals. Rather, increases in the number of households using electricity productively, of schools and clinics electrified, or of water pumping and irrigation accomplished through the use of electrical pumps should be tracked. Ultimately, performance needs to be measured in terms of its contribution to welfare and per capita income.

The Scope and Organization of the ESMAP Project

The ESMAP activity in Peru started in 1995 following a request by the Government of Peru (GoP) and the World Bank's Latin America and Caribbean Region Energy Department to develop non-grid-extension rural electrification models.

International—as well as national—experience shows that several issues need to be resolved for sustainable rural electrification;[1] they closely mirror those encountered when dealing with other rural services:

- Determining a national strategy and effective institutional structures for rural electrification;[2]
- Selecting the criteria for investment—such as the consumers' willingness and ability to pay, bundling with other rural services, and access to markets;
- Securing financing for the investment—cofinancing through public and private sources with the private sector taking the lead; and soliciting financing from local entrepreneurs or communities;
- Using appropriate technologies—these reduce investment costs and are easier to operate and maintain;
- Ensuring cost recovery—tariffs for all consumers should at least cover operations and maintenance (O&M) costs; and capital investment subsidies should be minimized;
- Establishing a delivery mechanism—such as fostering community involvement in planning, educating consumers, and so on, but also planning for increased reliance on local operators, particularly for O&M, who are trained in technical, financial, and organizational matters;

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1 See, for example, Douglas Barnes and Gerald Foley, *Rural Electrification in the Developing World: Lessons from Successful Programs*, Draft EMTEG Paper, World Bank, Washington, D.C., November 1998.

2 The formulation of a rural electrification strategy for Peru is the subject of a study carried out 1998/99 by NRECA International under a PHRD grant, "Estratégia Integral de Electrificación Rural," Informe Preliminar, February 1999.

- Dealing with the political dimension of rural electrification—even if all the other issues are resolved, political interference can still lead to a wasting of resources, operational ineffectiveness, and ultimately to abandoned systems; and
- Establishing monitoring indicators such as ex ante development and tracking socioeconomic indicators to measure the success and relevance of electrification programs.

The ESMAP project evaluated, through post-investment investigations, several small-scale projects in Peru. These projects were not performing well because they lacked several of the sustainability features outlined above. Two sample evaluations are summarized below:

- The study of the 25 kW micro hydroelectric power plant (MHP) in the Andean town of Chalán revealed that even though local training and a more labor-efficient model involving the community in the management of the MHP had improved operations, the plant remained politically vulnerable because it was still managed by the municipality.
- Twelve case studies on the ex post performance of small isolated power supply systems—10 MHPs and 2 diesel generators located in different parts of the country, operating under different forms of management, belonging to different owners, and set up under different conditions—revealed a number of problems, mainly concerning sustainability and costs. Many of these systems were plagued by shutdowns and high subsidies. Many of the small systems were oversized due to poor planning. Finally, several of the smaller systems were hampered by a lack of management skills, such as the ability to establish a tariff system.

The main focus of the ESMAP activity was to provide practical suggestions on how the sustainability of small-scale rural electrification projects in Peru could be improved. The project activities investigated the following issues:

Rural Households' Willingness to Pay for Services

Information on family income and amounts spent on energy was gathered in three isolated Andean villages (Chetilla, Tongod, and Tumbadén) in order to obtain real indicators regarding energy use and expenses in communities not yet electrified. About 70 percent of the population in these villages lives below the povertyline. Even among these very poor families, average monthly expenses for energy are quite high, varying between US$2.60 and US$6.30. These data will be used for reference when judging the population's willingness and ability to pay for electricity and in the design of tariff systems.

Models for Rural Electrification Management

Two management organization models were designed and tried out in the towns of Conchán and Trinidad. This involved reviewing the current legal framework—including the electricity concessions law and the laws governing municipalities, small-scale companies, and related tax aspects. The resulting models were "Management Services" (suitable for systems owned by the government or municipalities, and for regional companies willing to hand over management to third parties), and "Property and Private Management" (which applies to small private companies that generate their own power).

Reducing Small Systems' Capital and Operating Costs

Small hydroelectric systems were classified according to their capacity ranges and different technical options and standards. By applying lower standards, costs can be reduced for all capacity groups but the cost-saving potential seems to be highest in a middle range of 5–20kW, for which local equipment is more widely available.

The engineering design of two small hydroelectric systems were redone using high, medium, and low standards, to establish the difference in the costs of small systems built according to different standards, taking into consideration all engineering components (civil works, electromechanical equipment, and grids). In both cases it was found that the cost ratio between the high standard and low standard designs was approximately 2 to 1, without putting either the quality or the supply of energy at risk.

Operator Training

Training material—consisting of a series of modules covering the operation, maintenance, and management of electricity services in small isolated electricity systems—was prepared.[3]

As part of ESMAP assistance provided to Dirección Ejecutiva de Proyectos (Directorate of Project Execution, or DEP), the materials were used to train different agents in two small power supply systems incorporated as companies (sociedad anonima)—MHP Santa Leonor and the San Francisco Solar Village.

The results of these investigations provide valuable lessons that can be used to improve the rural population's chances of gaining access to electricity under sustainable conditions. A summary of the results appears below in the "Lessons Learned" section.

Lessons Learned

The Legal Framework and National Rural Electrification Strategies

The legal framework currently in force makes no distinction between rural electrification and the electricity business in urban areas. At the present time, the electricity business is divided into power generation, power transmission, and power distribution (this does not apply to rural electrification, unless the grid is extended). The Electricity Concessions Law states that a concession is required to generate more than 10 MW, a permit is needed to generate between 0.5 and 10 MW, and that simply notifying the government is all that is required to generate less than 0.5 MW.

3 The modules cover administration aspects, accounting, tariffs, electricity marketing, and technical aspects of the operation and maintenance of mini and micro hydroelectric power plants and photo-voltaic (PV) systems.

There is no law that specifically promotes rural electrification in Peru. During the 1970s when electricity companies were nationalized and ELECTROPERU was created, a rural electrification fund was established based on electricity taxes. This fund no longer exists. Since the 1990s, DEP, which operates as a special project within the Ministry of Energy and Mines (MEM), has been responsible for all energy projects, including rural electrification.

The development of a national strategy for rural electrification is considered necessary in an environment dominated by the privatization of the energy sector. The development of this strategy was beyond the scope of this ESMAP project and is instead being carried out by MEM/DEP under a Population and Human Resources Development (PHRD) grant (see footnote 2). It should suffice here to note that an agency should be in charge of gathering and providing basic information on rural energy markets to potential investors, of overseeing the implementation of rural electrification projects, and of disseminating the experience of lessons learned through successful and unsuccessful approaches.

Opportunities for Gaining Access to Electricity Services

As explained in the introduction, geographical location and consequently, degree of isolation are obstacles that prevent rural towns from gaining access to electricity. The more isolated a town is, the greater the difficulties, since investment costs increase and organization and management skills are limited owing to the lack of education and of access to information. In addition there is a greater migration rate among rural youth—and conditions are unfavorable for trading with other parts of the country, leading to economic stagnation.

Given their proximity to the grid, rural people on the coast generally are in a better position to acquire access. In fact, as mentioned above, the rural electrification coefficient increased from 5 percent in 1993 to 20 percent by the end of 1997, as a result of large public investments in grid expansion, through DEP-MEM, FONCODES, and FONAVI (see footnote 4). However, the only way the vast majority of the highland and jungle population can gain access to electricity is by taking advantage of local energy resources in isolated power supply systems, such as hydroelectric power on a small scale, solar energy, and biomass (still not tested in Peru)—and to a lesser extent and in specific cases, by using diesel fuel.

The Financial Aspects of Rural Electrification in Peru

The rural market in Peru is a poor market, with the average annual cash income of the majority of rural families ranging from US$300 to $1,400. Therefore, before any rural electrification strategy is implemented, a careful analysis of financial aspects is required.

The significant investments in rural electrification made in the early 1990s were not governed by a sound, government-established financial framework. There were no common investment guidelines concerning subsidies, means of payment, and so on. One of the most common beliefs was that "private investments should do everything under market conditions," including rural electrification. To a certain extent, the public sector followed the same trend. Nevertheless, the energy demands of small towns were constantly met, mostly through direct donations of equipment (mainly diesel-based generation).

While free market principles were being quoted, grids or small isolated power supply systems were set up under a range of funding schemes, ranging from donations to commercial loans.[4]

It is worth mentioning that since 1994 ITDG, under an agreement with the Inter-American Development Bank (IDB), has been implementing a credit program that includes subsidized (with an interest rate of 8.5 percent over five years) transaction and technical management costs. Thanks to this program, 15 MHPs were implemented, nine of which were set up in districts and the remaining six were handed over to small-scale rural entrepreneurs. The latter required no additional input (other than technical assistance), but extra funds were required for the plants set up in districts, which were obtained from various sources (including regional and local governments).

The Rural Electrification Organization and Its Management and Property Aspects

Organization is a key factor in the sustainability of isolated systems. Existing management models fail to meet quality and efficiency standards. Although it is true that all aspects (legal framework, finance, technology, and so forth) are important for improving the rural population's access to electricity, the continuity of the service (that is, the system's sustainability) can only be assured if its management models are functional and efficient. Unlike three or four years ago, promoters of rural electrification and other rural services believe that having such a model is important for achieving sustainability. DEP-MEM has experimented with three models:

- The first was a total solution through privatization. According to this scheme, companies purchasing the systems would commit to earmarking a part of the expenses for grid extension for the electrification of poor rural towns and the management and operation of the plants. They were to receive subsidies in this endeavor for an indefinite period. This was the method followed for Peru's first electricity distribution privatization (Electro Sur Medio).
- The second proposal was the creation of corporations in which all beneficiaries would participate as shareholders. This system was tried out for a short time in the San Francisco Solar Village and in the Santa Leonor MHP, but has now been abandoned.
- The third proposal again involved a privatization process, whereby the companies awarded the concession would be responsible for O&M work, under a scheme of subsidies for indefinite periods. This is the system currently in force.

Under this project, the creation or improvement of local skills is proposed as a promising solution, which involves the creation of small local companies that would provide privately

[4] FONCODES (National Social Compensation Fund of the Ministry of the Presidency) financed grid expansion on a full grant basis. PRONAMACHS (National Watershed Management Programme of the Ministry of Agriculture) financed the installation of hydroelectric power plants through loans subsidized with FONAVI funds; and FONAVI (National Housing Fund) itself financed grids with subsidized loans. PROER (established from a Dutch bilateral grant), under the management of COFIDE, granted loans under commercial conditions. DEP-MEM, through various sources (particularly through the Japanese cooperation agency), has been setting up isolated systems that are 100 percent grant-funded and continues to do so.

managed electricity services. Initially this would involve extensive training. The advantage, however, is that over the long term it would not only cost less but also boost the local management capacity.

Local Capacity

This has two components: the local capacity to manufacture equipment and spares and implement systems, and the local capacity to manage and maintain them.

A large number of Peruvian engineering firms are capable of designing and implementing small-scale rural electrification systems. Supplies of equipment, parts, and spares for MHPs are also widely available locally. However, the government and other organizations, particularly in the public sector, have little confidence in them and continue importing foreign-made equipment. A significant amount of electromechanical equipment has been purchased from or donated by other parts of the world in recent years. This has had a negative impact on local companies making a strenuous effort to place their products on the market. Local consultants are also affected by this bias, although to a lesser extent.

As mentioned above, it is possible to generate the capacity required for private and efficient organizational management at a local (community) level. This requires a significant investment in training, as well as clearly defined implementation strategies and knowledge about the socioeconomic characteristics of the communities concerned, in order to overcome certain prejudices that tend to become obstacles. These prejudices include such slogans as "electricity is the government's responsibility," "MHPs use no fuel, therefore there is nothing to pay," or "private companies exploit the people." The slogans are usually introduced by politicians, and they influence public perception. This influence needs to be countered by consciousness-raising and training.

Promoting Alternatives for Implementing Sustainable Rural Electrification Systems

In general, rural electrification is a complex subject and, pursued in isolation, an "unprofitable" business. Furthermore, if the population is poor, the effort's sustainability will always be in doubt as long as there are no clear government policies or imaginative and efficient ways of promoting investment and establishing management structures.

The following recommendations are proposed to make the implementation of rural electrification, particularly by isolated power supply systems, more viable:

(a) *Financing.* Since the 1970s, various ministries (such as MEM, Agriculture, and Presidency) and decentralized organizations (COFIDE, PRONAMACHS, FONCODES, universities, NGOs, and so on), have made a tremendous effort to provide access to electricity, using a variety of approaches and applying different criteria. These players need to coordinate their work better and establish common rules and guidelines, especially for funding mechanisms.

Credit mechanisms in which owners of power supply systems can negotiate the terms so that customers assume more responsibility for their future and their priorities must be designed and implemented. The credit system managed by ITDG under an agreement with the IDB proves that this type of investment is possible as long as technical assistance is provided in isolated rural areas.

(b) *Subsidies*. When people are as poor as Peru's rural population and provision of electricity is so expensive that rural households cannot afford it, rural electrification subsidies will be required for the time being. This should not be hard to justify: Investment in rural electrification contributes to development, in terms not only of the opportunity to generate more income, but also of the different social benefits implied - education, health, communications, integration, and so on. Any subsidies, however, should be minimal and well targeted.

Small projects in isolated areas have *higher specific costs* associated with identification, feasibility studies, and operator training. If these tasks are carried out well, a considerable drop in overall costs and consequently greater sustainability could be achieved. For communities or local entrepreneurs who might otherwise be able and willing to finance a large part of the investment costs, it would make a big difference if these "set-up" costs were financed by the government.

(c) *Appropriate technology*. Regulations should establish standards to reduce costs without affecting the quality or sustainability of the service. Experience has shown that it is possible to implement small systems that cost 50–60 percent less than those implemented under international standards.

Also from a technological point of view, the *sustainability of small manufacturers of equipment and spares and small consulting firms* should be promoted at a national level, both for the implementation process and for subsequent services. By developing and announcing annual public investment programs, manufacturers and service suppliers would have a clear vision of the opportunities available to them as investors or entrepreneurs.

(d) *The organization of management.* It is advisable to take advantage of local skills for the management of isolated systems. If such skills are nonexistent, then they should be created through training at different levels. Private companies should be encouraged to provide management services. These should be for-profit companies so that entrepreneurs have an incentive to generate income. Compared to large corporations the involvement of these small local companies would result in significant cost savings, smaller required profit margins, lower personnel expenses, lower investments, and so forth.

Certain models of organizing rural electrification require permanent *subsidies*. The "management services" model designed and tried out through this project is a realistic alternative to the current situation in Peru and might be workable with minimal subsidies. It would be advisable to carry out pilot work on a wider scale, however, before launching this model as a national proposal.

The implementation of isolated power supply systems requires a consistent *education* of users, in order to do away with the prejudices mentioned previously and to make users become aware of the need to pay for the energy they consume, the need to pay for the facilities' upkeep, and the need to use energy in a rational and environmentally sustainable manner.

(e) *Legislation.* In principle, according to the electricity concessions law, all that is required to set up power plants with a 0.5–10 MW capacity is permission from the government. Tariffs for these systems are not regulated,[5] and all companies are subject to the same tax system. It would be advisable to have at least some minimum guidelines concerning tariffs for isolated rural areas, however. These could be used as points of reference for private investors or in the management of services. The current lack of legal regulations or guidelines makes investors extremely vulnerable. Exempting very small rural energy service companies from certain taxes, as is the practice with other ventures with small incomes, also should be considered. It is not only the payment of taxes that causes a problem in rural areas, however, but also the work and time it takes individuals to travel to be able to submit their monthly tax statements.

Legal standards should be developed—regarding property and taxes, tariffs, organization, the sale of energy to the grid, and so on—to encourage private sector participants not only to invest in power plants, but also to engage in the management of small systems.

Recommendations for Future Actions

The achievements of the last three years of continuous work with ESMAP are considerable and of much relevance to the country. It is necessary to disseminate the results on a wider basis and to try out the management models on a larger scale.

It has become clear that electricity does not contribute much to the development of target communities if it is delivered to isolated areas in an isolated manner. It is important to promote and encourage the productive use of electricity while the generation and distribution systems are being implemented. Furthermore it is important to keep in mind that electricity is only one of the many important factors in rural development, and that it will contribute effectively to rural development only if its delivery is bundled with that of other infrastructure services (see figure 2).

The main recommendations derived from the activities of this project are as follows:

- Incorporate socioeconomic indicators into the methodology when selecting sites for rural electrification.

[5] Subsequent to this report, the Electricity (now renamed "Energy") Tariff Commission created a "fourth tariff category" for rural systems.

- Create a data room with socioeconomic data, GIS information, and other data relevant for market assessment within the agency responsible for promoting rural electrification.
- Bear in mind that municipal or private delivery of rural electrification can work—provided that financing is available, low-cost standards can be applied, the consumers' willingness to pay is taken into account in project and tariff design, O&M is carried out by appropriately trained personnel, and politicians do not interfere in business decisions.
- Organize a workshop on isolated power supply systems, attended by government officials, representatives of distribution concession companies, mayors, experts in this field, and so on. The models designed and implemented by this project would be introduced at such a workshop, together with others developed either in this country or in other parts of the world.
- Design a rural development project in which the energy component plays an important role in community development. Such a project should permit the application of the models developed in this technical assistance project on a larger scale, so that they have the necessary demonstration effect and any adjustments required can be made, particularly to the training modules which were designed as part of this ESMAP project (see table 7).

1

Rural Energy Electrification in Peru

This report covers ESMAP project activities between November 1995 and September 1998. The activities fall into three phases: phase one from November 1995 to March 1996, phase two between April 1996 and July 1997, and phase three from November 1997 until September 1998. Broader information on each subject or activity can be found in the consultant reports submitted at the end of each phase.[6]

Household Surveys in Isolated Rural Towns without Electricity Supply

The purpose of this activity was to obtain and analyze data on family income, and energy consumption and spending in small isolated towns. The surveys were designed to produce realistic indicators of the proportion of family earnings spent on energy in towns without electricity; such indicators can then be used to determine households' capacity and willingness to pay for electricity once the supply is set up.

The work was based on the following premises:

- There is an undeniable need for energy to meet the population's basic needs such as lighting and cooking;
- Electricity is not essential for cooking, particularly in rural areas—therefore this was not taken into account in the study; and
- There is a positive relationship between rural families' income and their energy expenditures: the higher the family income, the more the family spends on lighting and other needs that can be covered by electricity.

Selection Criteria

- **Andean areas.** The study focused on Andean areas where most of Peru's rural population is concentrated.
- **Political status.** Districts are the smallest political areas with an elected local authority—the mayor. They have small municipal administration facilities and

[6] See the annex for a list of documents.

have access to a small proportion of central government funds. In some cases these jurisdictions generate their own income, through activities, taxes, or mining licenses.

- **Access to services.** For this criterion we decided to take into account the distances from the rural center to the province capital and to the location of the services to be analyzed (battery charger, fuel suppliers, and so on).
- **Poverty.** We decided to evaluate three districts with different poverty rates: Chetilla (extremely poor), Tumbaden (very poor), and Tongod (poor). All three districts are in the Cajamarca department, which is representative of the Peruvian Andes.

During the project's second phase, we designed and used the records from the first phase to obtain more information. Based on the results we created a map, covering a wider range of Andean and jungle fringe towns exhibiting characteristics that were similar to those found in our study area.

The Main Criteria for Evaluating the Towns

- **Family income levels.** The idea was to identify available funds and standards of living and to establish determinants of different family income levels. To this end, we considered the following: the topography of the land (high mountain area, slope, or valley) and the distribution and location of families in each of these areas.
- **Sample size.** In order to obtain reliable information for comparison purposes, we studied 75–80 percent of the total number of families in small communities (with less than 50 families). In larger communities, a minimum of 30 percent was considered representative.

Table 1 shows the location of the towns and number of families covered by this study.

Table 1: Rural Towns Surveyed

Rural village	*Location*			*Altitude*	*Inhabitants*
	District	*Province*	*Department*	*(Meters)*	*Total (Fam.)*
Chetilla	Chetilla	Cajamarca	Cajamarca	2,800	150
Tumbadén	Tumbadén	San Pablo	Cajamarca	2,800	68
Tongod	Tongod	San Miguel	Cajamarca	2,700	150
Pipus	Daguas	Chachapoyas	Amazonas	1,870	60
Moyán	Incawasi	Ferreñafe	Lambayeque	1,600	27
Palca	Palca	Tarma	Junín	3,250	50
Ushcamarca	Sto. Tomás	Chumbivilcas	Cusco	3,600	160
Cascarilla	Jaén	Jaén	Cajamarca	1,860	120

Source: Evaluation studies by ESMAP/ITDG.

Methodology for Obtaining Information

In addition to surveying randomly selected families, we obtained information by meeting with local authorities and leaders. Our main objective was determining the families' socioeconomic situation and identifying their productive activities, their energy requirements, the amounts they currently spend on energy, their energy sources, and their capacity and willingness to pay for energy services.

Analysis Criteria

- **Productive tendencies**—the technological level of production dictated by the household's field of expertise (farming, livestock, or industrial production).
- **Energy type.** We analyzed only those domestic lighting energy sources that could be replaced by electricity—such as candles, kerosene lamps and wick burners, and batteries.
- **Access to services.** Since the towns are situated in rural areas, we had to establish their level of dependence on energy services, bearing in mind each family's needs and expenses.
- **Family type.**[7] The categories below help paint a portrait of the population's social structure, different social tendencies, occupational preferences, and economic levels.
  - (a) **Infrasubsistencia**. These are families with hardly any income and an average of 0–3 hectares of land. They rely on rainfall for agriculture, and what they grow is essentially for their own consumption.
  - (b) **Autosubsistencia**. These are families that own 4–10 hectares of land and produce a variety of products for their own subsistence. They earn enough to cover their basic needs, but have to do temporary work to cover other needs.
  - (c) **Excedentario**. These are families that own 12 hectares of land or more, earning enough to cover all their needs and to invest in another activity. Their production levels are generally high.

Specific Characteristics of the Towns Covered by the Study

- The Chetilla and Ushcamarca communities, situated in the high part of the Andes on barren land, are classified as extremely poor communities.
- Tumbadén, Moyán, and Palca are classified as very poor. Their land—and consequently their productivity rate—is of average quality.
- Tongod is located in an Andean valley on more productive, good quality land. However, the community is still considered poor according to the poverty map.

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7 Based on categories established by CEPAL and the Food and Agriculture Organization (FAO).

- Pipus and Cascarilla, in the Upper Jungle region, are also classified as poor groups.

Survey Results

- **Population structure.** The majority of the population (70 percent) is below the subsistence level (see table 2). Consequently, very few people have any disposable income.

Table 2: Family Structures According to Subsistence Level

Rural village	*Families interviewed*	*Infrasubsistencia (percent)*	*Autosubsistencia (percent)*	*Excedentario (percent)t*
Chetilla	80	85.0	12.5	2.5
Tumbadén	55	70.9	20.0	9.1
Tongod	98	59.2	30.6	10.2
Pipus	22	72.7	18.2	9.1
Moyán	20	40.0	50.0	1.0
Palca	39	74.4	25.6	0
Ushcamarca	53	94.3	3.8	1.9
Cascarilla	44	38.6	40.9	20.5

Source: Evaluation studies by ESMAP/ITDG.

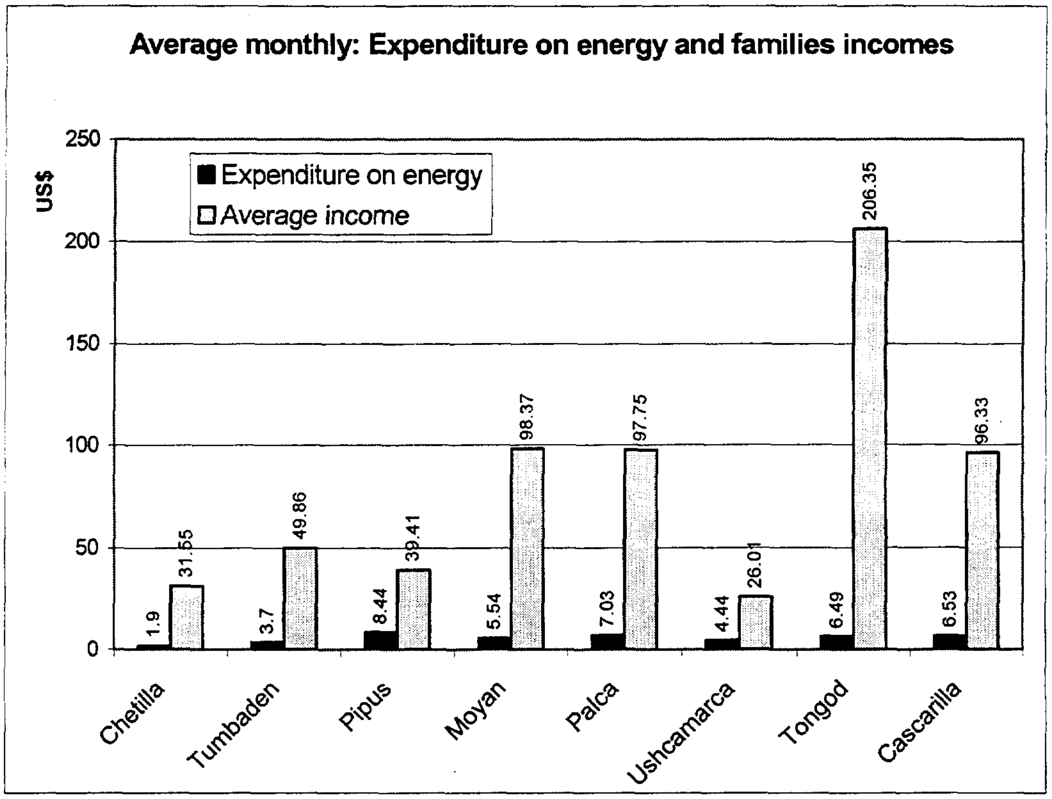
- **Energy source.** The main sources of energy are kerosene (for burners and lamps), candles, batteries, fuelwood, and in some cases, dung.
- **Lighting expenditures.** The summary in table 3 shows that on average, families spend between US$2 and $10 per month on some source of lighting, and in a few cases, TV.
- **Family income/energy expenditure ratio.** On average, families with higher income spend more on energy (see figure 3). There is a clear difference between incomes found among families of the excedentarios type and others. However, the former group is only a small part of the population—therefore average energy spending in each community is closer to the average of the poorest groups (below subsistence level).

Table 3: Family Incomes and Energy Expenditures

Rural villages	*Estimated energy expenditures (US$/month)*			*Estimated income per family (US$/year)*		
	Infrasub.	*Autosub.*	*Excedent.*	*Infrasub.*	*Autosub.*	*Excedent.*
Chetilla	1.61	2.88	6.68	217.10	907.40	3,223.20
Tumbadén	2.56	5.55	8.56	236.00	660.20	3,285.50
Tongod	5.17	7.67	10.58	1,342.50	3,247.60	6,741.30
Pipus	6.00	15.20	14.40	300.00	919.10	961.70
Moyán	5.12	4.80	8.80	575.70	1,130.20	3,850.20
Palca	6.30	9.14	Not applic.	933.30	1,869.50	Not applic.
Ushcamarca	4.52	3.80	1.90	289.20	696.30	679.70
Cascarilla	3.52	9.88	5.52	426.70	1,942.80	959.20

Note: Exchange rate 1 US$ = S/. 2,45, July 1996.
Source: Evaluation studies by ESMAP/ITDG.

Figure 3: Energy Spending and Household Income (monthly averages)



Source: ESMAP/ITDG.

Case Study: The Management System in Chalán

In the Andean community of Chalan, a MHP was established and placed under the management of a Community Committee. The committee was created as the management unit of the electricity service and other related services that might develop based on the electricity supply from the small power plant. It consists of five people who are not involved in local government but who do represent the community. The structure of their organization is consistent with the provisions set forth in the Organic Law governing municipalities. In effect, the municipality's responsibility to manage the public services within its jurisdiction has been decentralized through this committee.

As the committee has no legal status, it cannot gain access to the credit system. Nevertheless, it can receive support from NGOs or government institutions that promote such organizations. Furthermore, this organization does not have to pay taxes to the tax authority (SUNAT).

The management structure was created directly by the District Council and is therefore subject to the criteria adopted by the local government system. If the local government decided to control the public electricity service directly, it could dispense with the committee. The local government's motivation for such a move would likely be political or personal disagreements; this would, of course, mean the wasting of the human resources trained to manage the committee.

This type of organization and its management must comply with the following conditions:

- Committee members should be local people with no profit expectations and they should earn no wages, unlike those who manage and operate the MHP.
- It is important to have the basic management equipment in place: materials, logistics, small office supplies, and so on.
- An administration fee should be allowed. This consists of the administrator's salary (without considering the minimum wage, life insurance, and social benefits), equivalent to S/. 200 a month.
- Operations and maintenance should be scheduled. Based on experience, two operators from the same area should be responsible for O&M, once they have been trained. They should each be paid S/. 150 a month.
- A "Reserve Fund" should be established to cover the maintenance or possible replacement of power plant components.
- Materials must be purchased for preventive maintenance—and in some cases, for corrective purposes.
- The Community Committee should be in charge of income from electricity bills, under the supervision of the Municipality.
- Eventually the Community Committee should be made responsible for the supervisory tasks regularly handled by the system administrator.
- The electricity supply timetable should depend on the population's requirements. For Chalán this would be 12 hours.
- In Chalán's case, operating costs consist of S/. 500 per month for wages plus the reserve fund, which implies a consumption cost of S/. 5.80 per month per family, based on 86 users.

Organic Structure

The Committee's role is managing the service and ensuring its quality. To this end, it relies on the services of an administrator and two operators who are in charge of monthly bill collection and O&M. Community participation is vital, particularly when manpower is required for maintenance work. The tariff structure is coordinated by the Municipality and the Committee.

Lessons from Chalán

The Chalán MHP was implemented under the following criteria: the participation of different community organizations, sustainability, and special care in the selection and training of the plant's operators. Nevertheless, the following weaknesses were identified in the model itself:

- Vulnerability to interference by municipal authorities—the model was created relying on the good faith of the authorities and without much research of the current legal framework.

- Social bias in tariff implementation—the revenues obtained from electricity rates fail to cover the system's operating costs in full, resulting in the Municipality (rather than the consumers) paying the salary of one of the three employees.
- Uncertainty regarding property ownership—the Municipality still owns the system, even though part of the assets were transferred to the Community Committee.

Property and Management Types in Peru's Existing Isolated Power Supply Systems

In Peru, five types of electricity supply system ownership can be distinguished:

- **State owned.** These are established by the government and managed through regional electricity companies referred to as "Electros."
- **Municipal property.** Most of these are negotiated by the Mayors and usually donated by some high-ranking Government authority, with a limited involvement of the MEM, then transferred to the Municipality for management purposes.
- **Community property.** Community systems are either set up by community members themselves or donated by international cooperation agencies, or a combination of both. They are managed by a community organization.
- **Privately owned.** These are usually very small plants set up by peasants interested in processing their products in some way or selling energy to their neighbors.
- **Cooperative property.** These are facilities built by cooperative associations to cover their own energy requirements.

The majority of existing isolated systems is either state- or municipality-owned. There are very few community plants or privately owned systems and even fewer owned by cooperatives.

An Evaluation of the Performance of Isolated Power Supply Systems in Peru's Rural Areas

One of the activities carried out during phase two of the ESMAP/ITDG work was evaluating the performance of isolated power supply systems in Peru, in order to establish which management systems had failed or succeeded and why. This work involved 12 case studies of small isolated power plants in different parts of the country. Ten of these were hydroelectric plants and two were diesel plants. Their plant capacity varied between 8 and 800 kW.

One of the most important criteria for selecting the systems was the management or property type. The idea was to cover all management models. However, a disproportionate number of municipal and community plants ended up being chosen because they relied on local management It was also presumed that state-owned plants would have few difficulties with their services and that their main problem would be high management costs. Table 4 contains a list of the locations of the systems, their capacity, and type of management.

Table 4: An Ex Post Evaluation of Small Isolated Power Systems

Powew plant (location)	*Plant capacity*	*Property or management type*	*Situation at the time of the visit*	*Observations*
Santo Tomás (Cuzco)	70 kW	Municipal	Working without interruptions	There is not much interest in the upkeep of this plant. It is expected that the local grid will be connected to the grid from the Machu Picchu plant.
Cocla (Cuzco)	120 kW	Cooperative	Working	This plant is used exclusively for the Cocla cooperative coffee processing plant.
Pangoa (Junín)	60 kW	Private	Working without interruptions	This is a private power generating company that sells electricity; it has 30 members.
Pacarenca (Ancash)	2x195 kW	State	Working	This plant is owned and managed by HIDRANDINA.
Congas (Ancash)	40 kW	Community	Working for 12 hours a day	Owned by the Congas community, which has some 150 families.
Cajacay (Ancash)	50 kW	Municipal	Out of service	The Municipality manages the plant; there is a dispute with HIDRANDINA regarding ownership. Diesel system.
Ocros (Ancash)	250 kW	Municipal	Working	This case is similar to that of Cajacay.
Los Patos (Amazonas)	8 kW	Community	Working	Community property, directly managed by 20 members
Pedro Ruiz (Amazonas)	200 kW	Municipal	Working	The property was transferred to the Municipality in 1992. Prior to that it was part of ELECTRONORTE.
Chusgón (Amazonas)	25 kW	Community	Working in a restricted manner, 4 to 6 hours a day	Each user is entitled to use one 11 W fluorescent light.
Pucará (Cajamarca)	2x200 kW	State	Working	Property of ELECTRONORTE
Pozuzo (Pasco)	2x400 kW	State	Working adequately	Property of ELECTROCENTRO

Source: ESMAP/ITDG.

Results: Organization, Management, Costs, and Tariffs

Organization

- **State-owned systems.** Systems owned and managed by the government are run by state electricity companies referred to as "Electros." Small isolated plants are at the very end of the administrative chain. The Electros own and manage all public power generation and distribution facilities in a given area. Each comes under the superstructure of Electroperu.

Electros have their main offices in the capital city of the most important department within their sphere of competence. For example, the main office of Electrosur Este is in Cuzco. There are also offices in lower-ranking capitals of other departments within the area covered, as well as at a provincial level.

This means that the management of small isolated systems reports to the office directly above it, and so on up the administrative chain. For example, Pacarenca is managed from Huaraz, Pucará from Jaén, and Pozuzo from La Merced.

Since they form a large management system these small systems have permanent or hired staff (or both) in charge of billing, collections, and O&M work.

- **Municipal systems.** The study revealed that there is no organization exclusively responsible for managing the electricity service, except in the case of Pedro Ruiz, where the municipal administration has an electricity unit. In general, the municipal management task is performed by employees who are in charge of billing, collections, O&M tasks. As a rule, a municipal council member is responsible for the management of the system.
- **Community systems.** The case of community systems is similar to that of municipal systems. There is no special organization in charge of managing the power plants; community leaders usually manage them directly. They make decisions at an assembly attended by the entire community. Many community members do not benefit from the system, but they are nevertheless entitled to make decisions regarding the service, creating conflicts that subsequently affect final users.
- **Private systems.** The owner is directly responsible for the management and O&M. These plants are usually very small in terms of installed capacity.
- **Cooperative systems.** Again, these are similar to community and municipal plants, which means that certain members of the cooperative are directly responsible for O&M and administration.

The Management Capacity of Small Systems

Most state companies have the required managerial capacity. Others, however, lack the requisite technical and management skills among their ranks.

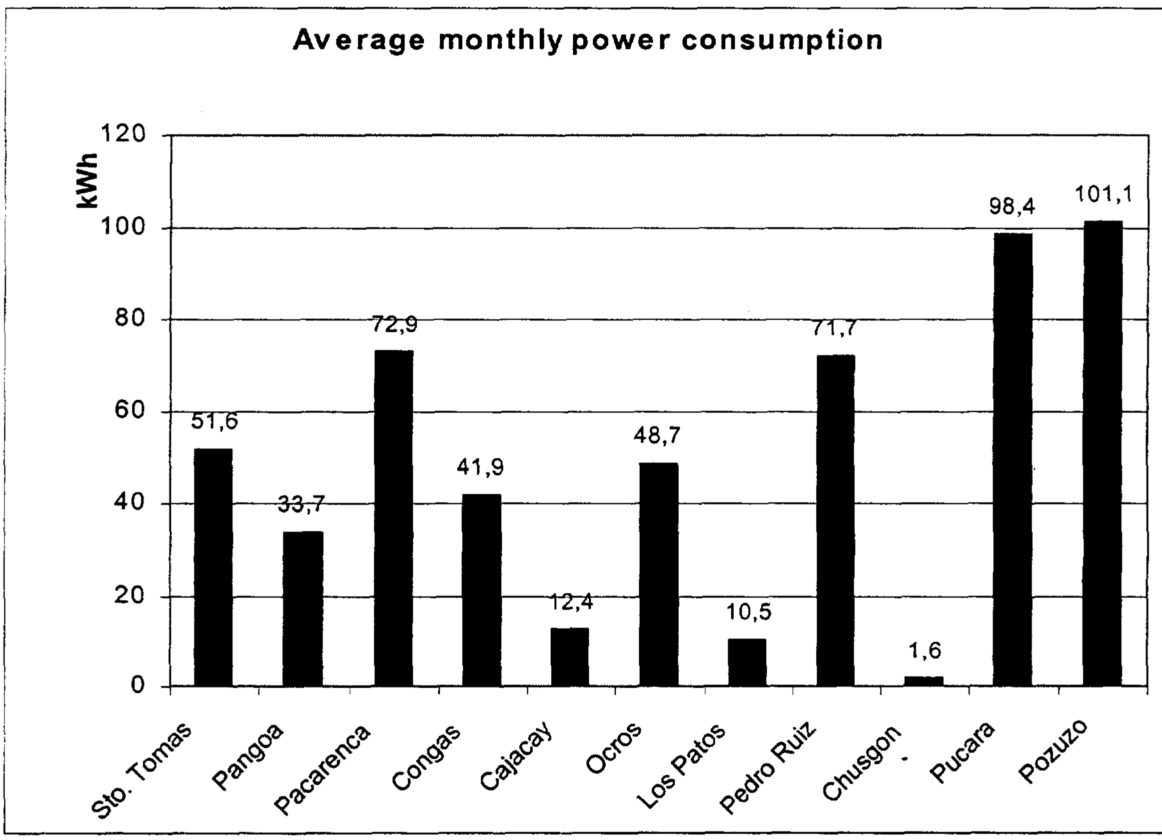
State companies can usually take care of power outages rapidly, if necessary transporting their engineers from the company's headquarters to the specific plant requiring repairs or maintenance. In other cases, when the equipment is faulty, the plants can remain out of service for a fairly long time—not only owing to the inability to repair or correct the faults, but because of the lack of contacts and limited knowledge about where to find adequate repair services.

The situation is even more critical in community-owned plants, in which community leaders are directly responsible for "managing" the place.

Power Consumption and Cost

In general, power in rural areas is used mainly for lighting. Hardly any power is consumed for productive or industrial purposes, with the exception of small bakeries, carpentry workshops, grocery or ice cream stores, battery-charging services, and so on. The service in the majority of systems is not continuous. Diesel systems provide services for 2 or 3 hours, and hydro systems for 8 to 12 hours. The exceptions are Pacarenca, Pucará, and Pozuzo, which do have uninterrupted service. The average consumption per household ranges from 30 to 100 kWh a month. The consumption of diesel systems is much lower—10.5 kWh in Los Patos and 12.4 kWh in Cajacay (see figure 4).

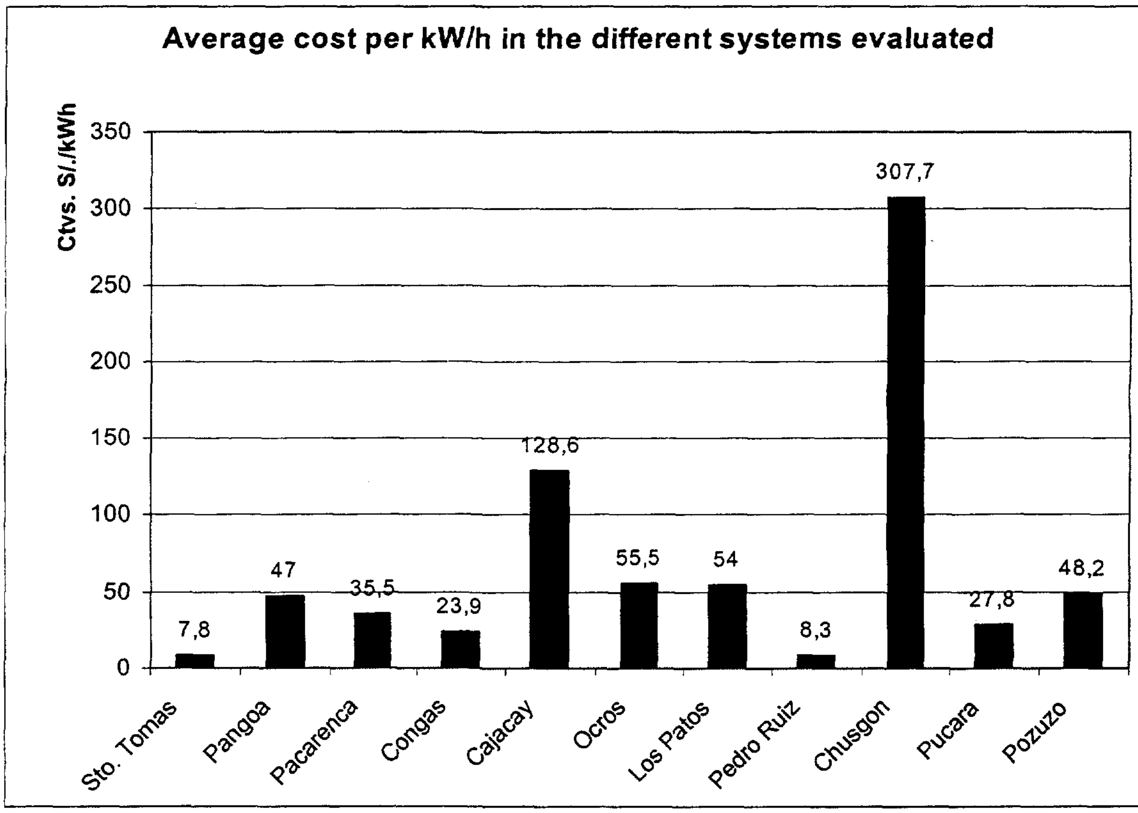
Figure 4: Average Monthly Power Consumption



Source: ESMAP/ITDG.

All these problems have an effect on customers, who refuse to pay for poor quality service. Such is the case of Santo Tomás, where the monthly payment is S/. 4.0 for 12-hour service for 15 days a month. A further analysis in which hours of service, consumption, and rates are considered provides a more revealing kWh cost indicator: The average cost of a kWh ranges from a high of cents S/. 307.7 per kWh in Chusgón, where the monthly tariff is apparently cheap (S/.5.0 a month), to a low of cents S/.7.8 per kWh in Santo Tomás, which has a similar monthly tariff (S/. 4.0). (See figure 5.)

Figure 5: Average Cost per KW/h in the Different Systems Evaluated



Note: Costs established in January 1997: US$1.0 = S/. 2.60.
Source: ESMAP/ITDG.

The following problems were identified in the tariff systems investigated:

- In the majority of cases, state companies use tariffs established by the National Tariffs Commission, which are adapted from the tariff systems applied in urban areas. The companies often receive claims or criticism from the public citing "steep payments."
- Tariffs charged by community and municipal companies differ in each case. Authorities do not know how to estimate tariffs or whether or not the tariffs can at least cover operating and maintenance costs. There are no calculation parameters and tariffs are generally subsidized by the administration or the community. As a rule, neither the authorities nor the population in general knows how to run the system as a business, let alone a profitable one. For example in Pacarenca, the costs are determined by the appropriate authority, who establishes the tariff "in accordance with consumption." To this end each family's appliances are checked so that a tariff can be established accordingly. In such cases the tariff established could depend less on technical and financial factors, and more on political connections and other extraneous considerations.
- Private systems generally charge a high tariff in terms of unit costs (cost/kWh.). However, these are very small plants that sell very little power to each user.

- Co-operative systems charge no tariff at all, and their costs are covered by the co-operative, meaning that every member of the cooperative, regardless whether he/she consumes electricity (see above) has to pay a share of the cost.

Personnel Employed for the Operation, Maintenance, and Management of the Systems

State-owned companies have a large number of employees for the operation, maintenance, and direct management of small systems. In addition, other staff at different levels of the company also spend some of their time managing or supervising the small plants. It is difficult to calculate the costs associated with the supervising and maintenance staff who work in the larger offices, as this information is not made available to outsiders.

Municipal systems tend to have a large number of employees, whereas community and cooperative systems have fewer employees exclusively devoted to managing the systems. Private systems are managed by family members.

The number of employees has an influence on operating, maintenance, and management expenses. State companies report the highest costs, given the number of people they employ and the high fixed costs of the large companies in charge of the systems. The same occurs in municipalities, in which the electricity system is often used as an excuse to hire staff who will be paid by the Municipality.

Typical load factors in isolated systems

The high costs of small rural electrification systems can often be attributed to low load factors and excessive capacity by design. The ex post survey investigated load factors closely to lay the groundwork for a more systematic investigation of low-cost alternatives. The load factor of a power system is the ratio of total energy consumed by users to the maximum power demand during the period under consideration, whereas the plant factor is the ratio of total energy consumed by users to the energy available.[8] Figure 6 shows the load factors and plant factors of the systems covered by this study.

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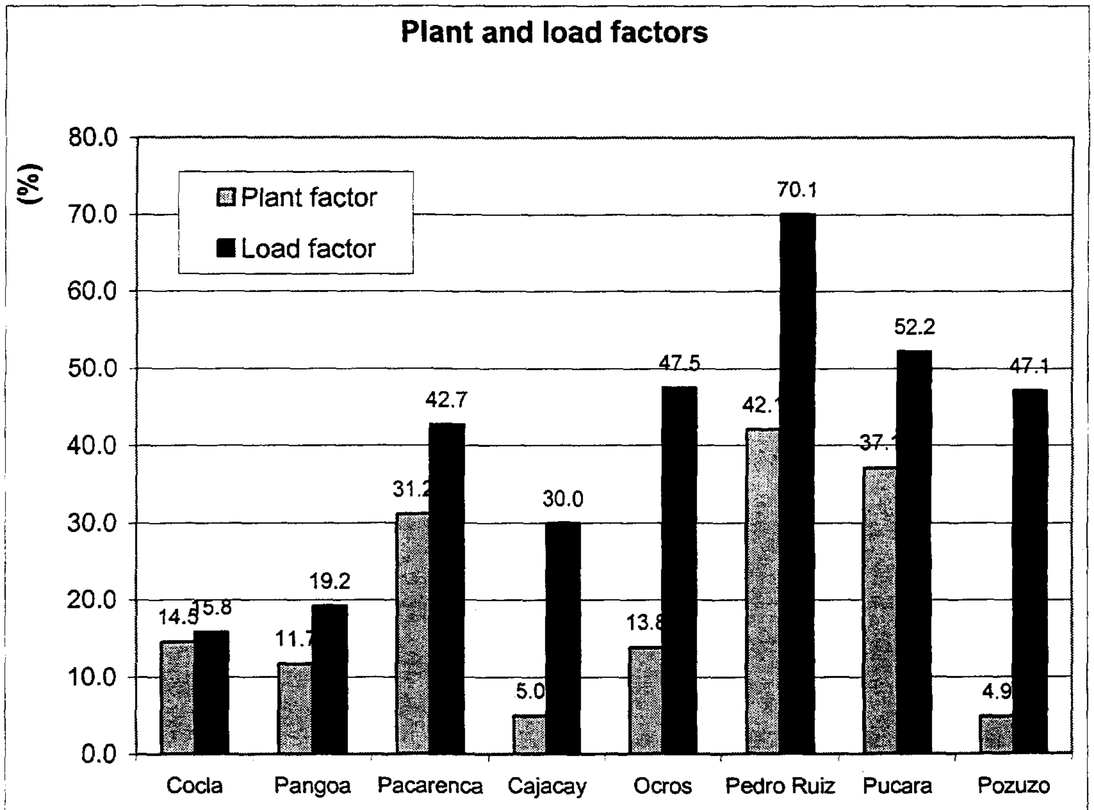
8 These concepts were taken from the following ITDG publications: *Handbook of Mini and Micro Hydroelectric Power Plants,* Lima, 1995, and *Micro Hydro Design Manual*, London, 1993. Some experts use the capacity ratio to determine the load factor: Minimum power demand (low hours) divided by the maximum power demand (peak hours).

Figure 6: Plant and Load Factors



Source: ESMAP/ITDG

It is initially puzzling to see that in Pedro Ruiz, Cajacay, and Pangoa, where the systems are saturated and the load factor should be high, close to100 percent, it is in fact only between 20 and 70 percent. There are several reasons for this: for one, the energy supply is not continuous, either because of the high cost of fuel (Cajacay), concerns about machinery wear and tear (Pedro Ruiz), or simply constant flaws (Pangoa). Poor maintenance, a badly designed system that will never work at full capacity because of the scarcity of water, or simply the lack of an operator are other factors that affect power supply activities and result in the low load factor. In plant factor terms, the situation becomes even more critical.

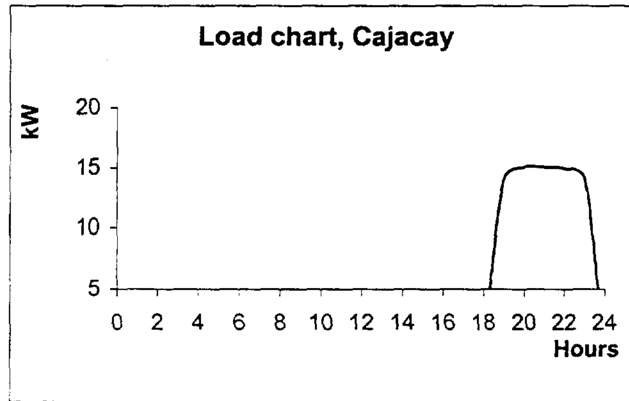
The load factors of the Pacarenca, Ocros, and Pucará systems represent the typical load factors for rural towns in Peru with an average poverty rate. Pozuzo with its high load factor is a special case because it has a "rich" population and a higher demand for energy—since people have access to appliances such as microwave ovens, cable television, electric cookers, and others.

Coca cannot be considered a representative case for rural electrification purposes, because the plant was designed for productive purposes (coffee processing). However, since that is a seasonal activity, there are certain times of the year when it only supplies energy to the administration block, whereas during the harvest season (three months a year) it works full capacity. Since the period considered in our study for establishing the load factor was one year, this resulted in a low annual load factor.

The following figures (7a through 7e) show some typical energy consumption curves (charge diagram).

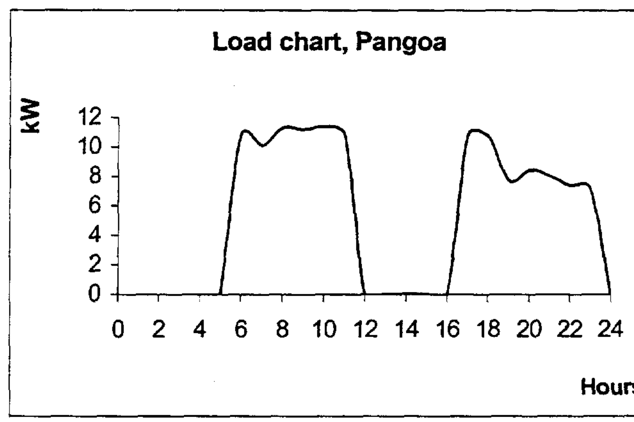
Cajacay: The electricity system in Cajacay is typical of a diesel system, in which the service is provided for only a few hours, mainly for lighting purposes. The nominal capacity of the generator is 50kW, although it only generates 15kW. The current demand exceeds the plant capacity and a large part of the population is not connected to the system.

Figure 7a: Load Chart, Cajacay



Pangoa: The figure shows how the energy consumption of this MHP varies on a particular day. Power cuts are not planned, but they occur frequently due to the deteriorated state of the equipment and facilities and the lack of maintenance. Another reason is the lack of technical guidance during the planning and implementation stage. The plant capacity is 60kW, but the most it generates is 15kW, which is far exceeded by the demand.

Figure 7b: Load Chart, Pangoa



Pedro Ruiz: This MHP was designed for 400kW in two stages of 200kW each. Only the first stage was implemented. It is impossible to implement the second as there is a shortage of water. No information on the hydrological study was available. This system is now saturated, mainly because of an atypical increase in the demand and equipment deterioration. To prevent further wear and tear, the supply is limited to certain hours, as shown in the figure.

Figure 7c: Load Chart, Pedro Ruiz

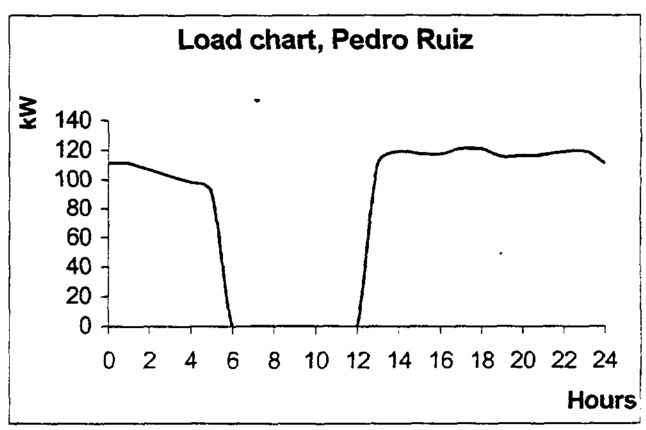
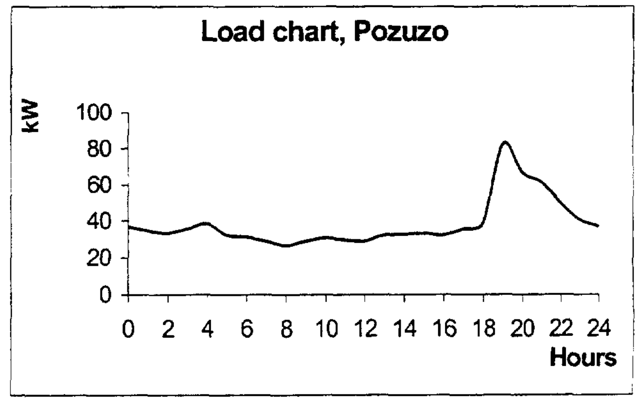
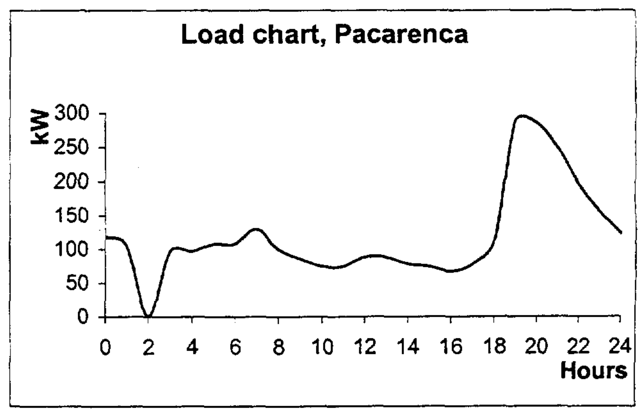


Figure 7d: Load Chart, Pozuzo



Pozuzo: The energy consumption curve of this MHP is typical of rural areas (when the plant works properly). In this case the supply (800kW) largely exceeds the demand (80kW during peak hours). The entire population is served by the plant and there is no further demand nearby. Consequently, this plant carries excess capacity.

Figure 7e: Load Chart, Pacarenca



Pacarenca: The nominal plant capacity of this MHP is 390 kW. As in the case of Pozuzo, the figure shows a curve that is typical of rural towns. However, there is a more pronounced variation between low hours and peak hours, mainly because people are poorer than in Pozuzo and use electricity mainly for lighting, television, and radio.

Opportunities for Reducing Costs in Small Hydroelectric Systems

The main arguments against mini and micro hydroelectric power plants (MHPs) as alternative sources of energy for isolated rural areas are high initial investment costs, high specific costs per unit installed, low load factors, and long implementation periods.

It is true that in the past many mistakes were made, that smaller systems have high unit costs, and that conditions for successful implementation must be closely monitored. These conditions include the distance between the power plant and the demand, the type of geography, the length of the channel, the type of soil on which to build (to build a channel on the rocky ground of rugged slopes can be a costly business), and the concentration of the demand (some towns have no well-defined streets and their dwellings are fairly widespread).

However, during the past 25 years a large amount of work has been done in setting up MHPs in different parts of the world, many of them for the purpose of reducing implementation costs. Considerable progress has been made in this field without sacrificing the quality of the service.

The high costs usually quoted tend to be based on international and, to a lesser extent, local experiences, based on projects built with an excessive amount of impressive engineering work—soil studies, geological studies, lengthy hydrological surveys, a series of topographical maps, designer plans that include the smallest details (for example, cuts every 20 or 30 meters in the head channel and in high voltage lines), oversized civil works, intakes designed based on high flow estimates for the next 50 or 100 years, enormous power houses, excessive public lighting, demand calculated based on up to 800 W per family when the actual consumption is only 30 to 50 kWh a month, and so on. Under such criteria and practices, high costs are not a surprise. If we add the very low load factors and, consequently, low revenues, there is ample reason to prefer other alternatives.

The Intermediate Technology Development Group (ITDG) has been involved in supplying energy to isolated areas in various parts of the world since 1978 and in Peru since 1986. Throughout this time in Peru, MHPs were preferred for the following reasons:

They can be implemented under much cheaper engineering schemes than the existing ones. There is plenty of water available for small power plants. There are a large number of isolated towns in this country with a limited chance, if any, of being connected to the grid. Costs can be reduced substantially using appropriate technology and appropriate concepts. Once installed, the plant's dependence on large developed towns is limited because it is possible to train the rural population to take over the operation, maintenance, and administration of the plant. Based on this experience, ITDG outlined opportunities for cost reduction for the ESMAP project.

Concepts for Reducing MHP Costs

As mentioned above, not only the initial investment costs of MHPs but costs for all stages—from preliminary studies and engineering designs to implementation and start-up—can be reduced substantially, provided certain important concepts are taken into account. These concepts are as follows:

- *Essential engineering.* When designing an MHP, one must remember that this is not simply a matter of reducing the scale of large plants. Large hydro-power plants use large volumes of water, large quantities of metal are transported and installed, large investments are required, and therefore associated risks are higher and the cost of mitigating them is also higher.
- *Efficiency.* In a large plant, a 1 percentage point drop in efficiency could mean megawatts less of power, implying a big difference in revenues. This does not occur in MHPs, in which the only important thing is ensuring that enough power is generated during peak hours and keeping the population growth rate in mind during the design.
- *Complementary works.* The construction of access roads, camps, and other facilities should be avoided if possible, since the size of the plant does not justify them. Organized communities can help transport equipment and materials, even when distances are great and access is difficult. This and other factors help to reduce costs.

- *Latest engineering*. There have been a number of developments over the last 20 years that have helped to reduce costs without placing the energy supply at risk. These developments range from methodologies for drawing up technical files and field studies, the implementation and start-up of MHPs, low-cost civil works, and machinery manufactured in local workshops, to the use of unconventional machinery, such as motors in reverse as generators or pumps in reverse as turbines.

Cost Reduction Examples

We systematically explored opportunities for cost reduction, using as our basis two examples—the Santo Tomas MHP in Chachapoyas and the Moyan MHP in Ferreñafe. We designed three different versions of each MHP, all with the same identical capacity but with different parameters and standards. The resulting costs are summarized in table 5.

Table 5: Costs of MHPs under Different Standards

MHP	*Type of cost*	*International standard*	*Intermediate*	*Low cost*
Santo Tomás (70 kW)	Initial investment	343,374.80	285,928.20	193,397.20
	Beneficiary's investment	1,107.70	922.40	623.60
	US$/kW installed	4,905.40	4,084.70	2,762.40
Moyán (10 kW)	Initial investment	52,235.40	37,884.0	23,677.30
	Beneficiary's investment	1,450.90	1,052.30	657.70
	US$/kW installed	5,223.50	3,788.40	2,367.70

Source: ESMAP/ITDG.

The highest cost is the result of using current national rural electrification standards and commercial equipment sold in the Peruvian market. Civil works are estimated with normal formwork. The intermediate cost value is the result of economizing on channels (using the ribbed method), and using PVC pressure pipes and a three-phase grid with cement posts and self-conveying cables. The lowest cost is the result of the simplest civil works (mixed inlet work), only 60 percent lining of the canal (in highly vulnerable parts), wooden posts for both low and high voltage lines, and a secondary three-phase grid similar to the one used in high-cost cases. In all three cases, a mark-up of 18 percent was assumed to cover profits and administration expenses.

It is worth pointing out that for both sites, costs could be even higher than the highest costs mentioned if the designs were excessive in size, costly equipment were imported, and profit margins and administration expenses were increased to 25 percent, which is considered normal. However, it is also possible to obtain slightly lower costs if smaller profit margins are considered acceptable and if there is a further reduction in the number of products transported over long distances. Cement is a prime example of the latter; it costs more because of the shipping expenses involved.

In any case, the lower values quoted are close to the absolute minimum, without risking the quality of the service and the technical sustainability of the MHPs and without resorting to the "appropriate technologies" that are often promoted for poor rural towns. More often than not advocates for these confuse "appropriate" with "cheap," which frequently leads to absurd proposals such as the use of artisanal machinery, artisanal works, and artisanal concepts. Many proposals have been introduced over the last 25 years targeting the manufacture and use of equipment and systems for renewable energy, some of them totally out of context and with no technical foundation, justified solely by their rock-bottom prices.

If the intention really is to reduce costs and enhance the service, then camps, access roads, and similar add-ons should under no circumstances be considered for plants under 150 kW capacity. Nevertheless, by-the-book designers do take these factors into consideration, even for the smallest plants (those with 30–50 kW capacity)—in many cases because they lack field expertise or simply because they are applying the engineering techniques used for large-scale power plants.

Commercial Costs of Nine MHPs Based on Project Feasibility Studies

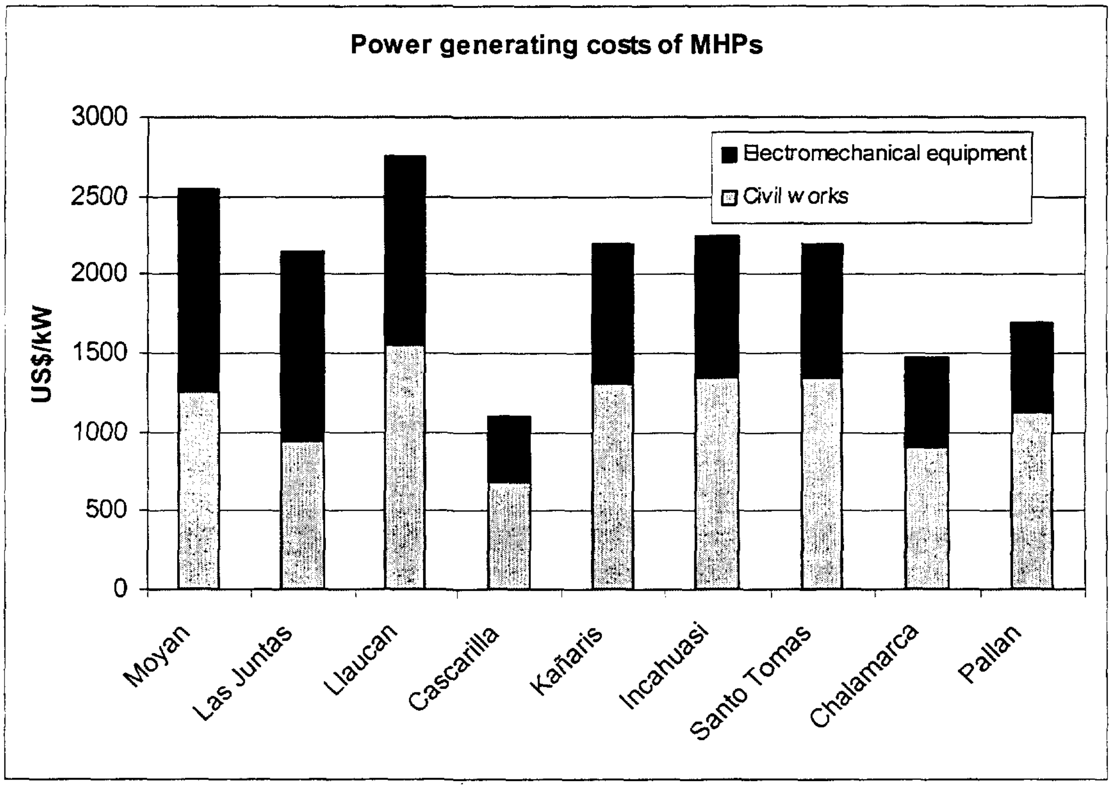
In 1996, ITDG prepared feasibility studies for nine MHPs. Official standards and requirements were considered, as well as conventional civil works, grids, and the purchase of commercial equipment. Oversized plants and unnecessary extras such as access roads and camps were not considered. In some areas, more affordable designs were chosen over expensive ones—for example, for the channel. On average, the studies cost US$5,000. The resulting costs and their breakdown are listed in table 6. Total cost per kW installed ranged between US$3,000 and US$5,500—with a big potential to further reduce costs. For comparative purposes, figure 8 shows the main cost components of the same MHPs. Grids were not included as they are fairly standard, which limits the possibility of reducing their costs.

Table 6: Costs of MHPs, Based on Feasibility Studies (US$)

MHP	*Power (kW)*	*Costs in US$*					*Total US$/kW*
		Civil works	*Electro-mechanical equipment*	*Grid*	*Overhead costs and utilities*	*Total cost*	
Moyán	10.0	12,555.07	13,110.98	12,867.60	6,936.06	45,469.71	4,546.97
La Juntas	15.0	14,488.29	17,344.00	14,918.54	8,415.15	55,165.98	3,677.73
Llaucán	50.0	77,495.98	57,615.06	101,435.22	42,578.33	279,124.59	5,582.50
Cascarilla	50.0	32,168.60	22,643.87	72,034.22	22,832.40	149,679.10	2,993.58
Kañaris	50.0	65,439.72	41,784.97	48,686.56	28,064.03	183,975.28	3,679.51
Incawasi	50.0	67,453.20	45,264.00	81,158.68	34,897.66	228,773.54	4,575.47
Sto. Tomás	70.0	94,695.85	56,371.39	139,928.38	52,379.21	343,374.83	4,905.35
Chalamarca	90.0	79,562.14	54,134.76	144,212.64	50,023.72	327,933.26	3,643.70
Pallán	100.0	113,238.72	52,085.51	232,470.28	71,603.01	469,397.52	4,693.98

Source: ESMAP/ITDG.

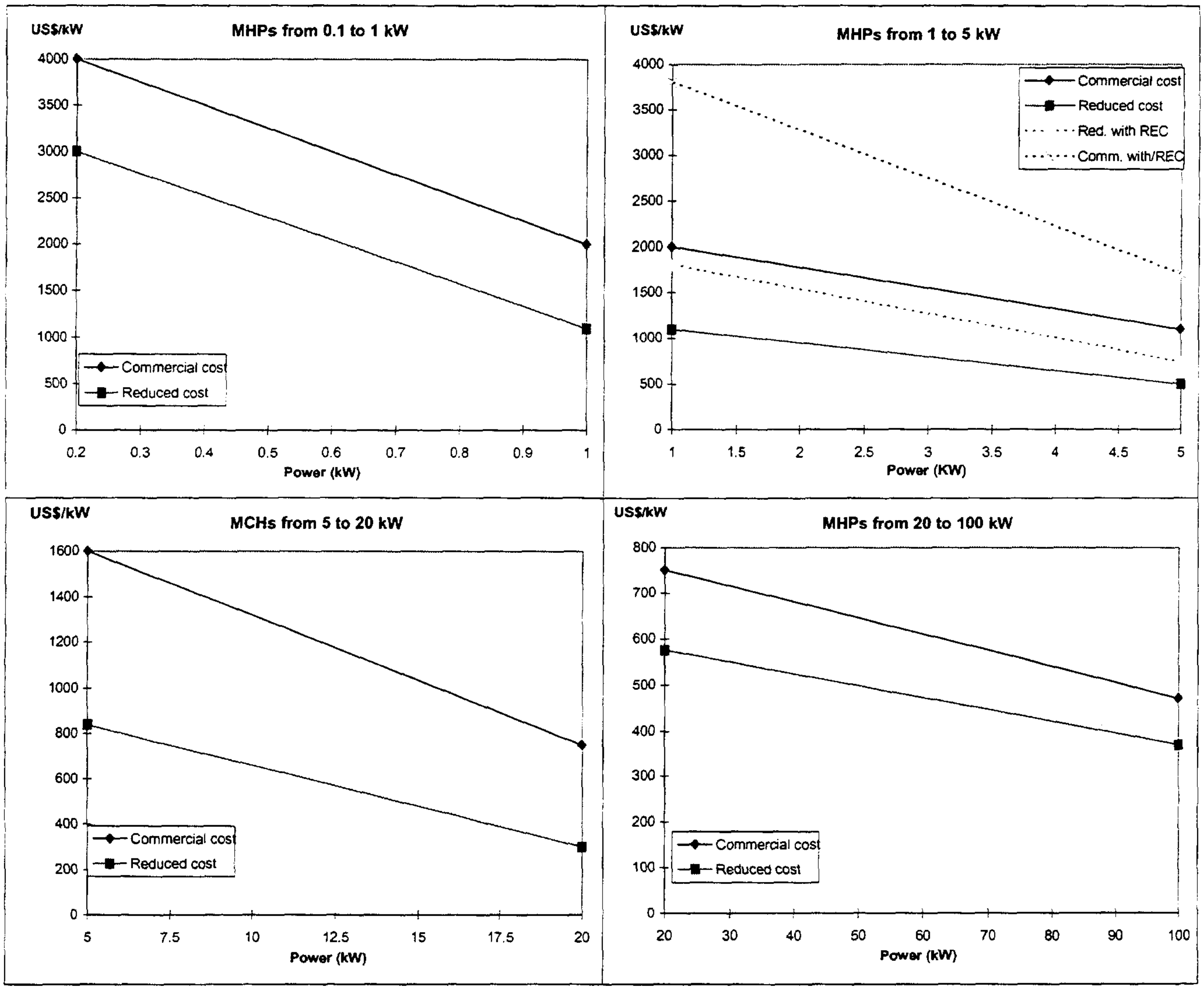
Figure 8: Power Generating Costs of MHPs



Source: ESMAP/ITDG.

One of the major cost components is the electromechanical equipment. In a separate exercise, the potential for cost reduction of electromechanical equipment was analysed. Small hydroelectric systems were classified according to their capacity ranges and different technical options and standards. By applying lower standards, costs can be reduced for all capacities, but the cost-saving potential seems to be highest in a middle range of 5–20kW, for which local equipment is more widely available. (See figure 9.)

Figure 9: Cost of Electromechanical Equipment by Range of Power Capacity



Source: ESMAP/ITDG; Note: REC: Governor

The Legal Framework for Isolated Power Supply Systems

The law governing the electricity sector is the electricity concessions law (D.L. 25844). However, this does not explicitly address power plants with less than 500 kW capacity—such as isolated rural systems. In fact, most of those have less than 100 kW capacity. Below is an extract of the main articles concerning this subject:

- D.L. Article 3: A CONCESSION is required for each of the following activities:

  (a) **Generating** electricity using hydraulic and geothermal resources, when the plant capacity is greater than 10 MW.

  (b) **Transmitting** electricity when the plant facilities affect state properties or require a right of way through them.

(c) **Distributing** electricity as a public electricity service when the demand exceeds 500 kW.

- D.L. Article 4: AUTHORIZATION is required to generate thermal-electric, hydroelectric, and geothermal power when the plant capacity exceeds 500 kW and a concession is not required.

- D.L. Article 7: Power generation, power transmission, and power distribution activities that require neither a concession nor an authorization can be carried out freely, provided that they comply with technical standards and the provisions regarding environmental conservation and public cultural domain.

- D.L. Article 34: Holders of DISTRIBUTION concessions are under the obligation to:

  (a) Provide the service to whoever requires it within the concession area, or to those who take their own lines to that area (and who qualify as public electricity services), within a period of no more than a year.
  (b) Have contracts in force with electricity generating companies, guaranteeing their total potency and energy requirements for at least the next 24 months.
  (c) Guarantee the quality of the service established in the concession contract.
  (d) Allow third parties to use the systems to supply energy to users not qualified as public electricity services, either within or outside the concession area, under the conditions established in this law and its regulation.

- D.L. Article 121: The supply of electricity that qualifies as a public electricity service and that does not require a concession, can be undertaken by individuals or companies with a permit—granted by the respective municipal council—that will establish the conditions for the supply, by mutual agreement with users.

Despite the above, holders may apply for a concession from the MEM for these activities, within the provisions set forth in this Law and the Regulation.

There are other laws or standards to be considered, given the various alternatives for supplying power for rural electrification purposes.

- *Water Law.* This law establishes the need for a permit from the irrigation district for non-irrigation water use.
- *Code of the Environment.* This law establishes that if power supply activities have a negative impact on the environment, the costs must be assumed by those responsible.
- *Law Governing Municipalities.* This law refers specifically to the organization of companies, since in many cases municipalities are directly involved in the financing or promotion of electricity companies.

- *Corporate Law.* This law should be considered if energy is to be managed or sold through a company.

Property and Management Models for Isolated Power Supply Systems

One of the most relevant factors for the viability of small isolated systems in rural areas concerns administration and management. It is well known that none of the models used so far has been convincing (see chapter 4). Therefore, we decided to design and test other models that seem to be more relevant to the sustainability of isolated rural power supply systems.

ITDG reviewed different models currently in use (state, municipal, private, cooperative, and community; see section 3), as well as electricity and corporate laws in force in Peru. We concluded that private management is one of the few alternatives that should be promoted, since it provided incentives for efficiency and for using existing, or generating the necessary, local capacity.

Two models were developed: "management services" and "private property and management." Both are in the pilot stage at the moment. The second is not a new model, since it already exists in a few very small plants; in this case the idea is to improve the probability of success by training the owners who also manage the service. The first model required considerably more planning than the second before it was implemented as a pilot project.

Management Services

The "Management Services" model can be used for systems owned by the state or municipalities. In this case there is no need to change ownership; instead, the owner hires a private company—preferably a local one—to take over the O&M and management of the small plant.

The small company is handed over by way of a public contract awarded by tender. Contracts must be negotiated for medium to long periods to guarantee the safety of the small company, to enable it to assume long-term commitments, and, if necessary, to allow it to make small investments.

Before awarding a contract to a small company, the corresponding terms and conditions must be established and then the local tender should be called. If there are no local companies, the terms and conditions must be adjusted to allow individuals to compete—under the commitment that they are to form a company should they win the contract.

Pilot Stage Model: Conchán

This model is currently being implemented in the Conchán district, in the province of Chota, department of Cajamarca. The MHP has a plant capacity of 80 kW; it started operating in 1995 and has so far been run by the district municipality.

A four-year contract was negotiated for Conchán; the successful bidder was Empresa de Servicios Electricos San Isidro. As was to be expected, there was no company in Conchán that was capable of submitting a bid. Consequently, bidders submitted a letter of intent. A committee elected by local residents was in charge of the entire qualification process.

It must be stressed that in this case the involvement and consent of the public was obtained for the entire process from the moment the idea was discussed until it was implemented. To this end several general assemblies (attended by the entire population of Conchán) and Council meetings were held. As part of a legal process, for which the corresponding municipal resolutions were issued, the responsibility for the electricity service was handed over from the municipality to the new company.

For the actual work, local authorities had to be shown that it was necessary to implement an efficient and effective management system so that the municipality in particular and the population in general could reap the benefits. Moreover the general public also had to be trained to understand this need, agree to the process, and promise to support it.

The following steps or activities summarize the process:

- Initial visits and detailed explanations to authorities;
- Visits and meetings with all members of the district council;
- Visits and presentations to users, explaining the advantages of an independent and efficient operation and administration;
- Organizing the committee responsible for implementing the model;
- Drawing up the bidding terms and conditions;
- Calculating tariffs, income, and spending;
- Incorporating the bidders, since not all of them were companies;
- Organizing the public tender for local companies and awarding the winning bid;
- Drafting contracts;
- Formally establishing a company in the district and officially handing over the service;
- Signing the contract;
- Training the successful bidder;
- Starting the service contract; and
- Monitoring.

As of early 1999, the last two points were pending—but inventories of existing assets had been made in preparation for signing the contract and formally starting the management service. Since the entire process was properly conducted with the involvement and acceptance of users, the service contract is expected to go into effect without any complications.

Private Property and Management Services

The private model consists of the owner promoting and managing a privately owned plant. Although examples of this model already exist, very few are functioning well. In this case the work was limited to evaluating the owner's skill set and based on that, creating the conditions for a proper and efficient operation, for which training was required.

This model was implemented in the Trinidad district, Contumaza province, department of Cajamarca. Mr. Maximo Diaz is a businessman who implemented a 4 kW MHP in 1996, with a loan from the IDB/ITDG revolving fund. The power generated is used to drive a grain mill, charge a battery charger, and to supply energy to 20 households in the neighborhood.

The entire training process has been completed and the small system is providing the services mentioned above.

Training Modules and Assistance to DEP

Training Modules

The weakness or poor performance of small isolated electricity plants is mainly attributable to poor staff training.
What is required is a training process involving everyone responsible for the service—including operators and the public in general. As part of the ESMAP activity, training modules were prepared to aid the process. These modules are divided into two large groups: operations and maintenance (O&M), and service management. They consist of 10 modules and one instructor's primer.

The technical part consists of three modules based on a hydroelectric system, in addition to a module on photo-voltaic systems. The management part is appropriate for all systems and consists of six modules, as shown in table 7.

Table 7: Training Modules

Operations and maintenance (O&M)	*Management of electricity service*
• Civil works • Electromechanical equipment • Electrical aspects and distribution grids • Solar photo-voltaic[a]	• Electricity service • Electricity service company • Introduction to management • Introduction to accounting • Marketing • How to structure an electricity tariff

a. Only for services supplied by photovoltaic panels.
Source: ESMAP/ITDG.

As the modules are prepared in general terms, the instructor must select the subjects to be covered in accordance with the needs of the target population. The instructor should also make good use of the instructor's guide that goes with the modules. This training process should take place through courses, talks, presentations, and discussion groups.

These training modules have already been conducted in Trinidad and Conchán (see the previous chapter) as well as in the public systems of Santa Leonor and San Francisco.

Work with DEP in the Organization of Pilot Facilities

ESMAP provided support to the Executive Projects Directorate (DEP) of the Ministry of Energy and Mines, by enabling ITDG to carry out training work in two pilot facilities, on the organization systems established by DEP as management models for rural electrification in Peru. The business models are based on a corporation in which the power plants are owned by "all users"—who are shareholders as well. These models were implemented as pilot projects in two isolated systems:

The San Francisco Solar Village is a rural electrification project for the indigenous community of San Francisco, situated about an hour and ten minutes by boat between Yarinacocha and Pucallpa, home to 134 families. Solar home systems were set up with 50 Wp photovoltaic panels, so that each family generates its own power. The Santa Leonor system is a rural electrification project based on a small 275 kW hydroelectric plant with a total of 465 users, spread over 16 small villages.

In both cases, DEP considered it appropriate to incorporate companies to run the systems, negotiating with the public and electing the members of the board of directors, the General Manager, Secretary, Treasurer, and so on at assemblies. The proposal consisted of organizing the companies and then handing the systems over to them on concession. In addition, the companies had to assume an investment commitment, which was different for each case. In San Francisco , the company had to buy 25 percent of the solar modules; in Santa Leonor, it had to invest in the setting-up of grids for certain towns that were not initially connected.

On the basis of the modules described above, ITDG provided the necessary training to the staff of the new companies. To this end, a series of conversations were held and arrangements made with DEP members, and the following activities took place:

- Socioeconomic and technical baseline studies on each of the towns.
- Preparation of training modules.
- Working trips to apply the training modules.
- Evaluation reports.
- Coordination with DEP.

ITDG hopes that this training improves the viability of the new companies.

Factors Contributing to the Successful and Profitable Management of Isolated Systems

There are many critical factors that influence the success of isolated systems. Whether the factors materialize depends on the actions of various agents (the state, owners, users, technicians, and managers). The attitudes and skills of managers, promoters, and users are closely related to the majority of these factors, which can be divided into two large groups:

- Factors that can only be managed, changed, or controlled as a result of the state's willingness to change or adapt them to the specific requirements of small isolated systems; and
- Factors that can (or should, or both) be managed by implementers and local agents.

Factors Requiring Government Involvement

The following aspects should be taken into account in the promotion of government programs, policies, and strategies, in order to promote viable and sustainable systems.

(a) *Legal and tax-related aspects.* The need for specific rural electrification laws has been inferred in several parts of this report. These should contemplate such aspects as property, guidelines on the use of economic resources by local governments (municipalities), the use of assets as guarantees, the use of local resources, permits and concessions, connection to the grid, the sale of energy, water uses and priorities, and so on..

It should be considered whether rural companies should receive tax-free status, since they make very small contributions, if any, thus taking into consideration their degree of isolation and their inability to fulfill some of the rules established by tax authorities. It should be remembered that all tax standards were designed and published for urban rather than rural companies.

(b) *Finance mechanisms.* This issue requires a national policy to make rural electrification a viable proposition by establishing clear subsidies for sectors that require them, or at least by defining common criteria for all agents. In other words, it would be advisable for the government to establish ground rules for the game. It seems absurd that the government should make donations on the one hand, whilst on the other it is promoting a commercial credit program..

(c) *Institutional framework.* Establishing institutions to promote and govern the sector and the criteria for their operation. The business side of the energy sector has been regulated or is about to be. There is a National Tariff Commission, an Organization Supervising Electricity Companies (OSINERG), the Consumers' Protection Office (INDECOPI), and so on. For a considerable time, those national entities showed little interest in the problems and concerns of very small, isolated systems. Subsequent to this report, however, the Electricity (now "Energy") Tariff Commission created a "fourth tariff category" for rural systems.

The implementation of management services in the manner proposed here—that is, as a way of solving organization- and management-related problems—is a viable proposition in both technical and financial terms, provided adequate training is provided. It has to be acknowledged that these services may still be vulnerable to political meddling and that disputes can easily arise. In the case of the above-mentioned model, for example, it would be worth creating an arbitrage clause in anticipation of potential conflict between the company and the local political authority.

(d) *Local technological capacity.* As mentioned previously, there are resources in this country capable of manufacturing equipment or spare parts for certain technologies, such as MHPs. Peruvian institutions can also carry out studies, create engineering designs, and implement projects. This capacity should be promoted and encouraged so that access to services and spares can be gained promptly at a reasonable price.

Local and Specific Factors

(a) *Management service organization.* Perhaps the most critical aspect in terms of sustainability is organizing the management of the service provided by small isolated systems. The ex post study carried out for this project evaluated all existing organization models—state, municipal, community, cooperative, and privately owned. Of these, privately owned systems seem to be the only viable propositions. None of the others had a satisfactory overall performance. State-owned systems operated well but at excessively high costs. Municipal systems were often characterized by chaos and/or by permanent subsidies. Community and cooperative systems simply disregarded costs, as energy is merely considered a consumable.

(b) *Training.* At a local level, training involves creating or strengthening local management skills, based on local human resources. Furthermore it involves training the general public—"users"—on the rational use of energy, on the value and costs of energy, the need to replace machinery, and so forth, to heighten their awareness of the need to make power systems sustainable.

(c) *Tariffs.* Even though this subject can be viewed as part of the organization, it is worth mentioning that on its own, it is a crucial aspect for the success or failure of small systems. Consequently adequate tariffs should be the main concern when establishing any infrastructure facility, no matter how small the system is and regardless of how poor the target population may be.

(d) *Use of appropriate technology.* This factor mainly concerns the implementation stage. Implementers should understand the need to use appropriate, low-cost technologies—appropriate so that they can be managed by staff with limited technical skills; and low-cost to ensure that once they fail, the population can afford to buy spare parts.

Annex

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Joint UNDP/World Bank
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

LIST OF REPORTS ON COMPLETED ACTIVITIES

Region/Country	***Activity/Report Title***	***Date***	***Number***
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop (English)	07/88	085/88
	Regional Power Seminar on Reducing Electric Power System Losses in Africa (English)	08/88	087/88
	Institutional Evaluation of EGL (English)	02/89	098/89
	Biomass Mapping Regional Workshops (English)	05/89	--
	Francophone Household Energy Workshop (French)	08/89	--
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English)	03/90	--
	Symposium on Power Sector Reform and Efficiency Improvement in Sub-Saharan Africa (English)	06/96	182/96
	Commercialization of Marginal Gas Fields (English)	12/97	201/97
	Commercilizing Natural Gas: Lessons from the Seminar in Nairobi for Sub-Saharan Africa and Beyond	01/00	225/00
Angola	Energy Assessment (English and Portuguese)	05/89	4708-ANG
	Power Rehabilitation and Technical Assistance (English)	10/91	142/91
Benin	Energy Assessment (English and French)	06/85	5222-BEN
Botswana	Energy Assessment (English)	09/84	4998-BT
	Pump Electrification Prefeasibility Study (English)	01/86	047/86
	Review of Electricity Service Connection Policy (English)	07/87	071/87
	Tuli Block Farms Electrification Study (English)	07/87	072/87
	Household Energy Issues Study (English)	02/88	--
	Urban Household Energy Strategy Study (English)	05/91	132/91
Burkina Faso	Energy Assessment (English and French)	01/86	5730-BUR
	Technical Assistance Program (English)	03/86	052/86
	Urban Household Energy Strategy Study (English and French)	06/91	134/91
Burundi	Energy Assessment (English)	06/82	3778-BU
	Petroleum Supply Management (English)	01/84	012/84
	Status Report (English and French)	02/84	011/84
	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987) (English and French)	05/85	036/85
	Improved Charcoal Cookstove Strategy (English and French)	09/85	042/85
	Peat Utilization Project (English)	11/85	046/85
	Energy Assessment (English and French)	01/92	9215-BU
Cape Verde	Energy Assessment (English and Portuguese)	08/84	5073-CV
	Household Energy Strategy Study (English)	02/90	110/90
Central African Republic	Energy Assessement (French)	08/92	9898-CAR
Chad	Elements of Strategy for Urban Household Energy The Case of N'djamena (French)	12/93	160/94
Comoros	Energy Assessment (English and French)	01/88	7104-COM
	In Search of Better Ways to Develop Solar Markets: The Case of Comoros	05/00	230/00
Congo	Energy Assessment (English)	01/88	6420-COB
	Power Development Plan (English and French)	03/90	106/90
Côte d'Ivoire	Energy Assessment (English and French)	04/85	5250-IVC
	Improved Biomass Utilization (English and French)	04/87	069/87

Region/Country	Activity/Report Title	Date	Number
Côte d'Ivoire	Power System Efficiency Study (English)	12/87	--
	Power Sector Efficiency Study (French)	02/92	140/91
	Project of Energy Efficiency in Buildings (English)	09/95	175/95
Ethiopia	Energy Assessment (English)	07/84	4741-ET
	Power System Efficiency Study (English)	10/85	045/85
	Agricultural Residue Briquetting Pilot Project (English)	12/86	062/86
	Bagasse Study (English)	12/86	063/86
	Cooking Efficiency Project (English)	12/87	--
	Energy Assessment (English)	02/96	179/96
Gabon	Energy Assessment (English)	07/88	6915-GA
The Gambia	Energy Assessment (English)	11/83	4743-GM
	Solar Water Heating Retrofit Project (English)	02/85	030/85
	Solar Photovoltaic Applications (English)	03/85	032/85
	Petroleum Supply Management Assistance (English)	04/85	035/85
Ghana	Energy Assessment (English)	11/86	6234-GH
	Energy Rationalization in the Industrial Sector (English)	06/88	084/88
	Sawmill Residues Utilization Study (English)	11/88	074/87
	Industrial Energy Efficiency (English)	11/92	148/92
Guinea	Energy Assessment (English)	11/86	6137-GUI
	Household Energy Strategy (English and French)	01/94	163/94
Guinea-Bissau	Energy Assessment (English and Portuguese)	08/84	5083-GUB
	Recommended Technical Assistance Projects (English & Portuguese)	04/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors (English)	02/90	100/90
	Power and Water Institutional Restructuring (French)	04/91	118/91
Kenya	Energy Assessment (English)	05/82	3800-KE
	Power System Efficiency Study (English)	03/84	014/84
	Status Report (English)	05/84	016/84
	Coal Conversion Action Plan (English)	02/87	--
	Solar Water Heating Study (English)	02/87	066/87
	Peri-Urban Woodfuel Development (English)	10/87	076/87
	Power Master Plan (English)	11/87	--
	Power Loss Reduction Study (English)	09/96	186/96
	Implementation Manual: Financing Mechanisms for Solar Electric Equipment	07/00	231/00
Lesotho	Energy Assessment (English)	01/84	4676-LSO
Liberia	Energy Assessment (English)	12/84	5279-LBR
	Recommended Technical Assistance Projects (English)	06/85	038/85
	Power System Efficiency Study (English)	12/87	081/87
Madagascar	Energy Assessment (English)	01/87	5700-MAG
	Power System Efficiency Study (English and French)	12/87	075/87
	Environmental Impact of Woodfuels (French)	10/95	176/95
Malawi	Energy Assessment (English)	08/82	3903-MAL
	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry (English)	11/83	009/83
	Status Report (English)	01/84	013/84
Mali	Energy Assessment (English and French)	11/91	8423-MLI
	Household Energy Strategy (English and French)	03/92	147/92
Islamic Republic of Mauritania	Energy Assessment (English and French)	04/85	5224-MAU
	Household Energy Strategy Study (English and French)	07/90	123/90

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Mauritius	Energy Assessment (English)	12/81	3510-MAS
	Status Report (English)	10/83	008/83
	Power System Efficiency Audit (English)	05/87	070/87
	Bagasse Power Potential (English)	10/87	077/87
	Energy Sector Review (English)	12/94	3643-MAS
Mozambique	Energy Assessment (English)	01/87	6128-MOZ
	Household Electricity Utilization Study (English)	03/90	113/90
	Electricity Tariffs Study (English)	06/96	181/96
	Sample Survey of Low Voltage Electricity Customers	06/97	195/97
Namibia	Energy Assessment (English)	03/93	11320-NAM
Niger	Energy Assessment (French)	05/84	4642-NIR
	Status Report (English and French)	02/86	051/86
	Improved Stoves Project (English and French)	12/87	080/87
	Household Energy Conservation and Substitution (English and French)	01/88	082/88
Nigeria	Energy Assessment (English)	08/83	4440-UNI
	Energy Assessment (English)	07/93	11672-UNI
Rwanda	Energy Assessment (English)	06/82	3779-RW
	Status Report (English and French)	05/84	017/84
	Improved Charcoal Cookstove Strategy (English and French)	08/86	059/86
	Improved Charcoal Production Techniques (English and French)	02/87	065/87
	Energy Assessment (English and French)	07/91	8017-RW
	Commercialization of Improved Charcoal Stoves and Carbonization Techniques Mid-Term Progress Report (English and French)	12/91	141/91
SADC	SADC Regional Power Interconnection Study, Vols. I-IV (English)	12/93	--
SADCC	SADCC Regional Sector: Regional Capacity-Building Program for Energy Surveys and Policy Analysis (English)	11/91	--
Sao Tome and Principe	Energy Assessment (English)	10/85	5803-STP
Senegal	Energy Assessment (English)	07/83	4182-SE
	Status Report (English and French)	10/84	025/84
	Industrial Energy Conservation Study (English)	05/85	037/85
	Preparatory Assistance for Donor Meeting (English and French)	04/86	056/86
	Urban Household Energy Strategy (English)	02/89	096/89
	Industrial Energy Conservation Program (English)	05/94	165/94
Seychelles	Energy Assessment (English)	01/84	4693-SEY
	Electric Power System Efficiency Study (English)	08/84	021/84
Sierra Leone	Energy Assessment (English)	10/87	6597-SL
Somalia	Energy Assessment (English)	12/85	5796-SO
South Africa Republic of	Options for the Structure and Regulation of Natural Gas Industry (English)	05/95	172/95
Sudan	Management Assistance to the Ministry of Energy and Mining	05/83	003/83
	Energy Assessment (English)	07/83	4511-SU
	Power System Efficiency Study (English)	06/84	018/84
	Status Report (English)	11/84	026/84
	Wood Energy/Forestry Feasibility (English)	07/87	073/87
Swaziland	Energy Assessment (English)	02/87	6262-SW
	Household Energy Strategy Study	10/97	198/97
Tanzania	Energy Assessment (English)	11/84	4969-TA
	Peri-Urban Woodfuels Feasibility Study (English)	08/88	086/88
	Tobacco Curing Efficiency Study (English)	05/89	102/89
	Remote Sensing and Mapping of Woodlands (English)	06/90	--

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Tanzania	Industrial Energy Efficiency Technical Assistance (English)	08/90	122/90
	Power Loss Reduction Volume 1: Transmission and Distribution SystemTechnical Loss Reduction and Network Development (English)	06/98	204A/98
	Power Loss Reduction Volume 2: Reduction of Non-Technical Losses (English)	06/98	204B/98
Togo	Energy Assessment (English)	06/85	5221-TO
	Wood Recovery in the Nangbeto Lake (English and French)	04/86	055/86
	Power Efficiency Improvement (English and French)	12/87	078/87
Uganda	Energy Assessment (English)	07/83	4453-UG
	Status Report (English)	08/84	020/84
	Institutional Review of the Energy Sector (English)	01/85	029/85
	Energy Efficiency in Tobacco Curing Industry (English)	02/86	049/86
	Fuelwood/Forestry Feasibility Study (English)	03/86	053/86
	Power System Efficiency Study (English)	12/88	092/88
	Energy Efficiency Improvement in the Brick and Tile Industry (English)	02/89	097/89
	Tobacco Curing Pilot Project (English)	03/89	UNDP Terminal Report
	Energy Assessment (English)	12/96	193/96
	Rural Electrification Strategy Study	09/99	221/99
Zaire	Energy Assessment (English)	05/86	5837-ZR
Zambia	Energy Assessment (English)	01/83	4110-ZA
	Status Report (English)	08/85	039/85
	Energy Sector Institutional Review (English)	11/86	060/86
	Power Subsector Efficiency Study (English)	02/89	093/88
	Energy Strategy Study (English)	02/89	094/88
	Urban Household Energy Strategy Study (English)	08/90	121/90
Zimbabwe	Energy Assessment (English)	06/82	3765-ZIM
	Power System Efficiency Study (English)	06/83	005/83
	Status Report (English)	08/84	019/84
	Power Sector Management Assistance Project (English)	04/85	034/85
	Power Sector Management Institution Building (English)	09/89	--
	Petroleum Management Assistance (English)	12/89	109/89
	Charcoal Utilization Prefeasibility Study (English)	06/90	119/90
	Integrated Energy Strategy Evaluation (English)	01/92	8768-ZIM
	Energy Efficiency Technical Assistance Project: Strategic Framework for a National Energy Efficiency Improvement Program (English)	04/94	--
	Capacity Building for the National Energy Efficiency Improvement Programme (NEEIP) (English)	12/94	--
	Rural Electrification Study	03/00	228/00

EAST ASIA AND PACIFIC (EAP)

Asia Regional	Pacific Household and Rural Energy Seminar (English)	11/90	--
China	County-Level Rural Energy Assessments (English)	05/89	101/89
	Fuelwood Forestry Preinvestment Study (English)	12/89	105/89
	Strategic Options for Power Sector Reform in China (English)	07/93	156/93
	Energy Efficiency and Pollution Control in Township and Village Enterprises (TVE) Industry (English)	11/94	168/94

Region/Country	*Activity/Report Title*	*Date*	*Number*
China	Energy for Rural Development in China: An Assessment Based on a Joint Chinese/ESMAP Study in Six Counties (English)	06/96	183/96
	Improving the Technical Efficiency of Decentralized Power Companies	09/99	222/999
Fiji	Energy Assessment (English)	06/83	4462-FIJ
Indonesia	Energy Assessment (English)	11/81	3543-IND
	Status Report (English)	09/84	022/84
	Power Generation Efficiency Study (English)	02/86	050/86
	Energy Efficiency in the Brick, Tile and Lime Industries (English)	04/87	067/87
	Diesel Generating Plant Efficiency Study (English)	12/88	095/88
	Urban Household Energy Strategy Study (English)	02/90	107/90
	Biomass Gasifier Preinvestment Study Vols. I & II (English)	12/90	124/90
	Prospects for Biomass Power Generation with Emphasis on Palm Oil, Sugar, Rubberwood and Plywood Residues (English)	11/94	167/94
Lao PDR	Urban Electricity Demand Assessment Study (English)	03/93	154/93
	Institutional Development for Off-Grid Electrification	06/99	215/99
Malaysia	Sabah Power System Efficiency Study (English)	03/87	068/87
	Gas Utilization Study (English)	09/91	9645-MA
Myanmar	Energy Assessment (English)	06/85	5416-BA
Papua New Guinea	Energy Assessment (English)	06/82	3882-PNG
	Status Report (English)	07/83	006/83
	Energy Strategy Paper (English)	--	--
	Institutional Review in the Energy Sector (English)	10/84	023/84
	Power Tariff Study (English)	10/84	024/84
Philippines	Commercial Potential for Power Production from Agricultural Residues (English)	12/93	157/93
	Energy Conservation Study (English)	08/94	--
Solomon Islands	Energy Assessment (English)	06/83	4404-SOL
	Energy Assessment (English)	01/92	979-SOL
South Pacific	Petroleum Transport in the South Pacific (English)	05/86	--
Thailand	Energy Assessment (English)	09/85	5793-TH
	Rural Energy Issues and Options (English)	09/85	044/85
	Accelerated Dissemination of Improved Stoves and Charcoal Kilns (English)	09/87	079/87
	Northeast Region Village Forestry and Woodfuels Preinvestment Study (English)	02/88	083/88
	Impact of Lower Oil Prices (English)	08/88	--
	Coal Development and Utilization Study (English)	10/89	--
Tonga	Energy Assessment (English)	06/85	5498-TON
Vanuatu	Energy Assessment (English)	06/85	5577-VA
Vietnam	Rural and Household Energy-Issues and Options (English)	01/94	161/94
	Power Sector Reform and Restructuring in Vietnam: Final Report to the Steering Committee (English and Vietnamese)	09/95	174/95
	Household Energy Technical Assistance: Improved Coal Briquetting and Commercialized Dissemination of Higher Efficiency Biomass and Coal Stoves (English)	01/96	178/96
	Petroleum Fiscal Issues and Policies for Fluctuating Oil Prices In Vietnam	02/01	236/01
Western Samoa	Energy Assessment (English)	06/85	5497-WSO

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	SOUTH ASIA (SAS)		
Bangladesh	Energy Assessment (English)	10/82	3873-BD
	Priority Investment Program (English)	05/83	002/83
	Status Report (English)	04/84	015/84
	Power System Efficiency Study (English)	02/85	031/85
	Small Scale Uses of Gas Prefeasibility Study (English)	12/88	--
India	Opportunities for Commercialization of Nonconventional Energy Systems (English)	11/88	091/88
	Maharashtra Bagasse Energy Efficiency Project (English)	07/90	120/90
	Mini-Hydro Development on Irrigation Dams and Canal Drops Vols. I, II and III (English)	07/91	139/91
	WindFarm Pre-Investment Study (English)	12/92	150/92
	Power Sector Reform Seminar (English)	04/94	166/94
	Environmental Issues in the Power Sector (English)	06/98	205/98
	Environmental Issues in the Power Sector: Manual for Environmental Decision Making (English)	06/99	213/99
	Household Energy Strategies for Urban India: The Case of Hyderabad	06/99	214/99
	Greenhouse Gas Mitigation In the Power Sector: Case Studies From India	02/01	237/01
Nepal	Energy Assessment (English)	08/83	4474-NEP
	Status Report (English)	01/85	028/84
	Energy Efficiency & Fuel Substitution in Industries (English)	06/93	158/93
Pakistan	Household Energy Assessment (English)	05/88	--
	Assessment of Photovoltaic Programs, Applications, and Markets (English)	10/89	103/89
	National Household Energy Survey and Strategy Formulation Study: Project Terminal Report (English)	03/94	--
	Managing the Energy Transition (English)	10/94	--
	Lighting Efficiency Improvement Program Phase 1: Commercial Buildings Five Year Plan (English)	10/94	--
Sri Lanka	Energy Assessment (English)	05/82	3792-CE
	Power System Loss Reduction Study (English)	07/83	007/83
	Status Report (English)	01/84	010/84
	Industrial Energy Conservation Study (English)	03/86	054/86
	EUROPE AND CENTRAL ASIA (ECA)		
Bulgaria	Natural Gas Policies and Issues (English)	10/96	188/96
Central and Eastern Europe	Power Sector Reform in Selected Countries	07/97	196/97
	Increasing the Efficiency of Heating Systems in Central and Eastern Europe and the Former Soviet Union	08/00	234/00
Eastern Europe	The Future of Natural Gas in Eastern Europe (English)	08/92	149/92
Kazakhstan	Natural Gas Investment Study, Volumes 1, 2 & 3	12/97	199/97
Kazakhstan & Kyrgyzstan	Opportunities for Renewable Energy Development	11/97	16855-KAZ
Poland	Energy Sector Restructuring Program Vols. I-V (English)	01/93	153/93
	Natural Gas Upstream Policy (English and Polish)	08/98	206/98

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Poland	Energy Sector Restructuring Program: Establishing the Energy Regulation Authority	10/98	208/98
Portugal	Energy Assessment (English)	04/84	4824-PO
Romania	Natural Gas Development Strategy (English)	12/96	192/96
Slovenia	Workshop on Private Participation in the Power Sector (English)	02/99	211/99
Turkey	Energy Assessment (English)	03/83	3877-TU
	Energy and the Environment: Issues and Options Paper	04/00	229/00

MIDDLE EAST AND NORTH AFRICA (MNA)

Arab Republic of Egypt	Energy Assessment (English)	10/96	189/96
	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
Morocco	Energy Sector Institutional Development Study (English and French)	07/95	173/95
	Natural Gas Pricing Study (French)	10/98	209/98
	Gas Development Plan Phase II (French)	02/99	210/99
Syria	Energy Assessment (English)	05/86	5822-SYR
	Electric Power Efficiency Study (English)	09/88	089/88
	Energy Efficiency Improvement in the Cement Sector (English)	04/89	099/89
	Energy Efficiency Improvement in the Fertilizer Sector (English)	06/90	115/90
Tunisia	Fuel Substitution (English and French)	03/90	--
	Power Efficiency Study (English and French)	02/92	136/91
	Energy Management Strategy in the Residential and Tertiary Sectors (English)	04/92	146/92
	Renewable Energy Strategy Study, Volume I (French)	11/96	190A/96
	Renewable Energy Strategy Study, Volume II (French)	11/96	190B/96
Yemen	Energy Assessment (English)	12/84	4892-YAR
	Energy Investment Priorities (English)	02/87	6376-YAR
	Household Energy Strategy Study Phase I (English)	03/91	126/91

LATIN AMERICA AND THE CARIBBEAN (LAC)

LAC Regional	Regional Seminar on Electric Power System Loss Reduction in the Caribbean (English)	07/89	--
	Elimination of Lead in Gasoline in Latin America and the Caribbean (English and Spanish)	04/97	194/97
	Elimination of Lead in Gasoline in Latin America and the Caribbean - Status Report (English and Spanish)	12/97	200/97
	Harmonization of Fuels Specifications in Latin America and the Caribbean (English and Spanish)	06/98	203/98
Bolivia	Energy Assessment (English)	04/83	4213-BO
	National Energy Plan (English)	12/87	--
	La Paz Private Power Technical Assistance (English)	11/90	111/90
	Prefeasibility Evaluation Rural Electrification and Demand Assessment (English and Spanish)	04/91	129/91
	National Energy Plan (Spanish)	08/91	131/91
	Private Power Generation and Transmission (English)	01/92	137/91
	Natural Gas Distribution: Economics and Regulation (English)	03/92	125/92

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Bolivia	Natural Gas Sector Policies and Issues (English and Spanish)	12/93	164/93
	Household Rural Energy Strategy (English and Spanish)	01/94	162/94
	Preparation of Capitalization of the Hydrocarbon Sector	12/96	191/96
	Introducing Competition into the Electricity Supply Industry in Developing Countries: Lessons from Bolivia	08/00	233/00
	Final Report on Operational Activities Rural Energy and Energy Efficiency	08/00	235/00
Brazil	Energy Efficiency & Conservation: Strategic Partnership for Energy Efficiency in Brazil (English)	01/95	170/95
	Hydro and Thermal Power Sector Study	09/97	197/97
	Rural Electrification with Renewable Energy Systems in the Northeast: A Preinvestment Study	07/00	232/00
Chile	Energy Sector Review (English)	08/88	7129-CH
Colombia	Energy Strategy Paper (English)	12/86	--
	Power Sector Restructuring (English)	11/94	169/94
	Energy Efficiency Report for the Commercial and Public Sector (English)	06/96	184/96
Costa Rica	Energy Assessment (English and Spanish)	01/84	4655-CR
	Recommended Technical Assistance Projects (English)	11/84	027/84
	Forest Residues Utilization Study (English and Spanish)	02/90	108/90
Dominican Republic	Energy Assessment (English)	05/91	8234-DO
Ecuador	Energy Assessment (Spanish)	12/85	5865-EC
	Energy Strategy Phase I (Spanish)	07/88	--
	Energy Strategy (English)	04/91	--
	Private Minihydropower Development Study (English)	11/92	--
	Energy Pricing Subsidies and Interfuel Substitution (English)	08/94	11798-EC
	Energy Pricing, Poverty and Social Mitigation (English)	08/94	12831-EC
Guatemala	Issues and Options in the Energy Sector (English)	09/93	12160-GU
Haiti	Energy Assessment (English and French)	06/82	3672-HA
	Status Report (English and French)	08/85	041/85
	Household Energy Strategy (English and French)	12/91	143/91
Honduras	Energy Assessment (English)	08/87	6476-HO
	Petroleum Supply Management (English)	03/91	128/91
Jamaica	Energy Assessment (English)	04/85	5466-JM
	Petroleum Procurement, Refining, and Distribution Study (English)	11/86	061/86
	Energy Efficiency Building Code Phase I (English)	03/88	--
	Energy Efficiency Standards and Labels Phase I (English)	03/88	--
	Management Information System Phase I (English)	03/88	--
	Charcoal Production Project (English)	09/88	090/88
	FIDCO Sawmill Residues Utilization Study (English)	09/88	088/88
	Energy Sector Strategy and Investment Planning Study (English)	07/92	135/92
Mexico	Improved Charcoal Production Within Forest Management for the State of Veracruz (English and Spanish)	08/91	138/91
	Energy Efficiency Management Technical Assistance to the Comision Nacional para el Ahorro de Energia (CONAE) (English)	04/96	180/96
Panama	Power System Efficiency Study (English)	06/83	004/83
Paraguay	Energy Assessment (English)	10/84	5145-PA
	Recommended Technical Assistance Projects (English)	09/85	--
	Status Report (English and Spanish)	09/85	043/85
Peru	Energy Assessment (English)	01/84	4677-PE

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Peru	Status Report (English)	08/85	040/85
	Proposal for a Stove Dissemination Program in the Sierra (English and Spanish)	02/87	064/87
	Energy Strategy (English and Spanish)	12/90	--
	Study of Energy Taxation and Liberalization of the Hydrocarbons Sector (English and Spanish)	120/93	159/93
	Reform and Privatization in the Hydrocarbon Sector (English and Spanish)	07/99	216/99
	Rural Electrification	02/01	238/01
Saint Lucia	Energy Assessment (English)	09/84	5111-SLU
St. Vincent and the Grenadines	Energy Assessment (English)	09/84	5103-STV
Sub Andean	Environmental and Social Regulation of Oil and Gas Operations in Sensitive Areas of the Sub-Andean Basin (English and Spanish)	07/99	217/99
Trinidad and Tobago	Energy Assessment (English)	12/85	5930-TR

GLOBAL

	Energy End Use Efficiency: Research and Strategy (English)	11/89	--
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	Development of Regional Electric Power Networks (English)	10/94	--
	Roundtable on Energy Efficiency (English)	02/95	171/95
	Assessing Pollution Abatement Policies with a Case Study of Ankara (English)	11/95	177/95
	A Synopsis of the Third Annual Roundtable on Independent Power Projects: Rhetoric and Reality (English)	08/96	187/96
	Rural Energy and Development Roundtable (English)	05/98	202/98
	A Synopsis of the Second Roundtable on Energy Efficiency: Institutional and Financial Delivery Mechanisms (English)	09/98	207/98
	The Effect of a Shadow Price on Carbon Emission in the Energy Portfolio of the World Bank: A Carbon Backcasting Exercise (English)	02/99	212/99
	Increasing the Efficiency of Gas Distribution Phase 1: Case Studies and Thematic Data Sheets	07/99	218/99
	Global Energy Sector Reform in Developing Countries: A Scorecard	07/99	219/99
	Global Lighting Services for the Poor Phase II: Text Marketing of Small "Solar" Batteries for Rural Electrification Purposes	08/99	220/99

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Global	A Review of the Renewable Energy Activities of the UNDP/ World Bank Energy Sector Management Assistance Programme 1993 to 1998	11/99	223/99
	Energy, Transportation and Environment: Policy Options for Environmental Improvement	12/99	224/99
	Privatization, Competition and Regulation in the British Electricity Industry, With Implications for Developing Countries	02/00	226/00
	Reducing the Cost of Grid Extension for Rural Electrification	02/00	227/00

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