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KEY FACTORS FOR THE IMPLEMENTATION OF SUCCESSFUL, STAND-ALONE VILLAGE ELECTRIFICATION SCHEMES IN PERU

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ABSTRACT

The hypothesis of this work is that there are social, financial, technical, managerial institutional and political key factors that may either support or prevent the success of small stand alone energy systems in rural areas. This research work aims at contributing to the identification of such factors and study their relevance to the performance and sustainability of stand alone energy systems in rural areas; to meet its purpose, a wide range of literature was reviewed including rural electrification programmes and projects, research and development projects on access to electricity in rural areas, impact studies and others, and a field research survey was done the Andes and Upper Jungle regions in Peru.

Nineteen possible critical factors were identified, thirteen with relevance at the local context (the community or village), and six with relevance at the national (or wider) context. From literature review it was found that the possible local critical factors were relevant only to four categories of factors instead of the six considered initially (i.e. social, financial, technological and managerial); the other two categories, political and institutional were found to be more relevant to the national context, therefore those were included in the group of possible critical factors of wider context.

A series of questionnaires were designed to collect field data information, which was later used to analyse and establish the relation of each identified factor with the success of the systems studied. The survey research was implemented in 14 villages, 7 with small diesel sets and 7 with small hydropower schemes, all spread in the Andes and Upper Jungle of Peru, which were carefully selected to be representative of regions with isolated stand alone systems and with different socioeconomic background.

Out of the 13 possible critical factors of local context, it was found that only 3 are really critical, the others are important but not critical; one of them (technical assistance) was found to be closely linked to national capacity, therefore for practical reasons both are considered as one critical factor or wider context. Although more research study is needed to establish a more clearer result on the factors of wider context (national context), it was found that out of the 6 factors of wider context only one appears to be critical, the other 5 are important but not critical. Therefore the summary of critical factors is as follows:

a) Critical Factors of Local Context

- Management
- Local capacity

b) Critical Factors of National Context

- Technical Support/national capacity

On the local factors, management appears to be the most critical of all factors, because with good management, most of the other factors can be overcome. It was also found that "The small enterprise model" tested by Practical Action on small scale hydropower schemes is proving to be successful and other organisations are starting to use it in different contexts. Therefore future research is recommended on this particular management model in order to be useful for rural electrification programmes based on decentralised energy generation systems.

LIST OF ACHRONYMS

ADINELSA	Empresa Administradora de Infraestructura Eléctrica
CCP	"Confederación Campesina del Peru" (National Association of Peasants)
CER	The Centre for Renewable Energies (National University of Engineering)
CF	Critical Factors
COES	The National Electricity System Operating Committee
CSF	Critical Success Factors
DEP	"Dirección Ejecutiva de Proyectos" (Executive Directorate of Projects for Energy Projects, a Government Agency).
DFID	UK-Department for International Development
ELECTROBRAS	The National Electricity Utility of Brazil
ELECTROPERU	The National Electricity Utility (Peru)
ESMAP	The Energy Sector Management Assistance Programme
ETW	Energy for Tomorrow's World
EU	European Union
FODEIS	"Fondo de Desarrollo de Interés Social" (Fund for Social Development of Electricity)
FONCODES	National Fund for Social Compensation
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Green House Gas
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
HDI	Human Development Index
IAD	International Aid Agency (USA)
IEA	International Energy Agency
IGN	Instituto Geofísico Nacional
INEI	Instituto Nacional de Estadística e Informática
ITDG	Intermediate Technology Development Group (presently Practical Action)
ITINTEC	National Institute for Industrial Research and National Standards
LAC	Latin American Countries
MDGs	Millennium Development Goals
MEM	Ministry of Energy and Mines of Peru

MERCOSUR	Mercado Común del Sur (The common Market of Brazil, Argentina and Paraguay)
NGO	Non-Governmental Organisation
NRECA	National Rural Electrification Cooperative Association
OLADE	The Latin American Organisation for Energy Development
OSINERG	Organismo Supervisor de la Inversión en Energía
PCSF	Possible critical success factors
PCSF	Possible Critical Success Factors
PEA	Provincial Electricity Authority of Thailand
PESENCA	The Special Program on Energy for the Atlantic Coast
PNUD	United Nations Development Program
PROMIDEHC	The Micro hydro Energy development programme
PRONAMACHS	"Programa Nacional de Manejo de Cuencas Hidrográficas" (National Programme of Watersheds Conservation)
PROPER	The programme on the Promotion of Renewable Energies
PSE	"Pequeños Sistemas Eléctricos" (Small Electric Systems).
PV	Photovoltaic Systems
REB	Rural Electricity Board (Bangladesh)
REC	Rural Electrification Coefficient
SHS	Solar Home Systems
SKAT	Resource Centre and Consultancies for Development (Switzerland)
TJ	Tera Jouls
UEB	Uganda Electricity Board
UNI	National University of Engineering (Peru)
UNOPS	United Nations Office for Project Services
USA	United States of America
VHS	Video Player System
WBCSD	World Business Council for Sustainable Development
WEC	World Energy Council

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CHAPTER I
INTRODUCCTION

1.1 Access to electricity

Electricity has been considered as critical element for human development and to access a range of other basic services, such as drinking water, health, education and communications. According to present literature about 2 billion people in the world have no access to electricity services, the great majority living in rural areas in developing countries.

UNDP, World Bank, IEA, EU and other important organisations show that access to electricity has clear links with countries' Gross Domestic Product (GDP) and human development indicators. Countries with low electricity access indicators have low GDP and low Human Development Index (HDI). The same organisations consider that energy access (including electricity) has to be first in place if the Millennium Development Goals (MDGs) have to be met. Statistics show that there are huge disparities on energy and electricity consumption within countries, within regions and within communities and villages in each country.

The International Energy Agency estimates that despite the 2.1US$ trillion estimated investment on energy generation in developing countries by the end of 2030, about 1.4 billion people will remain without electricity access by that time; in contrast developed countries will continue increasing their energy consumption, with huge investment. The World Energy Council estimates that the global investment on energy from 2004 to 2030 will be about $ 17 trillion to maintain the present level of energy services.

For most countries grid extension is no longer an option to provide electricity services to rural areas, and especially to isolated rural communities; that is because the high initial investment required, and high maintenance and administrative costs to operate such grid extensions due to the dispersion of the consumers.

Small scale stand alone energy generation systems such as, micro hydro, diesel sets, solar PV, small wind and biomass energy generation systems are considered viable technical and financial solutions to attend rural energy needs; however frequent failures reported in many parts of the world have stopped their deployment

and created a lack of confidence from government and planners regarding the sustainability of these systems.

During the last three decades; universities, research Institutions, NGOs and other organisations, have done a large number of research and piloting activities in order to prove the technical and financial viability and the sustainability of small stand alone energy generation systems; governments in developing countries, Multilateral and Bilateral organisations (World Bank, UNDP, Aid Agencies) have been searching strategies to scale up such systems; however most present literature reports still show the existence of important barriers that prevent the success of small stand alone energy generation systems in isolated rural areas.

1.2 Purpose of the research

The purpose of this research is to contribute to the elimination of the existing barriers to rural electrification in developing countries, by identifying the critical factors for successful implementation of small scale isolated stand alone electricity generation systems for rural electrification.

1.3 Research Hypothesis

The hypothesis of this PhD research work is that "There are critical factors (CF), which influence the success or failure of isolated stand alone energy systems in rural areas; those CF may be related to social, economic, technological, managerial, institutional and legal aspects". The identification of these factors worth consideration requires a literature review of previous field research studies related to isolated stand alone energy systems installed within rural electrification projects and programmes, renewable energies and/or rural energy pilot projects. The identification of critical factors and their ranking according to their relative influence as far as Peru is concerned, should be established by means of field research work and data analysis.

1.4 Research Objectives

1) Identify the Possible Critical Success Factors (PCSF) through a comprehensive literature research internationally.
2) Develop field research methodology and apply it to a country case study, considering all PCSF and critically analyse the data, considering trends and anomalies.

3) Draw conclusions about which of those factors identified from literature have really played critical role in the success of small stand alone systems, and arrange them in categories according to their degree of criticality.

1.5 Definition of Critical Success Factor (CF)

For the purpose of this study "Critical Factors are those that play a great role in the success or failure of a stand alone system; the absence or ill existence of a Critical Factor contributes greatly to the failure of the system; on the contrary, if a Critical Factor is properly dealt with, the system is much more likely to succeed".

Those factors identified from the literature review were considered "Possible Critical Success Factor" (PCSF), see chapter IV table 4.3. Some of them were identified as really critical ones after the work research and analysis.

1.6 Summary of the research work

This research work included literature review at international and national level on background information on the different energy issues and specifically on rural energy issues, literature review to identify possible critical success factors for small stand alone electricity generation systems, on field research methodologies and other issues related to sampling, preparation of questionnaires for field data collection among other issues.

The literature review also included the reading of available published information from relevant organisations engaged on issues related to energy access in developing countries, rural electrification and development; among such organisations are World Bank, UNDP, the International Energy Agency and World Energy Council. The most relevant documents revised were impact evaluations, lessons learn, case studies, project reports, research papers and others. Also important number of grey information documents has been gathered and analysed, among the most relevant were those related to projects of organisations such as Practical Action (Previously ITDG) in Peru, Project PERZA (Nicaragua), and OLADE. The grey literature information from Practical Action was accessed thanks to my position as employee of this institution and from the other thanks to contacts with officials of these institutions.

Few documents were found on the specific issues of critical factors for rural electrification and rural energy, some more were found on impact evaluation of rural electrification programmes and projects, including grid connection, renewable energy projects and programmes; but a large number of documents were found on technology piloting and testing.

Nineteen possible critical factors (PCSF) were identified from literature, thirteen with relevance at local context (the community or village), and six with relevance at national (or wider) context. The possible local critical factors were found to be relevant to four categories instead of the six considered initially (i.e. social, financial, technological and managerial); the other two categories, political and institutional were found to be more relevant to the national context.

The case study was decided to be done in Peru, because of the familiarity of the researcher with that country, hence good opportunities to get information and easy to mobilise in the country. A research field methodology was developed in order have results possible generalise. Since the research was predominantly on socioeconomic issues, a social research methodology was necessary to apply. The most appropriate methodology for this particular research was found to be "Survey Research".

The sampling was done at two levels, the first at national level to choose the sample of villages, the second at local level to choose the sample interviewees for each village. The survey population was based primarily on the existing official information, it was composed of two technology strata (hydro power generation schemes and diesel sets), 75 hydro schemes and 61 diesel sets ranging from 20kW to 200kW, located in the Andes and upper Jungle areas of Peru. The initial research sample was made 10% of the survey population, i.e. 7 hydro schemes and 6 diesel sets; however during the field visits it believed to be convenient to increase the number of diesel sets to 7, because there were found quite a few small diesel sets non-registered within the official information systems and also the interest of including a private system[1]; therefore the final survey research sample was composed 7 hydro schemes and 7 diesel sets, the process of selection was using the so called "Systematic Sampling Method"

[1] No private diesel schemes in the research range were found in the official information systems, but during the visits there were found few ones, especially in the lower power range.

Regarding the sampling at village level, four strata of interviewees were considered: electricity consumers[2], management team (operators and administrators), business people and leaders and authorities. A total of 337 electricity consumers, 84 business people, 25 leaders and/or local authorities and 28 administrators and/or administrators were chosen and interviewed.

The choice of the interviewees was also done by using the systematic sampling methodology for the stratum of electricity users, while for the businesses people it was decided to interview a percentage of the total (50% of business people)[3]; for the stratum of leaders and authorities one or two for each village and similarly for the stratum of administrators and operators. A set of questionnaires were prepared for each stratum of interviewees, which were used in all villages. The questionnaires were first tested in two villages, in the Andes region.

Visits to villages were made only after contacts and permission were got from local leaders or local authorities. The first activity after arriving to the village (in each case) was to explain to authorities and leaders about the nature and purpose of the visit and the study; in all cases they welcomed and supported the process, and people were helpful on answering the questionnaires.

The analysis of the data includes a large number of graphs and tables, which provide indicators about the performance of the systems against the different factors. The most relevant findings are:

Poor people have essential requirement of energy to cover basic needs such as lighting and cooking, which have to be overcome despite their poverty. People in small villages or communities have a very low cash income, and they expend a large proportion of it on energy. It was also found that generally the poorest people expend larger shares of their budget on energy than those better off.

The degree of communication and linkages with other people and markets play a role on the benefits of electricity to villagers, those living in villages with better

[2] Household energy users.
[3] The decision of choosing about 50% was considering the fact that very few small businesses are present in isolated rural villages.

access roads; and markets have more benefits of electricity in terms of business and income generation.

Out of the 13 possible critical success factors (PCSF) considered at local context, only 2 are found to be really critical; these are Management and Local capacity (in the village) to operate the systems; the other 11 were found to be important but not critical (see table 7.1). Similarly, out of the 6 PCSF for wider context, only one is found to be really critical, that is national capacity (capacity to manufacture equipment, spare parts, design, and assess needs and resources); the other 5 are important but not critical.

Management appears to be the most critical of all the factors; this is because with good management they can overcome almost all difficulties[4].

The "small enterprise management model" used in the community Las Juntas shows to be a successful management model. This model has been developed and piloted by Practical Action in few hydro systems in Peru, for all cases where this management model was used, the small hydro schemes have been reported to be very successful.

From verbal information provided by personal contacts with officials of the rural programme in Nicaragua, it was found that the Wold Bank is presently using the small enterprise model used in Las Juntas for hydropower schemes implemented through the project PERZA "Projecto de Electrificacion Rural y Zonas Aisladas"; in Peru the World Bank Regional Office (Andean Office) for Water Access is in negotiations with Practical Action Peru office to test this management model in a number of small water supply schemes in different parts of the country.

Further research study is recommended on the different management models for small scale electricity generation schemes; with particular attention to "The small enterprise management model".

[4] There may be extreme difficulties which could not be overcome even with good management, these could be for example the complete lack of spare part nationally of the complete lack of skills in the community to operate and maintain the schemes.

1.7 Overview of the contents

Chapter two includes a short description of the main characteristics of Peru including geography, language, economy, and the more recent history and policy issues. It also includes some discussion about the poverty in developing countries and the situation of access to services, in particular the access to electricity in Peru, and finally it includes some discussion on the Agenda 21 and the concept of sustainable development.

Chapter three includes a wide literature review of rural electrification, its evolution during the last decades with indicators, which reveals that a total of nearly 2 billion people has been without access to electricity by 1990, 1.65million in rural areas and 0.35 million in urban areas. It also reveals that the number of people in rural areas without access to electricity has increased from 1970 to 1990 on about 150 thousands. This chapter also includes the findings about energy needs and energy consumption in the developed and developing countries, and the rural energy options available to tackle the energy needs. It also includes some information on the rural electrification situation in Latin America and Peru.

The section on Peru, includes information on energy resources, the history of the development of the electricity sector, the changes in policies and ownership from the beginning of the use of electricity to present, the situation of rural electrification and the different indicators of the regions and the government plans for the coming years on rural electrification; it also includes it includes a section on the role of stand alone energy schemes in Peru and the national capacity for manufacturing and installing small stand alone energy systems, and finally some conclusions on the importance of electricity for human development and about the present situation of electricity access in the world and in Peru.

Chapter four focuses its attention in the identification of the critical factors for successful stand alone energy schemes; the first part includes a review of the most relevant sources of information found during the process of this study. The review was done using specific cases studies on renewable energies, projects and programmes, rural electrification projects and programmes and stand alone energy systems, highlighting the most relevant possible critical factors; a second section includes a review of case studies related to projects and programmes of rural electrification in Peru. A limited number of case studies specifically related to the

focus of the research were found, most of the available literature is referred to piloting, specific cases.

A second part of chapter four groups the different possible critical factors extracted from the literature according to the main categories suggested in the hypothesis of this research work, i.e. social, financial, technological, managerial, institutional and political issues. A careful scan of the different possible Critical Factors was done in order to reduce the total number of possible factors suggested in the literature, eliminating repetitions, and merging those much similarities.

Chapter five focuses its attention in the methodology for the field data collection, firstly with a review of the existing methodologies for this sort of research, the choice of the methodology. It was found that "survey research" was the most appropriate methodology for this particular case, because of the extension of the work, the number of case studies involved and the time available.

Chapter five also includes the methodology of sampling within the villages (the sampling of the interviewees in each village), and the different categories of interviewees, which were split in users, business people, authorities and leaders, and administrators and operators of the schemes, finally it includes a information about the design of the questionnaires and the organisation of the possible critical factors in the different questionnaires, which was done separately for each of the categories above mentioned.

Chapter six initially includes a brief discussion about the sample and the sampling conditions, the reasons for the change of the number of systems in the survey sample from 13 to 14. Following there is a detailed discussion about the results including 27 graphs and 16 tables showing results of the analysis and of the data collected. The analysis is organised in two sections, the first includes all the results related to the possible local critical factors and the second to the possible critical factors of wider context. This chapter also includes a summary (which is at the end of this chapter) of the analysis of the different factors, this is mainly due to the large number of factors analysed hence the extension of this chapter.

Chapter seven also includes a list of other conclusions and recommendations. The conclusions refer mainly to the critical factors and important factors on small

decentralised stand alone electricity generation systems. The recommendations are split into two parts for local context and for national context.

Finally chapter seven includes a small section regarding the way forward to this study and possible ways of contributing to the research in the field of sustainable stand alone systems for rural electrification.

At the end of this document there are five appendixes.
Appendix A: Sampling
Appendix B: Short description of each village visited,
Appendix C: Questionnaires
Appendix D: A sample questionnaire filled in the field
Appendix E: Abstract of a paper based in this research study published, and the cover page of a small book published by the author where the background information has been taken from this Research Study.

Appendixes F, G, H, and I are saved in the CD and attached to this document. This is done because length of the document, but also because all the relevant information has been processed included in the main body of the Thesis, however in these appendixes there is base information about the process that may be useful to the readers y/o researchers.
Appendix F: Excel sheets of the data processing
Appendix G: Graphs of power generation curves of 14 systems studied
Appendix H: Blank forms used to pass the information collected from the field before processing in the excel sheets
Appendix I: contains the same information of Appendix G, but in Spanish, this is because the information was collected in Spanish and it may be useful for Spanish speakers.

CHAPTER II
BACKGROUND ON PERU

2.1 Geography

Peru is a developing country located in the mid-western part of South America, between 0° 01' 48.0" and 18° 20' 50.8" latitude south and meridians 68° 39" 27.0" and 81° 19" 34.5" longitude west, covering a total area of 1'285, 216 million square kilometres [IGN, 1989]. There have been several attempts (hence proposals) to divide Peru into natural regions; one of the most accepted among the scientific community is the proposal by Javier Pulgar Vidal [Pulgar Vidal, 1996], which considers 8 natural regions, focusing on existing ecosystems. Nevertheless, this work refers to the three natural regions – the Coast, the Sierra or Highlands (Andes) and the Jungle – mainly because that is the formal division still in use in the present education system in Peru; see figure 2.1. Each of these three regions has its own particular topography, climate, weather, landscape and so on, which make it different from the others.

2.1.1 The Coast

It is a narrow strip of land from north to south, between the Pacific Ocean on the West and the Andes on the East, with altitudes ranging from 0 to a few hundred metres above sea level, occupying about 10% of the total national territory. It is a mostly arid region, with very little rain ranging from 40 to 200 mm a year, on average. Weather conditions along the coast vary from north to south, with a few slight changes in temperature, mm of rainfall, hours of daylight etc. The exception is the "El Niño" Phenomenon, a cyclic occurrence every 6 to 8 years, which causes heavy rainfall, especially in the northern part of this region. The coast

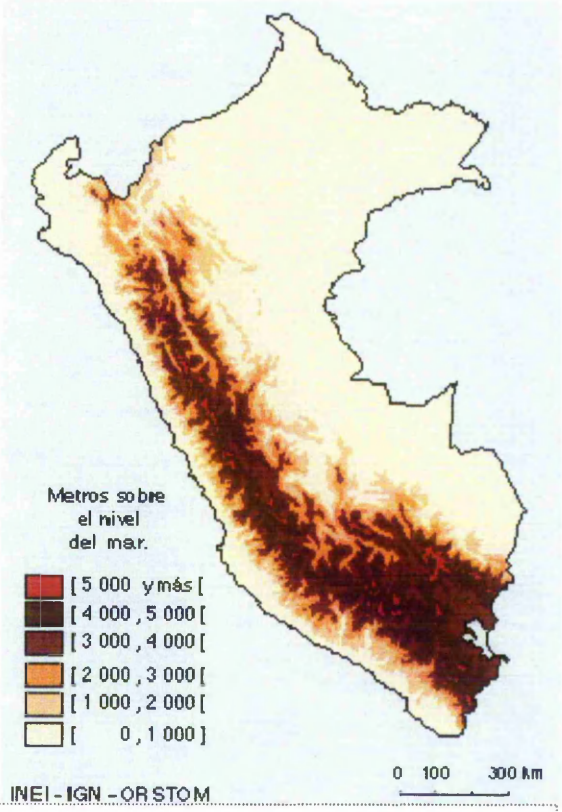


Fig 2.1 The three natural regions of Peru

includes important deserts like the Sechura located in the northern part of the country (in Piura) and the "Atacama desert" in the south, which crosses the border into Chile.

In this region, only a very small proportion of the land is suitable for farming, except for a few small valleys formed by small rivers, fed by the rainfall in the mountains and flowing into the sea; the rest of the coast is unproductive due to the weather conditions (arid), lack of water and other reasons.

2.1.2 The Sierra (Andes)

Also referred to as the Andean region, it is situated in the middle between the Coast and Jungle regions, occupying more than 30% of the national territory. It comprises a difficult and mostly rugged terrain, with very high peaks distributed throughout the length of this territory[1], with deep inter-Andean valleys and a few Plateaus like the "Altiplano" bordering with Bolivia in the south and "Pampas de Junin" in the central Andes. This region has a large variety of ecosystems and, consequently, a large variety of weather conditions, ranging from warm climates along the borders with the jungle and coastal regions to freezing temperatures on high Andean mountain peaks. Like the Coast, most of the territory in this region is not suitable for farming and livestock activities. However, due to the large variety of existing ecosystems, the limited areas of farmland produce a large variety of products, consistent with their climate and altitude. Unfortunately, the products have little or no access to large markets, especially to foreign markets.

2.1.3 The Selva (Jungle)

This is the largest of the three regions, occupying nearly 60% of the national territory, situated in the east of the country. It is mostly flat, except for transition areas between the Andes and the Jungle, where the topography is a continuation of the Andes. It has a warm climate all year round with temperatures varying from as low as 20 and as high as 40 degrees Celsius.

This region is covered by abundant natural wildlife resources. It also contains several large rivers like the Amazon, Marañon, Napo, Ucayali and others, all of them originating in the Andes region and flowing into the Atlantic Ocean after crossing

[1] The second highest peak in the continent, Huascaran, is located in the Peruvian Andes; the highest is the Aconcagua in Chile.

Brazil. Although this region is rich in natural resources (especially high quality timber) and is exploited mainly for the exportation of wooden products, ornamental plants, fish species and a large number of wild animals, the exploitation of those resources is difficult due to the isolation of most of the markets.

See more about Peru's geography, weather, ecosystems and others related issues to in [Pulgar Vidal, 1996; Brack E, 1986, Dollfus 1981]

Politically, Peru is divided into 24 departments (see figure 2.2), 180 provinces and more than 2000 districts, although these figures vary every now and then due to changes in status of certain districts and the creation of new ones.

Lima is the capital city of Peru, situated on the shores of the Pacific in the centre of the coastal region. It has a population of nearly 8 million inhabitants and is by far the most populated city the country. Peru is a highly centralised country, with more than 60% of the national industry and all other services, like the finance system, public services, etc. centred in Lima.

The second and third towns are Arequipa and Trujillo with about 0.7 million inhabitants each, the first one located south of Lima and the second in the north, both on the coast.



Fig. 2.2 Political regions of Peru

2.2 Population, Language and Ethnic Groups

The total population at the end June 2000 was 25.662 million people, of which 18.662 million were living in urban areas (72%) and 7.106 million in rural areas (28%) [INEI, 1988/1989]. However, it is worth pointing out that the distribution of the population throughout the territory is highly uneven. Nearly 60% live on the Coast (the smallest region) less than 10%, live in the Jungle and slightly more than 30% live in the Andes.

An important feature of the Peruvian population has been the progressive urbanisation process. The total population in 1940 was 7 million, of which 2.5 (35%) lived in urban areas and 4.5 (65%) in rural areas, by 1970 it was 13.193 million inhabitants (57% urban and 43% rural); by 1990 it was 22.332 million 68% urban and 32% rural; by 2004 it was 27 million (72% urban and 28% rural).

The fastest population growth rate in Peru occurred during the 1961/1972 period, when it reached 5% a year, while in rural areas the highest growth was during the 1972/1981 period at a rate of 1.1%. The fastest growth of the national population was during the 1961/1972 period at a rate of 2.9%; by the end of 2000 it was at 2.2% [Peru Acorde, 2000].

The above figures show that there have been very important migration processes, mainly from smaller to larger towns and from rural to urban areas. However, looking at the regions, there have also been very important migration process from the Andes to the other regions; according to national statistics, the largest migration occurred from the Andean region to the coast and the Jungle [IGN, 1989]. The most important reasons for migration are said to be the lack of basic services like drinking water, education, electricity and others; at the same time, the isolation of the communities due to the lack of roads is responsible for those deficits.

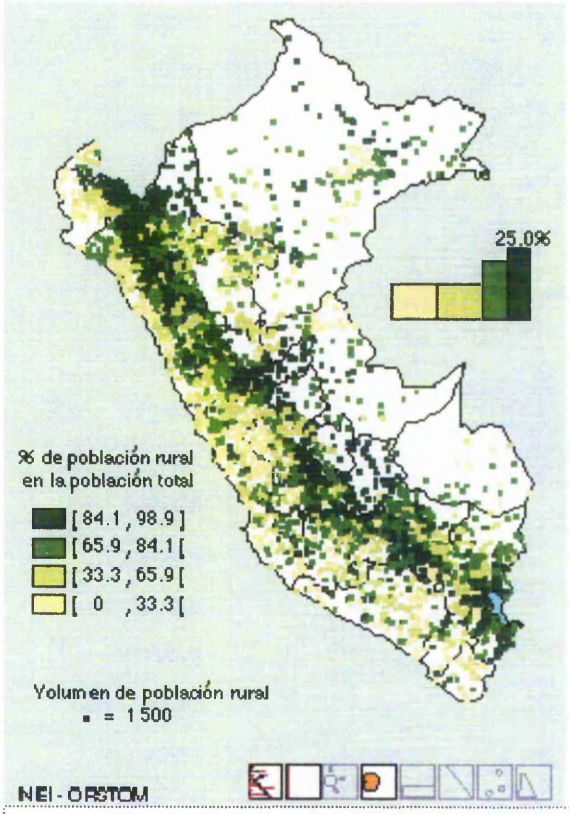


Fig 2.3 Rural population density

According to national statistics, [INEI, 2000], the region with most rural population is the Andes; see figure 2.3 map rural population density.

The official language is Spanish, although two important local languages have existed since Pre-Inca and Inca times: "Quechua and Aimara", which are spoken by a large number of people, mainly by communities located in the central and southern

Andes. Furthermore, there are 58 small ethnic groups comprised of a total of 240,000 people spread out in the country, mainly in jungle areas, where the western culture has had little influence so far [GEF/PNUD/UNOPS, 1997]. These ethnic groups have their own languages, although they are grouped in a total of 12 linguistic tribes.

2.3 Government

Peru has had a presidential government since its independence from Spain back in 1821; the President is elected every five years by popular vote; the president forms his/her Cabinet Council by appointing collaborators to the different Ministries. There are also another three institutions that have independent power:

The Legislature (Parliament) is responsible for drawing up laws and regulations. At present it has a single chamber (since 1993), formed by 120 members elected at the same time as the president, every five years. Previously the parliament had two Chambers, a Chamber of "Deputies" with 180 members and the Chamber of Senators with 60 members.

The Judiciary, which is responsible for law and order and the enforcement of the Peruvian Constitution, with the Supreme Court as its top decision making organisation.

The Electoral Power, which is in charge of preparing and running the elections of different authorities (central and local)[2]. Its members are appointed by the Parliament.

The Executive Power responsible for the government is formed by the elected President and a Cabinet Council comprised of 12 Ministers in charge of as many government sectors: Industry, Education, Health, Energy and Mining, Defence, Internal Affairs, Foreign Affairs, Fishing, Family, Economy, Justice, Employment. The President appoints the Prime Minister, and the other members of the Cabinet (Ministers) are chosen by the President and the Prime Minister together[3]

[2] There have been advances and drawbacks with the creation of the regions and hence with the election of their authorities.
[3] See web page www.georgetown.edu/pdba/Constitutions/Peru/per93.html

As far as decision-making powers are concerned, Peru is a highly centralised country. All top decisions are made by the executive power in the capital city and representatives of the different government institutions are appointed by the President or by his close collaborators (Ministers). Likewise, the President appoints representatives in each of the departments, provinces and districts. Those representatives are referred to as "Prefecto" for the departments (Regions), "Sub-Prefecto" for the provinces and "Gobernador" for the districts.

The president and members of Parliament are elected every 5 years in general elections. According to the 1993 Constitution, the President can run for a maximum of two periods, whereas MPs can run as many times as they want to.

There are also Local governments. Mayors (Alcaldes) are elected by vote and are in charge of the administration of provinces and districts. Their resources are based on some municipal rates (cleaning, security, and some taxes)[4]; however, they have limited decision-making powers.

2.4 Economic activities

Peru is a developing country with a small economy; its gross domestic product (GDP) in 1999 was US$ 52.08 Billion [INEI, 2000], the structure by sectors and their contribution in percentage terms in the same year was as shown in figure 2.4.

Other services, the largest sector of the economy, is comprised of transport and communications, electricity, water and sanitation, health, education, tourism, and other services.

Manufacturing, the second largest sector of the economy, has enjoyed a 31% growth during the last 20 years (1980 to 2000), albeit in an erratic and inconsistent manner (a high growth rate some years, but most years a limited growth, if any). The 6 most important sub-sectors in 1999 (in order of their economic share in the GDP) were food products, textiles and leather, wood and furniture, chemicals, non-metal products and metal products. In 1998 the largest manufacturing component was the chemical industry followed by the food industry and in the third and fourth places, textiles and wood and furniture, respectively.

[4] In small towns and rural areas, taxes are negligible, if any, therefore there is a permanent lack of own resources and a large dependence on central government contributions.

Although wood and furniture is a growing industry, it is considered not to have reached its full potential, since the natural reserves in this country are huge, especially in Amazon areas. However, it is worth pointing out that at the present time there are important external factors which may prevent the fast growth of this sector, especially those related to international pressure regarding forest conservation, environment and other issues.

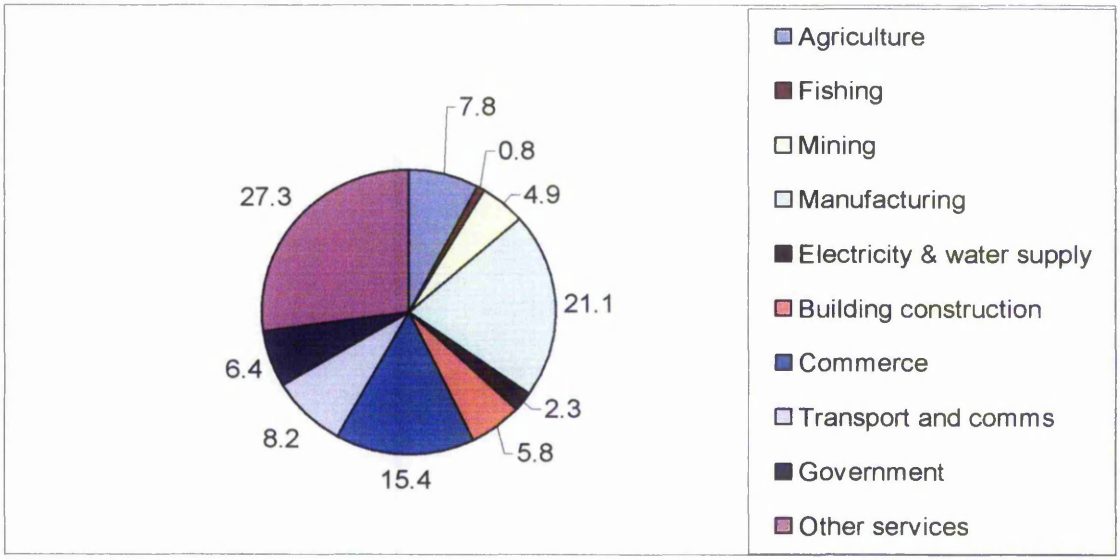


Fig. 2.4 Structure of GDP (%) by 1999; source (INEI, 2000)

Although Peru is a relatively large country, less than 5% of the territory is farmland, therefore it is not considered to be an agricultural country; even so, agriculture is the third contributor to the GDP In most of the country, farming is for the farmers' own self-consumption, except for few cash crops like cotton, sugar cane, coffee, rice and asparagus.

During the 50s and 60s, sugarcane was one of the most important export products, but due to the political changes implemented by the Military government between 1968 and 1980, particularly the agricultural reform, exports of this product were gradually constricted until finally international markets lost interest. At the present time, the cultivation of sugarcane has been reduced to a minimum compared with that of 30 years ago, barely meeting the demand of the domestic market.

Mining has been an important activity in Peru since ancient times. During the pre-Inca and Inca eras, gold was used to produce a variety of products, religious

symbols and objects and tools for ornamental purposes. Immediately after the Spanish Conquerors arrived, most of the existing gold (at that time) was transported to Spain and other European countries; there was also an intensive gold mining activity throughout the colonial period, when the indigenous people were forced to work as slaves.

Although there are no statistics regarding total mining reserves in Peru, there are important indicators of the existence of huge reserves, especially in the Andes. In fact, despite the complicated political situation of the last three decades, Peru has an important world status as one of the leading countries as far as the mining of various metals is concerned, ranking fifth in copper production and fourth in lead. Moreover, during the last fifteen years, gold mining activities have been one of the fastest growing sub-sectors of the economy, rising from 4.7 tons in 1980 to 20.1 tons in 1990 and 127.8 tons in 1999 [Peru Acorde, 2000] and exploration and exploitation activities continue to grow. New important gold mining projects are in the initial steps or in the planning stage.

As regards oil, about 30% of the current internal oil consumption is imported from different suppliers. Although the oil reserves discovered are limited, important exploration and exploitation programmes are still needed to identify the actual national reserves; however, there is not much hope about the existence of large reserves.

Fishing is a small contributor to the GDP at present, although it is worth pointing out that during the 1960s Peru was one of the world leaders in the exploitation of fish and exportation of fish products. Furthermore, Peru has an extensive 3000km. long coastline stretching from the extreme north to the extreme south, with fishing rights within 200 miles offshore. These unique conditions plus its location near the Equator provide an interesting potential for fishing. Nevertheless, there are ongoing discussions about the appropriate management needed in this sector to avoid the depletion of resources in the sea biomass.

In the fields of flora and fauna, there is tremendous biodiversity due to the existence of a large number of ecosystems. It is estimated that Peru has as many as 70% of the total number of ecosystems in the world [Pulgar Vidal, 1996]. This is due to the geographical conditions, the existence of three different regions, the Andes with high

peaks (the highest is Huascaran with 7600m above sea level), and large rain forest areas.

The per capita income in 1999 was US$ 2200 (current value), although that amount does not seem so low compared to the income levels of most other developing countries. This conceals the disparities of income within the Peruvian population, with a large majority in the bottom of a wide based economic pyramid. In fact nearly 50% of the population is qualified as poor or extremely poor; only a small group of well off inhabitants live a comfortable life and have access to all sorts of modern services and privileges provided by the government system and cultural traditions.

The excessive centralisation in Peru mentioned previously is the result of successive governments with no interest in decentralising the country and the lack of appropriate policies. However, it is important to point out that the country's complicated geographical conditions have made it difficult and expensive to connect the different regions and towns, contributing to the centralisation of the country. Furthermore, most of the time the power has been in the hands of people who represented the economic interests of the dominant social class located in Lima and other cities on the Coast.

2.5 Recent History

2.5.1 Policy and Government

The basis of the present Peruvian civilisation was the important pre-Inca and Inca civilisations, the latter having collapsed during the Spanish Conquest back in the 15th century. "The Inca Empire" developed in the present Peruvian territory and large parts of various other bordering countries. Between the 8th and 15th centuries it was a strongly agricultural society, with central planning administration and polytheist religion. The Spanish conquered the empire in 1492 and implemented a colonial government that lasted about 3 centuries, when the indigenous people were used as slaves to provide labour, particularly in the mining sector. After several rebellions and fights, independence was declared in 1821 and the Spanish finally withdrew in 1824. Since then, Peru adopted democracy as its model of government. The President is elected every five years, although the history of governments has been a combination of about 50% democratically elected presidents and 50% dictators. During the republican period there have already been 12 Constitutions, the last one written in 1993.

The most important political events in the recent history of Peru affecting the present situation, started with the military coup of 1968 which resulted in 12 years of military government (two periods of 6 years). The first was led by General Juan Velasco, who implemented a pro-Communist government, the main allies being the Soviet Union, East European Countries, Cuba and other communist regimes. The second period led by General Francisco Morales Bermudez had a more conservative profile.

The first phase of the military government headed by General Velasco (1968-1974) was characterised by a vast campaign of reforms affecting agriculture, industry, mining, transport, communications, education and other sectors. During this period, services like water and sanitation, electricity, health, transport and telecommunications were nationalised and converted into state companies.

Although the second military government (1974-1980) was supposed to be conservative and pro-capitalist, little or no changes were made to the main policies dictated by Velasco; in fact, most government actions were aimed at the continuation of the "Staus Quo"

In 1979 there was a call for national elections to reform the Constitution and in 1980 there were general elections to return to a democratic government. From 1980 to 1990 there were two democratically elected Presidents, Fernando Belaunde and Alan Garcia, the first coming from a conservative party "Accion Popular" and the second from a Social Democratic party "Alianza Popular Revolucionaria Americana - APRA". During the 1980s, despite the return to democracy, there were no structural reforms, but a simple continuation with two different styles of governments: conservative and social democracy.

In 1990 President Alberto Fujimori (a first generation Japanese descendant) became President, when the country was undergoing a severe crisis in all sectors and political chaos reigned. In April 1992, Fujimori carried out a self-coup in alliance with the army to enable the implementation of policy reforms. After that, he managed to change the constitution and remain in power until the year 2000, with a re-election in 1995 and a second re-election in the year 2000. However, within a few months of having assumed power for the third successive period, extremely serious acts of corruption were made public, forcing Fujimori to abandon the government.

Subsequently, the democratic forces organised an emergency transition government (Nov 2000 – July 2001).

During the Fujimori decade, the government carried out a large reforms programme, privatising most of the government businesses and promoting new laws and regulations to make the country attractive to foreign investment. The free market type of government was largely promoted and implemented.

2.5.2 Economy

During the 1968 -1980 period, the central planned economy was largely inefficient. Productivity indicators, the country's net savings, the trade balance and others decreased to levels never seen before, most of the international markets were lost and the national debt grew enormously.

During the 1980 -1990 period, as mentioned before, the two democratic governments continued the "Status Quo" and there were no important reforms to promote investment, therefore the economy continued deteriorating. Unfortunately for the Peruvian people, the economic indicators at the end of that period reflected a very negative loss of purchasing power, extremely high inflation rates, a weak banking system, extremely high cost of capital, exports were reduced or remained stagnant, etc. The highest inflation rate in the history of the country was recorded at the end of that period (during Garcia's government) reaching the astronomical figure of more than 7600% per year. Peru was excluded from the world banking system (IMF, The Paris Club and others) and Peru was declared a non-eligible country for financial transactions.

During the 1990 to 2000 period there was a strong economic adjustment initially, and then in 1990 a disciplined management of the economy began. During the 1993 to 1997 period, Peru cleared its non-eligible status and was re-inserted into the world economy. Economic reforms were promoted and most state businesses were privatised. Inflation was reduced gradually, reaching single digits by the end of the decade. This proved the significant success of the economic policy, at least in macroeconomic terms. Nevertheless, poverty has grown and at the present time, more than 50% of Peruvians are considered to be poor and about 20% extremely poor.

2.5.3 Social issues

During the1970s, people became increasingly more aware of their rights and there was a considerable increase in the number of social organisations. A few extreme left movements also appeared, proclaiming the need for violent actions in order to seize power in the country and "put it under the control of the people".

From 1980 to 1992, Peru experienced the hardest time in terms of internal violence, mainly because of the spreading of two pro-Communist movements, "Sendero Luminoso" (Shining Path) and "Movimiento Revolucvionario Tupac Amaru" (MRTA), who launched the strong campaign against government assets, government employees, NGOs, church members everyone who opposed their ideas and methods. The losses caused by such violence during that period have been estimated at more than 25,000 deaths and about US$ 30 Billion.

The violent movement was successfully defeated during the 1990s; in fact by 1992 the top leader of the Shining Path and other mid range leaders had been imprisoned, as were the leaders of the other movement.

It is also important to mention that during the 1990-2000 decade, there were very important international factors that helped achieve peace and social development in Peru, namely the Definitive Peace Agreements with Ecuador and Chile.

However, the extensive corruption that was rampant in the last part of Fujimiri's government was very unfortunate for the country, this being the main cause for a large social protest that forced the President to give up power and abandon the country. Many of the main agents of corruption have been prosecuted, including several top military officials and ex-President Fujimori's collaborators.

2.6 Sustainable development

2.6.1 Poverty in Developing Countries

At the present time, political leaders and an important part of society (especially those who are closer to the academic world) recognise that the world is facing a critical moment in history, as disparities between human beings seem to be increasing steadily. The Agenda 21 Preamble section states "Humanity stands at a defining moment in history. We are confronted with a perpetuation of disparities between and within nations, a worsening of poverty, hunger, ill health and illiteracy,

and the continuing deterioration of the ecosystems on which we depend for our well-being" [UNDP, 2000]. According to world statistics, the different poverty indicators have been increasing progressively despite important efforts made by poor and rich countries during the past decades to reduce poverty, while wealth increases in rich countries. Statistics of population and income distribution between rich and poor countries reveal the truth behind the previous statement about disparities; for example in 1994, the 1.2 billion people living in rich countries had a global GDP of nearly US$ 22,000 billion, whereas the 4.3 billion living in developing countries had only US$ 4,500 billion; in other words, the average income of citizens in a developed country was about 16 times the average income of an inhabitant in a developing country.

However, the average figures shown previously only reveal the macroeconomic conditions of large regions, not the actual circumstances of poor people in poor countries. By 1994 for example, the number of people living on less than US$ 1/day was about 1.3 billion, of which 70% were women. These people lack opportunities and services, they feel isolated and powerless and often feel excluded because of their ethnicity, caste, geography, gender, or disability [DFID, 2000].

Most developing countries have highly centralised economies, although in relative terms it is different in each country. Most of the productive resources and social services are concentrated in a few large cities (in most cases in one, two or three). During the last 3 or 4 decades there have been huge changes in terms of urban and rural percentages of population in developing countries, especially in those where industrialisation has grown. Such is the case of Latin America, which switched from a predominantly rural to a predominantly urban region, mainly as a result of migratory movements of people looking for a better life and seeking jobs in industries, attracted by the better services and commodities that urban areas offer and because of the continuous abandonment of rural areas by governments.

Such changes in urban and rural populations have created new social and economic structures and needs, new distribution in terms of GDP, and also a new distribution structure of needs within rural and urban people. In large cities in developing countries, where migration has continuously grown during the last decades, the number of informal settlements (or shanty towns) have grown dramatically, creating a new and growing social pressure for basic services like

drinking water, health and education, electricity and others. However, financial resources have been more and more limited, becoming a permanent problem for governments and forcing them to prioritise the investment of important amounts of financial resources to provide such services in large towns, to the detriment of isolated rural communities.

The difficulties in creating an appropriate number of jobs in urban areas and providing basic services of good quality in large cities have become more evident with time, creating a series of social effects like delinquency, organised crime and other social consequences. Furthermore, the lack of services, facilities and opportunities for rural people are becoming more dramatic, generating more pressure on local resources and negative effects on the environment. Consequently, reducing poverty has become one of the most important issues in the agendas of different world agencies [DFID, 2000]. "It is the single greatest challenge that the world faces, eliminating poverty".

There is also evidence that poverty has adverse effects on the sustainability of the planet, especially in rural areas where the inhabitants are increasing their pressure on natural resources in order to meet their needs.

2.6.2 Poverty in Peru

As shown in section 2.4, Peru has important reserves of natural resources, like minerals, fish stocks, forests, and others; however it is a poor country in the process of development, with a small economy based mainly on extractive activities. It is also a very centralised economy with a highly unfair distribution of economic resources between rich and poor, between those who own the means of production and the labour class.

Table 2.1 reveals that the poorest people are concentrated in the Andes and in the Jungle. Furthermore, if we split these into rural and urban areas, the worst poverty indicators are in the rural areas of these regions. This is due to isolation, centralisation, the great difficulties encountered by the government and other development agents in providing basic services and creating employment and, perhaps the most important, and the isolation of the large markets.

2.6.3 Access to basic services

Although during the 90s large investments were made in basic services like health, education, drinking water, energy, and other services, there is still a significant gap, especially in rural areas. Table 2.1 shows poverty indicators in the different regions of Peru by the end 1998; and table 2.2 shows indicators on access to basic services

Table 2.1 Peru: Poverty levels by Natural Regions and Area, 1998 (%), (Estimation of the poverty based on the expenditure per capita)

Area and Regions	Total	Levels of poverty			Not poor
		Extreme poverty)	Poverty (not extreme)	Total	
Total	100	15.6	21.7	37.3	62.7
Regions					
Lima (city)	100	2	19.2	21.2	78.8
The coast (excluding Lima)	100	8.5	12.9	31.4	68.6
Andes Region	100	30.5	20.9	51.5	48.5
Amazon Region	100	17.2	26.9	44.1	55.9
Regions and Area					
Urban COSAT	100	5.1	22.8	27.9	72.1
Rural COSAT	100	19.9	23.2	43.1	66.9
Urban Andes	100	8.6	24.2	32.8	67.2
Rural Andes	100	42.9	19.2	62	38
Urban Amazon	100	6.7	26.8	33.5	66.5
Rural Amazon	100	26.2	27	53.2	46.8
Lima (city)	100	2	19.2	21.2	78.8

Source [INEI, 1998]

The general trend has been the government's efforts to place priority on meeting the basic needs of the urban and urban-fringe groups, depriving the rural population of those privileges. Experience shows that the more isolated people live, the less attention they get. Although there may be several reasons why governments place priority on meeting the needs of urban areas to the detriment of rural areas, an important fact is that urban inhabitants have more opportunities to organise

themselves and to influence government decisions through political pressure, whereas rural people cannot afford such organisations and are consequently denied political pressure, due to their isolation from decision-making centres.

Table 2.2 New Access to Basic and Social Services, 1994-1997 (percentages)		
Service	Urban	Rural
Water	57	43
Electricity	72	28
Sanitation	78	22
Outpatient health-care	74	26
Schooling	67	33

Source [World Bank, 1999]

Although during the last decades there have been special programmes to deal with poorer groups of people, such as "Cooperacion Popular" during the 1980s and the National Fund for Social Compensation (FONCODES) implemented by the government of Eng. Fujimori during the 1990s, which is still operating, the indicators clearly show that they have not been enough to eliminate or even reduce poverty.

It is important to point out that both the country leaders and the international community are very much committed to finding new and better approaches and new development concepts, which hopefully will substantially improve the effectiveness of the development efforts.

2.6.4 The agenda 21 and the Sustainable Development Concept

Sustainable development is a modern development concept, which is currently being successfully promoted in developing countries in order to reduce poverty. This concept considers that the driving force behind sustainable development is human beings, who should live in harmony with and relate to their ecosystem.

Agenda 21 shows the concerns about past and present poverty-reduction approaches and suggests an integrated approach, considering environment and development issues. It also suggests that sustainable development requires a better understanding of the environment and ecosystems and a better fulfilment of

people's needs. Furthermore, it suggests that sustainable development can only be achieved if there is a strong commitment by developed and developing countries to implement a range of international and national policies, which can conduct a better distribution of resources and opportunities and reduce disparities. Among the most relevant policies suggested are those related to market regulations for equal opportunities, such as globalisation and equalisation of market conditions, the removal of every kind of subsidy on production and consumption, the elimination of production inefficiencies, debt negotiations, reducing debts whenever possible and suitable, especially for developing countries; better market conditions, especially for developing countries and specific key products which are cost effectively produced in the countries. Therefore we can say that Agenda 21 is an interesting framework for a more harmonious development in the world and for the fight for a world of better justice and fewer disparities.

Nevertheless, in addition to government understanding, a common willingness and agreement is required to set policies aimed at reducing disparities and increasing equal opportunities, in order to achieve sustainable development, especially in developing countries. Institutions like DFID, the Institute for Sustainable Development and others recognise that there is a great need for direct involvement of people (grass roots) in the implementation of policies and strategies. They are now effectively promoting the sustainable livelihoods concept as a strategy for achieving the long-awaited sustainable development of the world in general and the poorer sectors of developing countries in particular.

2.6.5 Sustainable livelihoods

The sustainable livelihoods concept states that: "*Poverty is a complex multidimensional problem with origins in both the national and international domains*". And *therefore no uniform solution can be found for global application. Rather, country-specific programmes to tackle poverty and international efforts supporting national efforts, as well as the parallel process of creating a supportive international environment, are crucial for a solution to this problem.*

DFID states clearly that "The eradication of poverty and hunger, greater equity in income distribution and human resource development remain major challenges everywhere. The struggle against poverty is the shared responsibility of all countries".

Sustainable livelihoods promotes an environmental policy that focuses on the conservation and protection of natural resources, taking into account those who depend on the resources for their livelihoods. Otherwise it could have an adverse impact both on poverty and on chances for long-term success in resource and environmental conservation. It suggests emphasis on the promotion of policies that can increase and improve the production of goods and commodities for people in order to improve their quality of life, while preserving the environment and achieving a sustainable development. It covers demographic issues, enhanced health care and education, the rights of women, the role of youths and of indigenous people and local communities and a democratic participation process in association with improved governance.

The sustainable livelihoods concept considers particular strategies and policies to attain the objectives for log-term sustainable development of individuals and of groups, the commitments that should be assumed by governments, and different crosscutting issues that should be focused on. It gives great importance then to the full participation of people, promoting and privileging community-driven activities and community-driven decisions.

CHAPTER III
RURAL ELECTRIFICATION REVIEW

3.1 Rural electrification world wide

3.1.1 Access to electricity

Electricity is recognised as an important element for the social and economic development of the population, contributing to economic growth and/or improving a range of basic welfare services like drinking water, food, health, education and many others. The World Energy Council states, "The message of ETW (Energy for Tomorrow's World) was to remember that health, water, food, education, and many other key aspects of welfare cannot be improved unless modern energy becomes available to all". It argues about the key role of energy is to provide other elementary services in the developing world, hence the priority of people's access to modern energy [WEC, 2000]; the World Bank sates "Likewise poverty in developing countries cannot be reduced without greater use of modern forms of energy" [World Bank, 1998].

Yves Mariginac & Mycle Schneider state "The degree of development of a society can be expressed in terms of increasing ability to meet a certain number of fundamental needs. They can be basic-food, housing, clothing, or more elaborate ones like education, culture, exercise of civil rights, quality of the natural environment, leisure, etc. But most of them require energy in varying degrees, thus making the availability of energy an absolute pre-requisite to economic and social development" [Yves Mariginac & Mycle Scheneider, 2001]. CP. Jain, Chairman WEC Studies Committee [WEC, 2006] states "The WEC is engaged in promoting supply of energy for the greatest benefit of all, this challenge is achievable but faces enormous challenges. Nearly 2 billion people do not have access to modern energy and demand is growing rapidly. There a need for a greater national and regional cooperation to: attract investment, energy security; optimize resources, energy efficiency, transfer technology, and protection of environment". The world Energy Assessment [UNDP, 2004], appendix 1 shows how energy plays an important direct or indirect role in the achievement of 7 out of the 8 Millennium Development Goals (MDGs).

However, access to electricity is one of the most difficult tasks that governments and development agencies face, especially in developing countries. It has been

estimated that nearly one third of the world's population had no access to electricity by the end of the 20th century, the great majority of them living in developing countries [WEC, 2000; D.F Barnes, 2001]. Figures in literature show that despite the efforts made to increase access to electricity in developing countries during the last three decades, and the rise in electricity coefficients (percentages of coverage), the total number of rural inhabitants without access to such a basic service is high and remains almost constant.

According to the World Bank [World Bank, 1996], by year 1990 a total of about 2 billion people in the world had no access to electricity, nearly 0.35 billion in urban areas and about 1.65 billion in rural areas, 16 years later access to energy by the poor has not been changed see [WEC, 2006].

The World Energy Council argues that "from an estimated of 1.4 billion people to be born by year 2020, about 30% (420 million people) will be faced with the challenge of energy poverty"; considering that these people will mainly live in rural areas and adding this figure to that of year 2000, the total number of rural people who will require assistance in gaining access to modern energy between 2000 and 2020 will still be around 2.0 billion; therefore in order to provide access to energy for all of them, almost 100 million people have to gain access to modern energy services each year for the next 20 years [WEC,2000]. The same reference compares the future demand with the only 40 million people per annum in the world that gained modern energy during the period between 1970 and 1990 or the 30 million per annum from 1990 to 2000, and mentioned the tremendous effort required in the immediate future to provide electricity to rural people in developing countries.

According the International Energy Agency estimates [IEA, 2002], despite the efforts and possible investment of the coming 3 decades, the situation of access to electricity services by 2030 would not change substantially; 650 million people in Sub-Saharan Africa, 680 million in South Asia and about 75 million in other parts of the world will still have no access to electricity.

Apart from the huge number of people without access, the following are other important issues related to rural electrification:

a) The uneven access to electricity within continents and regions, and similarly within countries in each region and within zones and areas in each country. According to table 3.1, while the Sub-Saharan countries had only 23% electrification coverage by 2000, southern East Asian countries had an average of 41% and Latin American and Caribbean countries recorded an average of 87% in the same year.

Table 3.1 Electrification rates by region (%)

	1970	1990	2000	2015	2030
North Africa	34	61	90	98	99
Sub-Sahara	9	16	23	33	49
Africa	14	25	34	43	56
South Asia	17	32	41	53	66
Latin America	45	70	87	94	96
East Asia/China	30	56	87	94	96
Middle East	36	64	91	97	99
Dev. Countries	25	46	64	72	78
World	49	46	64	72	78

Source (IEA, 2002)

b) The need for huge amounts of financial resources to improve such a situation, and the great challenge that governments and development agencies have to face globally [A. Cabraal, M. Cosgrove and L. Shaeffer, 1996; O'Keefe, 1996]. O'Keefe page 12 states "The World Bank currently estimates the total energy investment needed in Africa by 2010 at US$ 110 billion, which is approximately the 1992 cost of the German reunification, or the total flow of all aid monies to the Third World in 1990. The World Bank has indicated that it can afford only 10% of investment, clearly indicating that private capital will need to finance a significant remainder", The International Energy Agency [IEA, 2002], page 380 states " over next three decades the investment needed for new power generation capacity in Developing countries will amount US$ 2.1 trillion – 10% in Africa and 15% in Asia, Even if that investment is secured over next 30 years, 1.4 billion people will still lack access toe electricity by 2030.

c) The uneven electricity growth of urban and rural electrification, [World Bank, 1996] shows that despite the fast growth of rural electrification coefficient (REC)

from 18% to 33% in that period and the apparently slow growth of urban electrification from 52% to 76%, if we count the number of new connections, the growth figures were the opposite, increasing from 320 to 1100 Million (3.5 times) in urban areas and from 340 to 820 Million (2.5 times) in rural areas.

Such an uneven progress in terms of access to electricity is due not only to the lack of financial resources in poor countries and/or to the "unwillingness" of governments to invest in rural energy, but also to the existence of important barriers that prevent the electrification progress [A. Cabraal, 1996], especially for rural areas. See chapter three about barriers

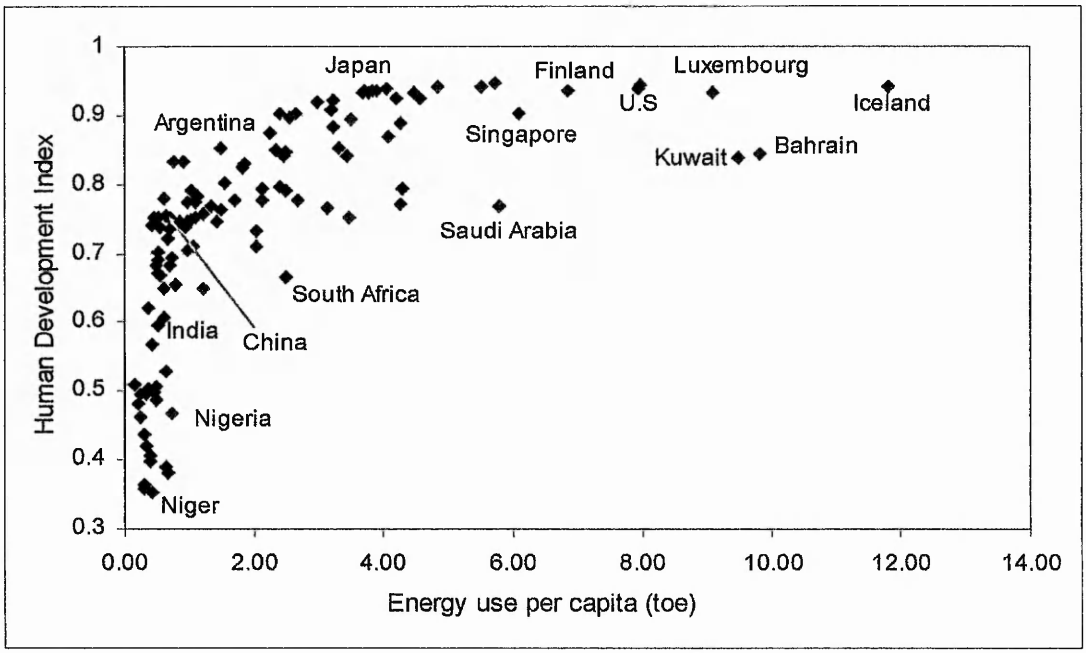
3.1.2 Energy needs and consumption in developing countries

According to literature, energy consumption is an important development indicator of the countries; the higher the average energy consumption per capita, generally the more developed the country is [UNDP, 2004; F. Sanchez Albavera and H. Altomonte 1997; Ambuj D. Sagar, Hongyan H. Oliver, and Ananth P. Chikkatur, 2006]; see figure 3.1. However the figures shown also confirm that energy consumption and development are not proportionate in linear terms to (HDI), especially for those countries with high human development index (HDI). This can be attributed to the fact that energy is used not only to generate income and development, but also for a variety of applications (industry, transport, heating, cooling, comfort, recreation and others). The weather conditions of the countries also influence energy consumption; developed countries with cold weather use energy for heating, whereas poor countries with cold weather cannot afford heating. The same occurs with energy for cooling in hot weather; but can also be attributed to the high capacity to purchase energy and inefficient use of it; [Garcia, 2006] shows that the high for some developed countries is associated to inefficient electricity consumption, in is article "An Introduction Linking Energy Use And Human Development" states: "electricity consumption not necessarily Given that HDI near 0.9 has been achieved with u near 3000 kWh/c, it is clear that untapped humane socio-economic efficiencies exist for countries that burn up more than 4000 kWh/c annually. Consider these examples of - high burners-"

UNDP statistics [UNDP, 2005] show how there are great difference in electricity consumption within countries around the world, while poorest countries electricity consumption is on tens of kWh/year; Ethiopia 32 kWh/year, Malawi 80kWh/year,

Burkina Faso 32kWh/year; those countries in transition are within the thousands of kWh/year, Brazil 2183, Colombia, 1190, China 1484 kWh/year, but developed electricity consumption is much higher, Norway 26640 kWh/year, USA 134456 kWh/year, UK 6614 kWh/year .

Fig 3.1 Energy consumption per capita vs. HDI (2002)



Source: [Ambuj D. Sagar, Hongyan H. Oliver, and Ananth P. Chikkatur, 2006]

Rural electrification researchers argue that rural families without access to electricity only need small amounts of energy to improve their quality of life and their income. In most cases such requirements may be limited to the provision of other basic services, like: lighting, schools with basic facilities for better education, lighting for health centres, vaccine preservation, food preservation, drinking water and others [Anna Tibaijuka, 2001; WEC, 1999; Robert van der Plas, 1997]; they also argue that small amounts of energy are required for transformation or preservation of products in isolated rural areas, among them: milling, packing, milk chilling, ice making, wood transformation, textiles, and others [World Bank 1998; N.P.A Smith 1994 NRECA 2001]

There is evidence that in rural areas of developing countries, the energy consumption hardly exceeds 30 kWh to 50 kWh per month [CER-UNI, 1998; N.P.A.

Smith 1994; UNDP, 2001], World Bank; and ITDG experience in Peru [World Bank, 2001] shows that in isolated rural villages in Peru, about 60% of the households hardly exceed 20kWh to 30 kWh per month; [T. Vorvate, D Barnes, 2000] shows that during the first year of the rural electrification programme in Thailand, the average energy consumption was between 11 to 22 kWh/monthly, and after 5 years it rose to 22 to 50KWh/monthly depending on the different villages; The World Energy Council [WEC, 2000] page 161 referring to the challenge of Rural Energy, states "It is calculated that an amount of energy roughly equivalent to 7% of the world's electricity production today could cover basic human needs. In an age of apparently advanced technological and management skills, we failed in this relatively modest challenge".

Besides the small amounts of energy (per capita) required, another important characteristic of the demand for rural electrification is the widespread nature of consumers, as most rural people live in small villages, communities or settlements spread over large areas of a country. This fact makes it difficult and expensive to gain access to commercial energy services, among them access to the national electricity grid.

3.1.3 Rural energy options

Although electricity generation in the world started with small scale power generating plants, the urbanisation process, industrial development, the fast development of power-generating technologies, the economics of scale, among other factors, have preferred the effectiveness of large and centralised power generating schemes to supply the world's electricity needs through large grids. Unfortunately, the great majority of rural people cannot access those grids.

Small stand alone energy schemes have been suggested as appropriate options to meet rural energy needs, especially those based on renewable energy schemes, solar photovoltaic systems (PV), small wind electricity generators, small hydro; biomass; and small diesel sets (when convenient) [ITDG-Peru, 2002; NRECA, 2001; N.P.A Smith 1994; D. Barnes and G. Foley, 2004]. This suggestion was based on their appropriateness for small and decentralised energy generation in terms of: low generating costs, the use of local resources, the feasibility of sizing plants according to needs, the feasibility of local management and the participation of local people in the selection of energy alternatives. Small diesel sets have been playing an

important role in providing rural villages with access to electricity; however this technology has proved to be demanding in terms of the financial resources required from the communities to purchase fuel and acquire specialised maintenance skills, which generally rural villagers cannot afford.

It is worth emphasising that the main driving force behind the development of renewable energy technologies in the world has not been rural electrification, but the need for alternatives to overcome the energy crisis (late 1960s and early 1970s) and, since the 1980s, alternatives to reduce or prevent Green House Gas (GHG), to save the planet from the greenhouse effect. The abatement of GHG has been a very strong driving force of implementation in developed countries, especially during the last decade, reaching important figures. In fact, despite their high costs[1] and, therefore, difficult competitiveness with other power generating technologies, the figures reflect important progress. The wind installed capacity rose from about 5000MW in 1995 to 28,000 MW in 2001 [Paul Gipe, 2002], while PV increased from about 0.1MWp in 1995 to about 1.5 MWp in 2001 (in both cases there was a growth of around 25% a year during the 1990s).

Although energy statistics hardly show the contribution of renewable energies as electricity suppliers in the energy balances of developing countries (apart from hydro energy), it is important to mention that these sources of energy have been contributing to the provision of energy to millions of people in developing countries. [N. Smith, A Harvey, S. Kapali, D. Upadhyaya, 1998], page 47, in "Renewables at Work in the Developing World", shows the following figures regarding the use of these energy sources for electricity in developing countries: More than one million solar home systems; among them, 150,000 in Kenya, 100,000 in China, 85,000 in Zimbabwe, 60,000 in Indonesia and 40,000 in Mexico. Around 150,000 PV and wind systems are being used for health clinics, schools and other communal buildings; over 45,000 small hydro schemes are being used in China, providing electricity to more than 50 million people; over 100,000 families in Vietnam use very small water turbines to generate electricity from hydro schemes; more than 50,000 small wind turbines provide electricity in remote rural areas around the world.

[1] According to [IEA, 2001], wind turbines have achieved power-generating costs as low as 4 US cents per kWh and solar PVs as low as 10 US cents per kWh for grid connected systems, at 2001.

According to information from GEF- Global Environment Facility - this organisation has provided more than 1 billion US$ for more than 270 changing climate-related projects in 120 countries in the past decade [Eric Martinot and Ramesh Ramankutty, 2002]. The GEF projects fall into two categories, "barrier removal" projects to develop and promote markets for commercial or near-commercial technologies, and "cost-reduction" projects which conduct research, demonstration and marketing activities to lower long-term technology costs.

3.2 Rural electrification in Latin America

3.2.1 The electricity sector in Latin America.

By 1950, most of the electricity sectors in Latin American and Caribbean countries were privately owned, supplying energy to the most important towns and productive activities, with limited regulation. During the 1950s and 1960s a wave of nationalisation was prompted by two main ideas, the first being to reduce the intervention of foreign companies as much as possible, and the second to keep control over a strategic force to boost economic and social development programmes for the majorities [OLADE & World Bank, 1991; OLADE, 1991].

The oil crises of the late 1960s and early 1970s forced the governments to invest important amounts of money in the sector so as to be self-sufficient, however those investments significantly increased the national debt. During the first half of the 1970s, the national electricity companies complied with the payment of their debts, however the poor management of such companies seriously affected the financial situation of the sector, so that during the second half of the following decade, the electricity government had serious difficulties in meeting their financial obligations.

Nevertheless, the poor economic performance of the sector was not only due to the poor management of the state companies, but also to the political intervention of the governments. The most important problems faced by the sector included poor planning, long project implementation periods, high overspending in implementation, poor administration, low tariffs (much lower than production costs), the lack of funds for new investments and difficulties in adjusting tariffs due to social and political pressures [F. Sanchez Albavera y H. Altomonte, 1997].

3.2.2 Structural reforms of the sector in Latin America

Given the poor results of the nationalisation experiment and the successful sector reforms in other regions, the LAC countries opted for important reforms during the 1990s, with the exception of Chile which started earlier, publishing a sector reform law in 1982 to restructure the energy sector, initially keeping the property in the hands of the state, and then intensifying the changes to market forces. However, the bulk of sector reforms in LAC countries occurred during the 1990s: Argentina (1992), Peru (1993), Bolivia and Colombia (1994), Guatemala (1996), Panama and El Salvador (1997), and Nicaragua (1998) [Mentor Poveda, 2004].

The private sector responded positively with large foreign investments and, consequently, increasing electricity generation, power transmission and the distribution of assets, hence the important growth of electrification coefficients in most countries; in some cases like Argentina and Chile, the market was saturated with power generating activities. Mr Mark Croke, Senior Vice-President for Europe and the Americas of the company "El Paso Energy International" stated on page 24. "The best electricity market in Latin America is Brazil, because it is a large and growing market; but it will change within 3 to 4 years, when the energy market is saturated, as occurred in Argentina and Chile with the open market regime" [Mark Croke, 2000]

Fig 3.2 Per capita energy consumption in Latin American Countries (kWh)

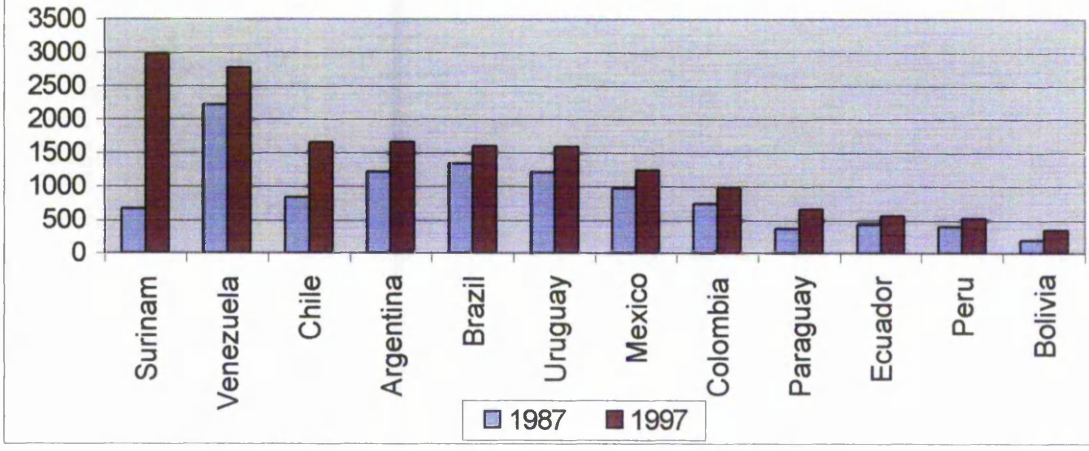


Figure 3.2, shows the per capita electricity consumption for different years, before and after the reforms; [Consejo Nacional del Ambiente, 2001]; the changes are important and at least in part attributable to the structural reforms. The greatest changes were in Chile and Surinam.

The successful energy sector reforms in LAC have had an important impact in the sector, improving quality and efficiency, securing investment, increasing the energy supply and reducing tariffs [OLADE 1999]. After the successful restructuring of the market, the present energy policies in Latin America are becoming more favourable and proactive to regional integration, particularly as far as the electricity and gas markets are concerned. The integration process is starting by sub-regions and is likely to continue so: MERCOSUR (The common Market of Brazil, Argentina and Paraguay) plus Bolivia and Chile, Central America and the sub-region of Andean Countries [OLADE, 1999]. In fact, Latin American leaders have been consistently expressing their interest in integration and OLADE is one of the most important and enthusiastic promoters of regional integration.

The total installed capacity of electricity in the region has been as follows: 39 159MW by 1970, 92 578MW by 1980, 120 713 MW by 1985 and 154 023 MW by 1988 [OLADE, 1991]. Certainly in all the countries there are active efforts to discover ways of accelerating the rural electrification process, considering different energy alternatives and the sustainability of the schemes.

3.2.3 Rural electrification in Latin America in the 1970s and 1980s

Table 3.1 shows that during the 1970s and 1980s, access to electricity in this continent enjoyed an important growth, at a faster rate than in other regions of the world. However the structural reforms of the 1990s did not have a positive impact on the rural electrification sector. Rural electrification is not yet a profitable business to attract private investment among other reasons, because a number of facts such as: high initial investment needed to connect to users due to the low population density in rural, low cash income of rural families hence low capacity to pay, families in rural areas are not used to do regular monthly payments as required for electricity services. Therefore governments are now trying alternative ways to provide access to the poor in rural areas mainly through subsidies, see section 3.2.4.

Table 3.2, which contain estimates made by OLADE[2] show the disparities between countries, while rural people in Argentina, Mexico, Chile and Costa Rica had high access to electricity, others in Honduras, Bolivia and Peru had a limited access to

[2] Although the data are for different years, most of them are for the late 1990s, except for Argentina and Cuba which were for 1993.

electricity in rural areas. Table 3.2 also confirms that, like in other regions, the relative development of the countries is related to the degree of access to electricity.

Table 3.2 Rural electrification coefficients (REC) in Latin America and Caribbean Countries

Country	Rural electrification coefficient (%)	Year	GNP per capita US$, 1999*
Argentina	65	1993	7600
Barbados	NA		
Bolivia	22.3	2000	1010
Brazil	72	1999	3240
Chile	75.7	1999	4740
Colombia	51	1999	2250
Costa Rica	84.8	1997	2740
Cuba	60	1993	
Ecuador	53.6	1998	1310
El Salvador	61.0	2004	1900
Grenada	NA	-	
Guatemala	56.1	2,004	1160
Guyana	NA	-	
Haiti	NA	-	460
Honduras	33	2,000	760
Jamaica	NA	-	2330
Mexico	82.9	2000	4,400
Nicaragua	40.0	2004	430
Panama	58.0	2004	3070
Paraguay	NA	-	1580
Peru	30	1999	2390
Dominican Republic	61	1997	1910
Surinam	NA	-	
Trinidad & Tobago	NA	-	
Uruguay	74	1996	5900
Venezuela	73	1999	3670

NA, means not available. Source: The Energy Economy Information System, [OLADE, 2002], *[Wold Bank, 2000]

3.2.4 Present rural electrification strategies in Latin America

New strategies and/or legal frameworks are being established in different countries of the region to accelerate the rural electrification process. In all cases, there is a clear awareness of the need for government intervention with subsidies; few models have been used for this purpose, among the most known are the following two models.

a) Government subsidy plus private investment. - The government provides clear subsidies and promotes competitive private investment to complement the production and/or running costs. Private investment is chosen by government, based on the lowest production cost, preserving quality and reliability. Such are the cases of Chile, Argentina [Fabris, 2000] and Panama. Under this model, the governments are in charge of the project execution

b) Rural electrification subsidies through local authorities. - The government provides the subsidies to local authorities, who decide about complementary funds and have full responsibility for the implementation; the funds should be completed with co-funding resources from private and/or public funds. This model has been developed and is under implementation in Bolivia, where the subsidies are based on the number of people living in the area [C. Rios, 1997]. In the case of Bolivia, this implementation model is complemented by the "Decentralisation Law" and the "Electricity Law". According to NRECA, this is a difficult model because it often requires co-funds and/or good co-ordination within communities in order to implement common schemes with a shared investment [NRECA, 2001].

c) Government programmes with clear access targets, such as the case of Brazil, where the government is committed to provide access to all by the end of 2008; in this case the government has a clear commitment to invest what it is needed to ensure its achievement, the investment includes not only capital for the equipment and the installation but also includes funds for social mobilization and for productive use of energy.

3.2.5 Use of stand alone systems for rural electrification in Latin America

During the last decades, rural electrification in Latin America has been implemented mainly by grid extension and diesel sets, and to a lesser extent by the installation of

small hydro schemes; in the last decade, pilot projects with solar PV and wind systems were introduced.

OALADE[3] (The Latin American Organisation for Energy Development) was created with a mandate to look after the regional policies of the sector. During the 1970s and 1980s, this organisation made significant efforts to develop and promote renewable energies, and to build the regional capacity for need assessment, design of energy systems and implementation of renewable energy projects. Although the aim was not specifically to promote renewable energy technologies for rural electrification, it helped build the local regional capacity in the field of micro hydro, wind, solar energy, and bio-gas. Such efforts were complemented with specific country efforts. Such was the case in Argentina through the National Aerospace Institute, in Peru through ITINTEC, in Mexico through The National Institute of Electricity of Mexico, ELECTROBRAS in Brazil, and other research and technology development institutions in the different countries.

Since the late 1970s (with more emphasis during the 1980s and 1990s) there have been important bilateral co-operation Programmes aimed at local capacity-building, among them: The GTZ Programmes to promote micro hydro energy; PESENCA (Programa Especial de Energía para la Costa Atlántica)[4] in Colombia and PROMIDEHC (Programa de Desaarollo de Microcentrales Hidroelectricas) in Peru; Programme for the Promotion of Renewable Energies (PROPER) in Bolivia, the ITDG-Peru Energy Programme to promote small hydro (1985 to 1995) and to promote renewable energies in Latin America from 1995 onwards.

The above-mentioned programmes and others, helped build the regional capacity. At present, there is an important capacity to design, manufacture and install stand alone renewable energy schemes. However, the contribution of renewable energies is still insignificant in national energy statistics. Except for large hydro schemes (which are considered a conventional source of energy), the use of renewable energies is negligible.

[3] OLADE is funded by the governments of Latin American and Caribbean Countries; its headquarters are in Quito Ecuador.
[4] PESENCA (Special Energy Programme for the Atlantic Coast), PROMHIDEC (Micro hydro energy Schemes Programme)

Despite the high cost, grid connection continues to be considered an important rural electrification alternative. Examples of grid connection costs [P. Gipe, 2002]: In Brazil, the World Bank shows costs ranging from US$ 1000 to US$ 5000 per family for small clusters of rural households of between 20 to 60 families for distances between 2 km to 10km of rural electrification. The Ministry of Energy and Mines in Peru reports costs above US$ 1300 per family for grid connection.

Nevertheless, it is important to mention that the efforts made during the last decade and the projects for the immediate future are trying to introduce more and more stand alone schemes for rural electrification. Examples of these are: Project BRA/00/015 of Electrobras (Brazil) [Reihard Haas, 2002], which is preparing the baseline for the electrification of 1 million households (5 million people) with solar PV in the States of Bahia, Caera and Minas Gerias in the North East of Brazil, which will mean an important step towards the expected access for all - 25 million people without electricity in 2004 [WBCSD, 2004]. The concession in the state of Jujuy in Argentina, where a private company was awarded the concession to provide electricity based on a mix of stand alone renewable energies, grid and small diesel sets, this concession is to provide electricity to 100% of the region of Jujuy[5], while the rest of the country is trying to connect using the conventional ways.; the GEF Project in Peru for 12,000 solar PV in the Amazon region[6], started in year 1999, and have not installed a unit by the end of 2005[7]; the 43MW small hydro project in Guatemala, which will be funded by the Carbon Finance Unit of the World Bank will increase the country's hydro installed capacity in about 5%; the renewable energies convention in Nicaragua for the rural electrification of the country, and others.

The main driving forces behind the introduction of stand alone renewable energies for rural electrification are the lower cost per household (in most cases) than grid connection, the use of local resources and the possibility of local management and community participation in their implementation.

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[5]Jujuy is one of the 24 regions of Argentine (Districts) and covers about 1/40th of the area of the country.

[6]This project has experienced several delays, so far no PV system has been implemented, and the activities have been limited to information gathering, planning and preparation of the Solar Radiation Map.

[7]This project has have great difficulties of implementation, the activities done so far has been on evaluation of solar resources, its slow progress could be attributed mainly to the poor planning of UNDP and lack of commitment of the "regional governments where the beneficiaries are"

Like in other parts of the world, most technologies are well known, some of them like small hydro or bio-gas plants can be manufactured and installed by regional or country's capacity, however they are still not playing an important role in rural electrification due to important barriers which prevent their wide dissemination.

3.3 The energy situation in Peru

3.3.1 Energy resources

The proven reserves of conventional sources of energy in Peru in 1999 were as shown in table 3.3 (the hydro energy reserve has been calculated considering that all the existing assets installed will function for 50 years). At present about 30% of the fuel oil is imported from different countries; also the proven oil reserves are estimated to last for only 10 years if its exploitation continues at the same intensity; the exploitation of natural gas started in 2004 with the construction of a gas pipeline from Camisea (in the Amazon Area in Cusco) to other parts to Lima and closer towns in the south. It is also expected to improve the trade balance of fossil fuels by introducing Liquid Natural Gas (from Camisea) as a substitute for diesel oil for transport purposes. Coal is used in very small proportion and there are no projects based on this resource for the near future [MEM, 2002].

Table 3.3 Energy resources in Peru

Source	Proven reserves (TJ)	Structure (%)
Natural Gas	8511512	38.93%
Liquid of Natural gas	3074222	14.06%
Hydro energy[8]*	5965666	27.29%
Mineral coal	1638917	7.50%
Oil	1793735	8.20%
Uranium	878639	4.02%
Total	21862691	100.00%

Source, [MEM, 2000]

Regarding non-conventional energy resources, according to a recent evaluation [MEM, 2002], there are good solar radiation systems in most parts of the country, ranging from as low as 3.5 kWh/m2/day in some areas of the Amazon region and on

[8]The technically feasible hydro potential is more than 60,000MW [MEM, 2001], the value included in the table above considers the total energy likely to be produced with current assets functioning.

the Pacific Coast to as high as 6.5 kWh/m2/day in some high southern Andean areas (such as in Puno, Arequipa and others); two sites with proven average wind speeds of over 7 m/s (Chicama and Marcona both on the Pacific Coast) have been identified; moderate wind speeds exist all along the Pacific Coast, which are very useful for small power generating systems; there are abundant biomass resources, especially in the Amazon region, and an estimated potential of about 3000 MW of Geothermal energy. Most of the inter-Andean Valleys have a variety of small rivers, and Andes-Coast and Andes-Jungle transition areas also have important hydro resources.

3.3.2 Development of the electricity sector in Peru

The development of the electricity business can be split into four different periods, with different policies and regulations:

3.3.2.1 From 1882 to 1921- absence of the State (starting period)

This period can be identified as the introductory period of the electricity business in Peru, during which the electricity business developed in a completely free environment and without state intervention. The first electricity generating plant was installed in a mining camp in "Tarijas", completed in 1884. Other small systems to supply power to private businesses as well as for public services became a new and attractive activity which attracted the attention of entrepreneurs willing to invest in and develop the sector.

The first public service facilities were installed in 1882, when representatives of a private foreign company called "Peruvian Electric Construction and Electric Supply Company" approached the government to request permission to generate electricity to provide lighting for Lima [A. Wolfenson, 1980][9]. Commissioning a 500 hp (0.4 MW) steam electricity system in 1886, this installation became the milestone of the electricity sector in Peru. Electricity arrived in Lima as an incipient but prosperous small industry and prompted a quick urbanisation process [A. Wolfenson, 1980]; subsequently, other important towns obtained electricity.

Electricity became an attractive business. In 1910 the main power-generating enterprise "Empresa Eléctrica de Santa Rosa" and three others (linked to the electric

[9] Prior to the arrival of electricity, public lighting in Lima, Peru's capital city, had been based on gas since 1855.

railway) in Lima and Callao [G. Bonfiglio 1997], merged together to form the "Empresas Electricas Asociadas (EE.EE.AA)", increasing their capital with own resources and foreign funds.

3.3.2.2 From early 1920s to early 1970s - Government regulator

In 1921, the current President (Leguia) considered it important to modernise the sector and awarded the concession of the electricity market in Lima to EE.EE.AA[10]. He also submitted a law to Parliament to regulate the use of water for power generating purposes, ordered the necessary registration of the electricity schemes in the Ministry of Public Works and established the obligation to pay taxes [ITDG-Peru, 1992]

During the late 1920s and early 1930s, foreign investments played an important role in the electricity business, helping overcome the crisis of the sector, which was mainly affected by the world crisis of that time [G. Bonfiglio, 1997]. The most important investors were the Italian Bank and Swiss Companies, thanks to whom a few new power plants were installed during the coming years, thus boosting the exiting service in the country's main cities. Several small electricity schemes were also installed in various towns in the country during that period, all on a private basis.

In 1955 the "Electricity Industry" law (12318) was issued. It established the State's role as regulator and promoter of the electricity business [EE EE AA, 1966]. As a result of this law, the national installed plant capacity increased considerably, basically to meet large concentrated demands. In 1957, electricity entrepreneurs formed an association called "Association of Electricity Producers", which lasted until the early 1970s when drastic changes took place in the sector. This association helped strengthen the sector by improving management and planning capabilities.

In 1956 the government considered it important to have a wider vision of national electricity needs; therefore it hired the company "The Electricité de France" to draw up a "National Electrification Plan" in conjunction with the "Association of Electricity suppliers". That task was completed in 1957, recommending the decentralisation of electricity generation, so that 9 regional enterprises would cover 12 of the most important departments of the country; and the others left as independent "Departments". The idea behind this was that electricity should be the driving force

[10] Lima had a plant capacity of 18MW at that time

behind the development of the country and, therefore, power plants should be situated close to the demand [Ministerio de Fomento y Obras Publicas, 1957]. The plan also considered long term interconnections between regions, which resulted in a consistent growth of the supply during the following 15 years. By 1965, the national installed capacity was 1318 MW, and by 1971 it was around 1700 MW. The first government initiatives to provide electricity to rural communities were also made during this period (see rural electrification).

3.3.2.3 From 1972 to the early 1990s - Government intervention, central planning (State Ownership)

In 1972, law 19521 created a big change, incorporating ELECTROPERU (The State Electricity Company)[11] with the following functions: planning, project designing, construction, supervision, project executions, technical assistance and energy research. The vision was to extend the electricity services according to the development needs of the country, since prior to that, the attention was focused on large and concentrated needs [Ana Maria Velazquez, 1993].

During the first half of the 1970s there was an important investment in the sector, especially in generation, adding 798 MW to the national capacity; however, during the second half of that decade, the growth rate slowed down. By the end of the decade, the financial situation of ELECTROPERU was poor due to the lack of capital and the inappropriate tariff systems [OLADE & Wold Bank, 1991; Sanchez Albavera 1997], as well as the electricity company's debt which increased the national debt significantly. It is estimated that investments in the electricity business during 1968-1980 was: 76% in generation, 10% in transmission and 14% in distribution [Ana Maria Velazquez 1993].

During the 1980s, attempts were made to promote private investment in the electricity sector, to which end the new "General Law for Electricity"[12] was approved in 1982 (law No 23406). Its main aim was to promote private investment in the sector, although in practice the result was the strengthening of the State's role [ITDG-Peru, 2002], this ref. in page 23 states "the law did not expressly establish that

[11] In 1968 the Army seized power though a military coup, implementing pro-Communist polices and reforms in all productive and social sectors. Then the state became the owner of all production and services companies throughout the country.
[12] When the "General Electricity Act" was issued in 1982, law No 12378 of 1955 was eliminated, as was law 19521 and other legal standards governing the sector.

the electricity sector was reserved for the state, however it consolidated the activity as a state responsibility, although it established more situations for private investment, the scope of it remained under state domain". This law created the concept of the "Master Electricity Plan" as the sector's most important planning tool, aimed at having short, medium and long terms plans.

The performance of the electricity business during the 1980s remained constant, among other reasons because of the lack of capital from the state and the private sector's lack of interest in investing in the electricity business; hence the slow increase in capacity. Moreover, the regionalisation[13] did not help improve the sector's performance [Ana Maria Velazquez, 1993], because the law had not clearly defined the responsibilities of ELECTROPERU and of regional enterprises, among other reasons, resulting in duplicity of efforts in most cases.

By end of the 1989s the sector confronted a severe crisis, in addition to the economic and social crises the country was facing[14]. By 1986, the total installed capacity was 3872.9 MW, of which 1249.5MW (269.9MW hydro and 979.5MW fossil fuel) were owned by self-suppliers and 2623.4MW (1947.7MW hydro 675.7 MW fossil fuel) was state owned [A. Wolfenson, 1980], however an important part of the assets were not operating due to the lack of proper maintenance.

3.3.2.4 From 1992 onwards - Deregulation and utility concessions period

The most relevant event of that decade was the "Concessions Law " issued in late 1992 and complemented with accessory legal standards by early 1993. Subsequently, other legal standards were issued to complete the regulatory framework, in particular that which created OSINERG (The National Regulatory Body for the Energy Sector) in 1997 to supervise investments in the sector and COES (System Operating Committee) in charge of operating the interface system and making adjustments to the legal aspects of the Tariffs Commission.

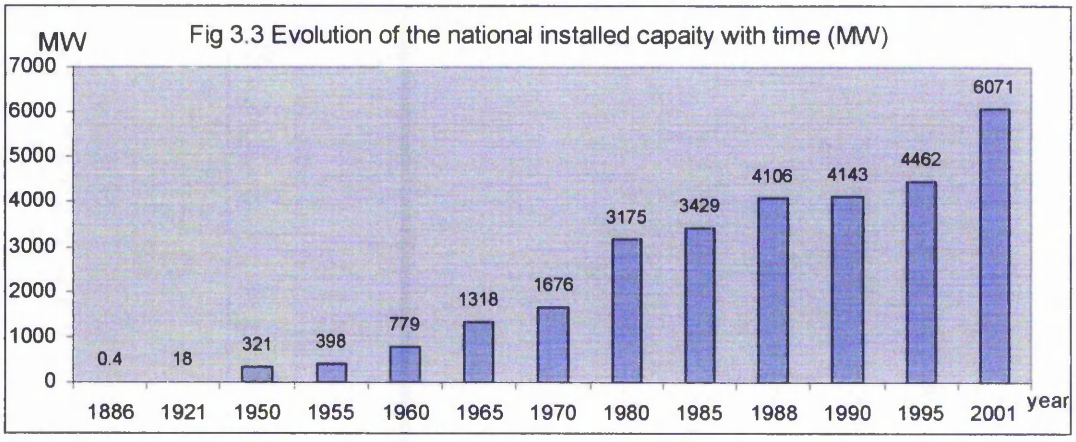
By 1994 ELECTROLIMA, the state Utility for Lima was privatised and split into two: ELDELNOR and Luz Del Sur. By 1995 the first regional concession was awarded (Electrosur medio), and in 1996 a national investment group GLORIA was awarded

[13] During the 1980s the country was divided into 13 geographically and political independent regions, a process that was reversed early in the 1990's.
[14] At the end of the 1980s there was a severe recession in all sectors and the inflation was the highest in history, with four digits a year.

the concession of another 4 regional utilities (HIDRANDINA, ELECTRONORTE, ELECTRONOTE- ESTE, AND ELECTRO- CENTRO); the intention was to continue the privatisation, however it was not possible to award any other concession, mainly because of social pressures on the one hand (to stop privatisation), but also due to the poor performance of regional electricity service companies on the other hand.

At present ELECTROPERU is still responsible for the operation and maintenance of the assets remaining in State hands (mainly transmission and a small part of generation), while the operation of the new assets implemented during the decade was assigned to ADINELSA which was created in 1998 to administrate such assets, and later transferred to definitive owners and/or administrators.

Fig 3.3 Evolution of the national installed capaity with time (MW)



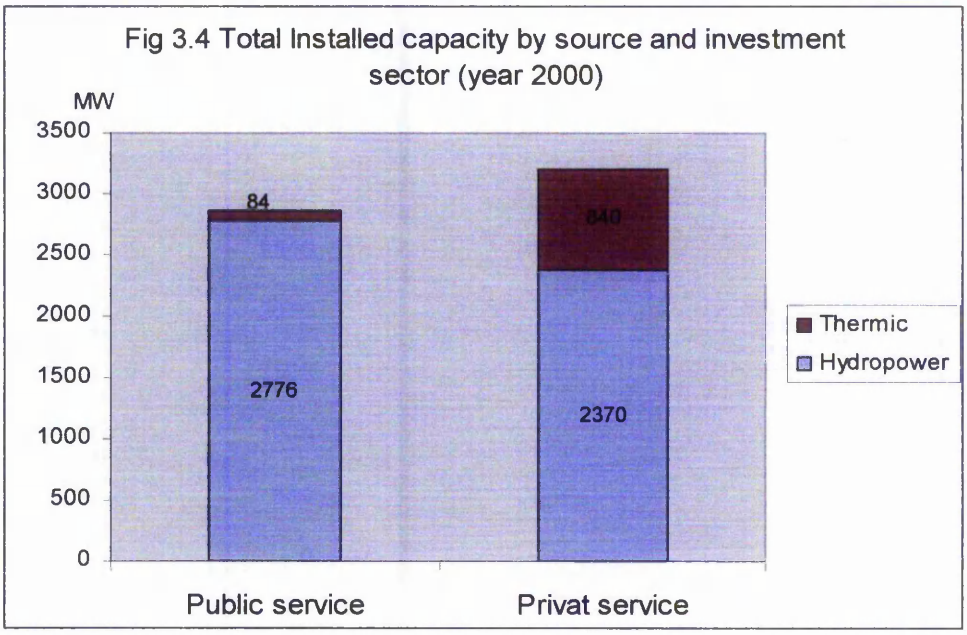
In 2000 the Gloria Group gave up the concessions. No information was made public regarding the actual reasons, however it is understood that the company was unable to meet the investment commitments signed in the contract. The present government is trying to promote new privatisations without success, mainly due to the strong public opposition of to privatisation and the politics involved. Those against privatisation argue about the possible high cost of energy for users and the transfer of national infrastructure to foreign hands.

3.3.3 Installed capacity by sectors and type of resources

The electricity plant capacity by early 2001 [MEM, 2001] was 6070.5 MW, nearly 47% based on hydro hydraulic resources and 53% based on fossil fuels (mainly oil, but with a small share of natural gas and coal). This capacity is largely used in public services (the grid) and only 924 MW for private services (self suppliers). Most of the

power generating capacity of the private sector is based on fossil fuels; whereas the public service sector has slightly more hydro capacity installed than fossil fuels, see figure 3.4.

Fig 3.4 Total Installed capacity by source and investment sector (year 2000)



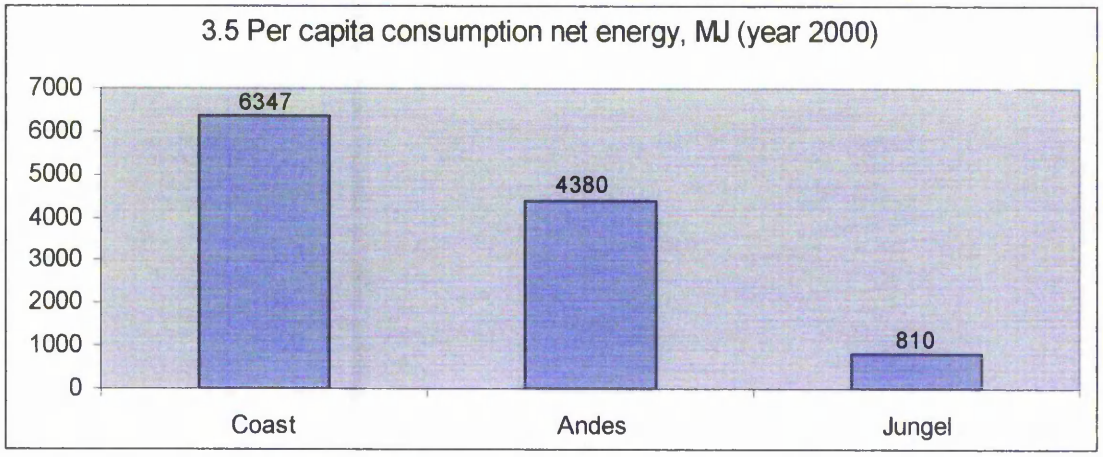
The lower capacity of self suppliers between 1986 and 2001 is explained mainly by two facts: on the one hand the extreme violence in the country during the 1980 – 1992 period, when private investment in all the sectors declined; and on the other hand, the success of the reforms that increased the national supply capacity through the grid.

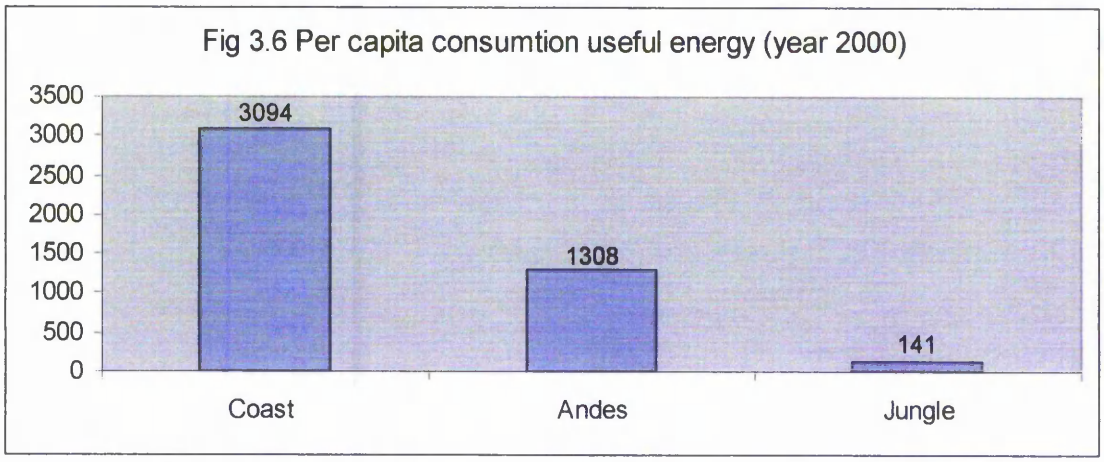
3.3.4 Per capita energy consumption

As shown in fig 3.5, the per capita energy consumption of net energy on the Coast is about 50% greater than that in the Andes and 5.5 times greater than in the jungle. However, the difference between regions is much more dramatic in terms of useful energy (see fig 3.6); in fact, the per capita consumption of useful energy on the Coast is 2.4 times that of the Andes and almost 22 times that of the Jungle. Some factors contributing to the pointed out inequalities (for both net and useful energy)[15] are:

[15] Net energy is the total energy consumed, useful energy is the fraction of net energy used effectively for the benefit of users (MEM, 2001)

- The better energy infrastructure in the Coast compared to the other two regions; for example, the grid lies mainly along the Coast, with only small branches penetrating to the Andes and there is no grid at all in the Amazon region.
- The better access to modern energy sources in the Coast (Electricity, LPG and kerosene), whereas the Andes and Amazon regions are more dependent upon wood and other biomass resources.
- The more limited access to commercial sources in the Andes and Amazon regions is a consequence of the widespread nature of the population, the lack of transport facilities and the centralisation of industry and other services in the Coast.
- The higher average per capita income of the population in the Coast.





3.3.5 Electrification coefficients by departments (regions)[16]

In Peru, access to electricity by regions is largely uneven, as can be appreciated in the following map drawn with the data available from [MEM, 2001]. While in some departments the electrification coefficient is high, like in Lima, Arequipa, Tacna and Tumbes; in others like Cajamarca, Amazonas and Huanuco it is very low, see figure 3.7; the main reasons for low electricity coefficient in some departments are:

- Distance from the national grid.- The departments located along the Coastal Region have benefited the most, because the grid lies mainly along the this region; for example, in Lima, Arequipa, Moquegua, Tacna and others.
- The degree of urbanisation. -The departments with a high proportion of urban population, such as Lima, Tacna, Ica, and others, have reached a higher electrification coefficient. This is mainly because of the financial considerations of government implementation agencies in the past and the profitability required by the present utilities.
- Centralisation. – Most of the commercial and industrial activities in Peru are located along the Coast (in towns alongside the Pacific Ocean), due to their privileged location for easy transportation for export purposes, among other reasons.
- Access to transport and other means of communication – The most important road in the country follows an extreme north to extreme south direction all along the Coast including Lima (the capital city).

Government policy. - The strategy of the last 12 years has been basically to invest in grid extension, starting from densely populated areas initially and then less densely populated areas and from easy to more difficult areas (in geographical terms), in other words from cheap to expensive connections. According to people from the MEM[17], the current cost for each new connection to the grid ranges from US$1300 to US$ 1500; consequently, the government is now looking at other rural electrification alternatives to complement the investment in grid extension work.

[16] The rural electrification coefficient is equal to the percentage of rural people with access to electricity in rural areas.

[17] Conference for Electricity markets in Peru held the 29th and 30Th of March 2001 in Lima

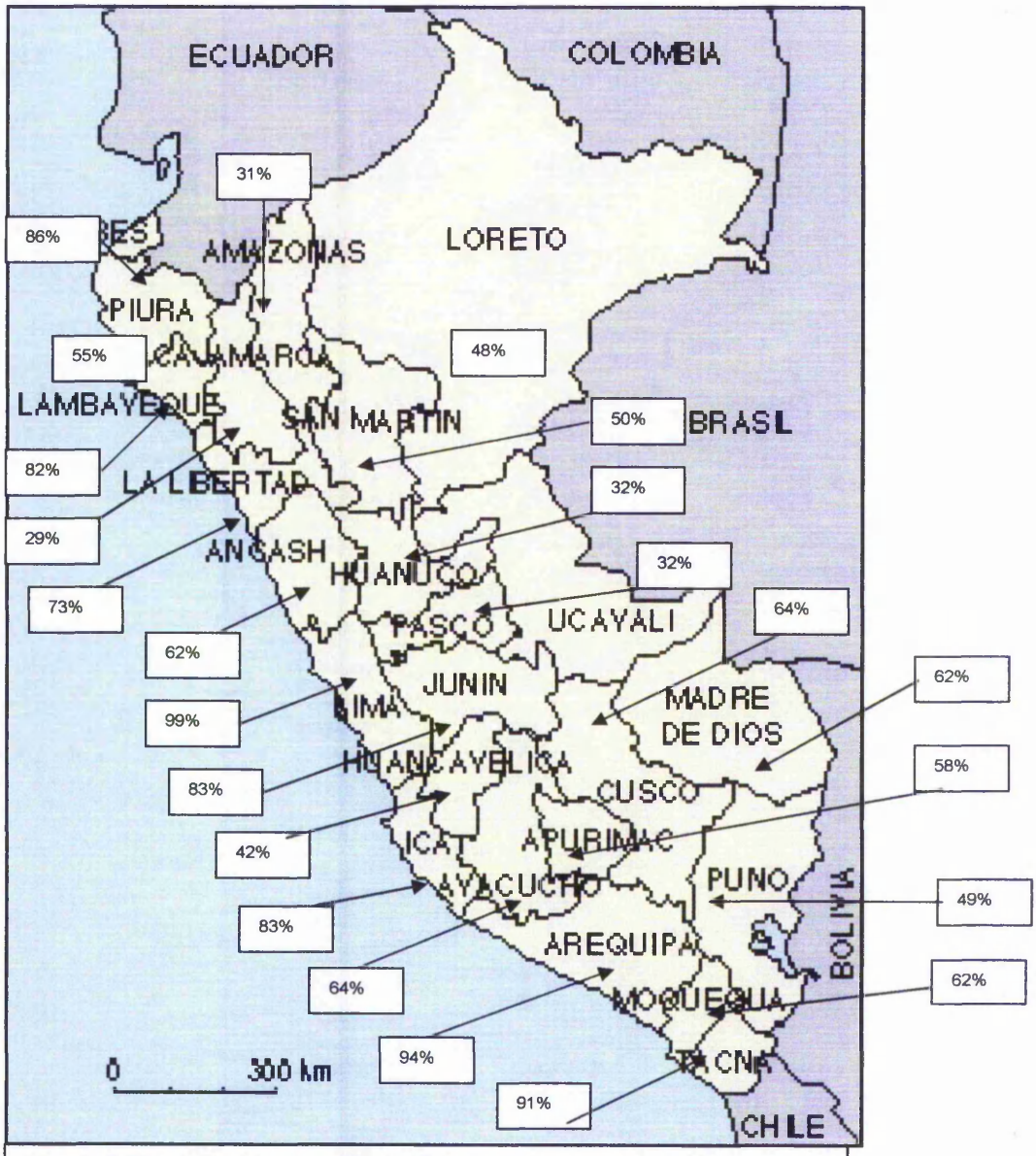


Fig. 3.7 Electrification coefficients by region (department)
Source [INEI, 1999; MEM, 2001]

3.4 Rural electrification

3.4.1 Development of rural electrification

The use of mechanical power from small hydro resources began with the arrival of the Spaniards back in the XV century, mainly for milling corn and other cereals, and later for the transformation other products, like crushing sugar cane, sawing and others [Manuel Glave, 1988].

Since the introduction of the electricity in Peru back in 1882 until the 1960s, there was a complete absence of the state and/or government in the field of rural electrification, however several plants were installed on a private basis, mostly associated to agricultural transformation, mining and lighting, mainly by Landlords or by Mining companies. However, it should be pointed out that during this period, very few small towns obtained electricity due to political influence of members of Parliament or high ranking government officials.

It was only in 1966 when a proper rural electrification project was implemented by the government, with financial assistance from the USA Government through the IAD (International Energy Agency). The objective of the project was to extend the grid to 63 communities in the Mantaro valley (in the central Andes). That project was finished and connected to users by 1972.

Between the early 1970s and early 1990s, when the electricity sector was under the full control of the government, rural electrification was considered a priority for the country, and small hydro energy was considered the most important option for isolated energy schemes. In 1976, ELECTROPERU created the "Jefatura de Electrificación Rural" (The Rural Electrification Division), an office in charge of extending electricity services to new markets, especially to rural areas; the first results of the efforts made by this office were achieved during 1979 and 1981, when10 rural electrification schemes were commissioned [Carrasco, 1989], adding 1.005 MW to the total power capacity of the existing isolated energy schemes.

When the "Ley General de Electricidad No 23406" (General Electricity Act)[18] was issued in 1982, the concept of the "Master Electricity Plan" and the "Annual Programme for Provincial, District and Rural Electrification[19] were introduced; subsequently, other policy instruments were issued, such as Supreme Government Resolution (Supreme resolution) 163 in 1983, creating a special 25% tax for a consumption in excess of 160kWh per month. The funds would be used to extend the electricity services to new consumers (expected to be mainly for rural sectors).

[18] When the "General Electricity Act" was issued in 1982, law No 12378 of 1955 was eliminated, as was law 19521 and other legal standards governing the sector.
[19] The order of importance of the geographical and political division is: Department, Province, District and "centro poblado" (town).

The strategy of EECTROPERU to reach isolated areas and towns (law 23406), was to provide electricity to clusters of small towns called the "Pequeños Sistems Electricos-PSE" (Small Electric Systems). By mid 1980´s an important rural electrification plan was developed, among the most important considerations was the investment of up to US$ 366 million during the 1985 to 1991 period; the funds for that plan were expected to come from three sources: from the implementation of the Government Supreme Resolution 163, the central government budget and international co-operation.

The first specific plan 1985-1991 to be implemented considered 97 PSE (reaching 220 small towns) and 149 installations for isolated towns [Carrasco, 1989]. The most benefited regions were expected to be Ancash and Cusco in the south and Cajamarca, Lima and Ancash in the central and northern parts of the country. However the results of the implementation of this programme were very poor; the total investment was only US$ 95 Million executed during the first three years (1985 to 1988); after that period the programme was stopped because it was impossible to raise any more funds, among other reasons due to the country's severe economic crisis and the terrorist activities of "Sendero Luminoso".

In June 1992, the government created the Social Interest Development Fund (FODEIS-Fondo de Desarrollo de Interes Social) [ITDG-Peru, 2002; A. Velazquez, 1993], aimed at extending electricity services to the poorest areas in the country. In May 1993 the "Direccion Ejecutiva de Proyectos (DEP)" was created an autonomous body with the power to execute government projects; project funds were meant to come from different sources, central government, donations, loans and others; among other activities, the DEP was responsible for the implementation of all rural electrification projects.

Between the early 1990s and 2000, there were some pragmatic answers to the rural electrification demands through DEP actions primarily related to grid extension. According to reports from the Ministry of Energy and Mines, from 1993 to 2000 the DEP had implemented 531 projects to meet social demands; of these, 34 were based on renewable energies, solar PV and Wind energy systems; 168 diesel units, 55 small hydro schemes, 38 grid extensions; 236 small Integrated electric systems. Nearly 4.2 Million people were benefited in total, reaching an electricity coefficient of

73% (overall) and a rural electrification coefficient of 25%, with a total investment of about 500 million US$.

3.4.2 Co-ordination of rural electrification

According to literature, there has not been a clear leadership on the part of the Ministry of Energy and Mines regarding rural electrification, consequently there have been several dispersed initiatives from different sectors, including the Ministry of Agriculture, the Ministry of Defence, the Ministry of the Presidency and other government institutions, within no co-ordination at all between them. In addition to those of central government agencies, there have also been several isolated initiatives, the most important being those of local government (municipalities), NGOs, universities, the Church, etc.

The Concessions Law of 1992 states that the installation of schemes for capacities larger than 10MW power requires a government concession, from 0.5MW to 10MW a government permission is required, and for capacities below 0.5 MW, the only requirement is that the installer notifies the government; it is understood that the only purpose of the latter is to maintain the statistics.

3.4.3 National rural electrification coefficient (REC)[20]

Despite the important increase in rural people's access to electricity during the 1990's, the rural electrification coefficient in Peru is still low; see table 3.4[21] the definition of rural for electrification purposes comprises all towns with less than 10000 inhabitants.

Table 3.4 Progress of rural electrification coefficient in Peru

Year	Rural electrification (%)
1972	2.5
1992	3
1995	5
2000	25
2005	30

ESMAP/World Bank, 2006

[20] The rural electrification coefficient is equal to the percentage of people with access to electricity in rural areas.

[21] Towns with less than 10,000 inhabitants are considered rural.

Despite the attempts made and the political decisions taken during the 1970s and 1980s regarding rural electrification, the data in table 3.4 show that there was no significant change during that period. It is only in the 1990s when rural electrification is clearly different from previous periods. Nevertheless, the country's global rural electrification coefficient is still very low compared to most other countries in Latin America and in the world.

3.4.4 Plans for the years 2001 to 2010

In 1999 the government entrusted NRECA (National Rural Electrification Cooperatives Association- American Consultancy Group) with the preparation of a draft Rural Electrification Strategy Programme; this proposal was concluded and handed over to the government in 2001. The following were among the most important recommendations made: i) the publication of a rural electrification law, ii) the appointment of the DEP as the official body in charge of rural electrification, iii) the creation of a National Fund of US$ 85 million per year (obtained from electricity taxes and privatization funds). The first recommendation was fulfilled in May 2002, but neither of the other two had been implemented by 2005 [Diario el Peruano, Mayo 2002].

Parallel to the issuing of Rural Electrification Law, the Ministry of Energy and Mines (through the DEP) has announced an ambitious programme for the coming years in order to increase the access to electricity for 90% of the population by 2010, with a total expected investment of US$ 817 Million, which is equivalent to about US$ 90 Million a year. The activities include grid extension, small isolated systems (various towns are connected to one generation scheme), and isolated energy plants, as follows [MEM, 2001; NRECA, 2001].

A total of 36 grid extensions, totalling 3065 Km of mid and high-tension lines, with an investment of US$ 239.9 Million.

270 small isolated systems, totalling 27,659 km of mid and low-tension lines, with an investment of US$ 513.1 Million (the technology not specified).

36 small hydro schemes, totalling 4.62 MW of installed capacity and an investment of US$ 19.5 Million

211 Diesel generators totalling 24MW with an investment of US$ 19.8 Million
29,328 Solar PV modules with a total investment of US$ 24.9 Million

It is expected that the resources to fund this programme will come from the Rural Electrification Fund created with the law issued in May 2002 mentioned above and that it will be implemented by the DEP in accordance with its new role. So far by 2005 (during the field data collection), there had not been much progress with the above-mentioned plan, but instead the government started negotiations with the World Bank to design a new rural electrification programme; consequently, decisions about the entity to be in change of rural electrification and the sources of funding are currently being revised.

3.5 Stand alone energy systems in Peru

3.5.1 Role of stand alone rural electrification systems and main agents

Although rural electrification mainly involved the extension of the national grid, stand alone schemes (diesel and small hydro) have played an important role in rural electrification. According to official statistics of the Ministry of Energy and Mines, by the end of 2002 there were 197 diesel sets of less than 1 MW (of which 74 are below 100 kW power), 158 hydro schemes of less than 1MW (of which 73 are below 100kW) [MEM, 1999]. However, such statistics do not take into account another 100 or so units below 100kW of power installed by international co-operation agencies, local authorities, communities and private entities[22].

According to literature, early in the 20th century some workshops in Lima and other important towns were capable of manufacturing some small hydro components schemes like turbines, penstocks and transmission devises, contributing to lowering implementation costs, among other things, thanks to the existing capacity to meet the needs of the mining activities in the country. Power generators and controllers were imported from USA and Europe. Interesting cases of local manufacturing have been reported, for example, in Quillabamba (a small town located in the upper jungle of Cusco), Mr. Molero a local manufacturer built and installed about 25 small hydropower plants for various post-harvesting applications during the 1940s and 1950s. Unfortunately, the workshop disappeared and all experience lost when the owner died. There were similar cases in other parts of the country, but consolidation

[22] See Chapter V (section 5.3) and Chapter VI(Section 6.1)

of any local manufacturer was never possible until the 1970s [Manual Glave, 1988; A. Carrasco, 1989].

Despite the experience mentioned above, there has never been a solid, well-established company dedicated to manufacturing electricity generating equipment. Only in the early 1970s a private company "ALGESA" started to manufacture generators and small hydro turbines and to assemble small diesel sets, equipment with a power capacity of up to units of MW.

During the 1980s there were important inputs from international co-operation agencies, the most important among them, ITDG -Intermediate Technology Development Group – (Presently Practical Action), GTZ (The Development Agency from Germany) and SKAT (from Switzerland). They all implemented co-operation programmes to create a local capacity to manufacture turbines. ITDG has been working continuously since 1984 in the promotion of small decentralised electricity generating systems for rural areas, building the local capacity by developing and transferring appropriate technologies[23]; GTZ worked for a period of about 8 years in the Cusco region and SKAT promoted a particular design of cross flow turbines by sending packs of drawings at the request of small manufacturers.

Important demonstration projects on solar PV were implemented in the country during the 1990s. According to the different sources of information (MEM Web page, installers, regional governments), by early 2000 there were more than 1500 domestic solar systems installed, all for lighting purposes. According to information personally requested from government officials, it was discovered that by 2004 there were 38 villages with solar PV systems for lighting, all of them ranging from 10 to 224 family SHS (Solar Home Systems), and some other systems scattered across the country for different purposes (lighting health centres, powering satellite phone communications, school lighting and home lighting). The most interesting example of a demonstration plant is evidently the Project on the Island of Taquile (in Lake Titicaca) in Puno, where 224 home systems have been installed using a revolving fund and technical assistance from the UNI (National University of Engineering). The Ministry of Energy and Mines has installed 28 wind generators throughout the

[23] Internal reports of ITDG show 6 formal technology transfer agreements (to 6 different workshops), apart from several training courses aimed at transferring the micro and pico hydro technologies.

country through the PAE (Programme Energy Savings), but unfortunately most of them failed (CER-UNI, 1998).

3.5.2 Manufacturing capabilities for small stand alone energy systems in Peru

3.5.2.1 Small hydropower

There is a good national capacity for feasibility studies and engineering designs for Pico, micro, mini and small hydro projects[24], for manufacturing Pelton and Francis turbines up to 10MW power, Cross flow turbines up to 200 kW and propeller turbines up 100kW, synchronous generators up to 10 MW power, adaptation of asynchronous generators (up to 10kW) for Pico hydro schemes, controllers (especially electronic ones), electrical cables and all types of penstocks. There are about 10 small manufacturers of different components at a national level, the majority of them in Lima. During the last decade, exports of small hydro to other parts of Latin American countries like Chile, Argentina, Honduras and Bolivia were also reported.

A variety of costs have been reported for small hydro schemes; government intervention costs are around US$3500 to US$ 5000 per installed kW [World Bank, 1999; Smail Khennas and Andrew Barnett, 2000], while those of NGOs or other organisations (Churches) are between US$ 2000 to US$ 4000 per installed kW; in both cases costs include generation, transmission, and distribution.

3.5.2.2 Solar Photovoltaic systems

There is national capacity for feasibility studies, engineering design and implementation of PV systems, as well as the national capacity to manufacture all the components apart from cells, such as controllers, batteries and others. There is interesting experience in the use of PV systems in telecommunications, and some in rural electrification applications. At least 20 small companies offer all kinds of consultancy work to asses needs design and implement solar PV projects, most of them located in the larger cities, i.e. Lima, Trujillo, Iquitos, Cajamarca and Piura.

The costs reported are between US$ 800 to US$ 1200 per 50Wp for both government intervention and private intervention. These systems provide very basic services (lighting, radio and a couple of hours of black and white TV)

[24] There are medium or large size companies that conduct feasibility studies and engineering designs for large hydro schemes, either themselves or in conjunction with foreign companies

3.5.2.3 Wind energy systems

There has been some interesting research work and there are people who can do feasibility work and installations. There is also the capacity to manufacture and install small wind generators (up to 1 kW). Experience in the implementation of wind power generating systems is limited. At present there are two small manufacturers of small wind energy generators, TEPERSAC who manufactures a 100W unit, with ITDG-Peru Technology and WAIRA, another small local company, which manufacturers units of up to 1kW.

As far as wind electricity systems are concerned, the experience in Peru is limited. During the late 1980s and early 1990s, the Ministry of Energy and Mines had a bad experience with the installation of 18 systems (WAIRA made), which at least partially affected the credibility of wind energy systems as an energy alternative for generating electricity. Regarding the costs of this energy option, installed (1kW rated) schemes have been reported at an average of US$ 3000 per kW installed. All of them have been installed for social services in communities (lighting community houses, school and health centres). The 100W units manufactured by TEPERSAC are being offered in the market at US$ 450.

3.5.2.4 Diesel sets

Diesel sets are commonly used for rural electrification and other purposes. Diesel sets have been assembled in Peru since 3 decades ago, using imported engines and country made generators. All the other components are manufactured and assembled in the country, where there are quite a few nationwide distributors of diesel sets. The most important advantage of these systems for rural electrification applications is their low capital cost; however they have a very important disadvantage - the cost and availability of fuel, particularly for very isolated villages).

3.5.2.5 Biomass systems

There is little experience in this field, among the few experiences is the experimental work on very small scale carried out by ITINTEC in the 1980s and the universities during the last decade, and the installation of a prototype power generating machine using wood in Pucallpa (late 1980s), which failed

In the private sector there is an interesting experience in the use of bagasse in sugarcane companies, where combined cycle systems provide heat and an important part of their electricity consumption is obtained from burning sugar cane residues.

3.6 Conclusions

- Electricity is a very important element for social and economic development of mankind, it is important for providing or improving other basic services, like health, education, communication, drinking water, etc.

- A large proportion of people in the world have no access to electricity, especially in the rural and remote areas of developing countries.

- There are important barriers to rural electrification; therefore it is one of the hardest and most complicated issues encountered by governments and development agencies.

- Poor people in rural areas require small amounts of energy for lighting, radio/TV and the transformation and/or preservation of products

- Rural electrification is one of the most important challenges that Latin American countries confront nowadays, especially after the deregulation of the sector during the 1990s. Some countries have been implementing specific strategies to increase rural people's access to electricity. Such is the case of Argentina, Chile, Bolivia and Panama, all of which recognise the strong role of the State as promoter and provider of the necessary subsidies.

- There are important disparities in the access to rural electrification in Latin American countries, as some of them have achieved a 90% rural electrification coefficient, whereas other likes Peru and Bolivia have a very low electrification coefficient.

- Historically, government intervention in rural electrification in Peru has been very limited and uncoordinated.

- The Peruvian State has issued the Rural Electrification Law and created a Rural Electrification Fund amounting to US$ 85 million per year from 2002 onwards. This law also mentions the importance of promoting renewable energies, as clean and local resources.

- Departments in the Coast have high electrification coefficients as the grid is well developed.

- Departments in the Andes and the Amazon regions have low electrification coefficients and have little or no opportunity to access the grid in the short or medium term. Stand alone energy schemes, especially those based on renewable energies, can play an important role for rural electrification in these regions

- In Peru there is the technology and capability to implement most stand alone electrification schemes, and to manufacture much of the equipment locally. However, investments in stand alone during the past decades has been limited; most of the rural electrification work has been done by grid extension Grid extension is reaching rural areas in Peru at high costs per family, ranging from US$ 1300 to US$ 1500 in villages and/or communities which are close to the national grid; stand-alone diesel and renewable energy systems are competitive with these prices, especially for more isolated communities.

- There are substantial renewable energy resources, including hydro and solar energy in the Andes, wind in the coast, and biomass in the Jungle areas. Along with diesel, these present a range of options for stand-alone schemes

- It is important that existing stand-alone schemes are studied so as to determine the critical success factors for sustainable projects, so that future projects and programmes can be successful and cost-effective.

CHAPTER IV
IDENTIFICATION OF THE CRITICAL FACTORS

The main hypothesis of this research work was that "There are critical factors (CF), which influence the success or failure of isolated stand alone energy systems in rural areas"; those CF may be related to social, economic, technological, managerial, institutional and legal aspects. The identification of those critical factors will be contribute with knew knowledge for successful implementation of stand alone energy schemes, which will help government policy and decision makers, bi-lateral and multilateral agencies involved in the promotion of rural electrification to accelerate the process of access to electricity in rural in developing countries, especially in those countries where grid extension is not a viable but local resources energy resources are present and are a viable financial option.

The identification of these factors worth consideration requires a literature review of previous field research studies related to isolated stand alone energy systems installed within rural electrification projects and programmes, renewable energies and/or rural energy pilot projects. The identification of critical factors and their ranking according to their relative influence as far as Peru is concerned, should be established by means of field research work and data analysis.

This chapter concentrates on the identification of possible critical factors. The first part contains summaries of international and national studies highlighting the critical factors found in each case. In some cases the critical factors have already been identified and pointed out in the literature by the authors, in other cases they were identified from the readings. The second section contains a table grouping all the critical factors identified and the third section contains a synthesis of the possible critical factors.

The literature reveals that there is vast reading material related to the technical aspects of rural electrification, rural energy and renewable energies; the main issues being technical performance, design, construction and piloting; although there are a considerable number of impact evaluations of grid extensions, there are few studies about stand alone energy systems, which are the direct concern of this research work.

However, there are some impact evaluations of rural electrification programmes which take critical factors into consideration, in some cases explicitly and in others implicitly.

For the purpose of this research work, the most relevant case studies considered are those related to evaluations of stand alone energy systems for rural electrification, both at national (in Peru) and international levels. However, considering the very few existing case studies of this type, it was also necessary to consider the review of rural electrification programmes with grid extension, especially impact studies of large programmes, because they reflect some of the benefits and the main problems for the sustainability of these programmes. Single system projects and purely technological case studies are excluded because they generally describe particular cases, for particular villages, which sometimes may not be replicable.

4.1 Review of rural electrification case studies worldwide

1) Rural Electrification in Thailand: Lessons From a Successful Programme, "Draft Report" [T. Vorbate, D. Barnes, 2000]. The objective of the study was to learn the lessons of a successful programme. The main features of such an extensive rural electrification programme in Thailand are: it started in 1976 with 11,000 villages electrified (22.3% of the total) and ended in 1992 with nearly 62,000 villages electrified (97.6% of the villages) with a total investment of more than US$ 1 billion; it was based on grid extension.

The study reveals that, the success of this programme and especially the sound financial standing during the 17 years of operation was due to different factors, the following being among the most important:

a) Institutional Focus on Rural Electrification Distribution; there was an institutional structure dedicated exclusively to village electrification extension, purchasing electricity from the main utility; the institution was called "Provincial Electricity Authority of Thailand" (PEA).
b) The prioritisation of villages was based on planning, with no political interference allowed; to achieve this, PEA developed a prioritisation strategy based on technical and economic indicators, under the following criteria: the degree of development of villages; it was assumed that more developed villages were in a

better position to pay electricity bills and had larger loads than less developed ones; distance from the grid to minimise costs (villages located close to the grid first); flexibility to accelerate the access to electricity for villages that could pay the total or majority of the investment costs[1], giving well-off villages the opportunity to gain immediate access to electricity at their cost.

c) It was mandatory for the PEA to be financially viable, although there was a cross subsidy programme of 30% (i.e. PEA paid 30% less than the price fixed by the utility) to compensate transaction costs; such criteria forced PEA employees to constantly look for strategies to minimise costs, including efficient bill collection methods, active marketing and load promotion, cross-subsidy and the use of different loans according to the needs and payment capacity.

d) PEA commitment to service affordability, which meant giving great importance to low connection costs, with emphasis on service and local participation.

The evaluation methodology used for this study was a review of existing data; the evaluators focused their attention on PEA, Government and the reports of Asian Development Banks that were the implementing agencies. There had been no collation of information at a village level, therefore this report fails to provide information on insights regarding the performance at a village level and users' opinions, however it does reveal the importance of a clear strategy and the commitments of the implementing agency.

Although it was a grid extension programme, it shows important factors that contributed to its successful implementation by a government agency.

2) Bangladesh Rural Electrification Preliminary Assessment Final Report. This case study [De Lucia Associates, 1989] refers to the preliminary assessment of a rural electrification programme based on grid extension in Bangladesh. The evaluators considered it a very successful programme, the most important indicators being the number of connections which rose from 22.3 thousand in 1982 to 396.1 thousand by 1989, and the national energy consumption which had risen from 11.4 GWh/year in 1982 to 373.4 GWh/year by

[1] There were two sub-programmes to accelerate implementation; participation of the village with 30% of investment costs had sooner attention, with 100% immediate connection

1989; the domestic energy consumption remained constant (26kWh/month) per family per month.

The pre-assessment had three specific goals: a) to develop preliminary findings regarding the socio-economic impact of the rural electrification programme, b) to prepare terms of reference for a more comprehensive evaluation to be made in the near future after the study and, c) to devise a system for the REB (Rural Electrification Board) to monitor and evaluate the socio-economic impacts of the rural electrification programme.

The most important findings were:

a) Rural electrification is only one rural development factor.
b) The benefits of rural electrification are significant only where the level of development has reached a point where the latent demand for equipment and appliances is significant.
c) The use of electricity for irrigation has been immediately put into practice, raising the energy consumption and significantly affecting the daily peak energy consumption.
d) The "industrial use" simply refers to small-scale crop processing activities and simple metal working; it is unrealistic to think that industry can be developed immediately after rural electrification arrives.
e) The main contribution to commercial activities is the extension of working hours.
f) The benefits in household are important, measured by the willingness to invest money in various appliances.
g) Where there are some commercial activities, the willingness to pay is higher.
h) When the evaluation was conducted, most rural electrification co-operatives (PBS's) were improving their financial performance and it was expected that they would soon be capable of servicing their debt.
i) Village electrification has significant social impact through other services like better lighting, health, education, communications and others. The study also reveals that it is possible to achieve financial sustainability if management and bill collection are well organised.

The report also includes three micro-studies containing field data: a) a household survey on the willingness to pay; the results of this study revealed the differences between the decision to connect and the decision to use electricity. The degree of development of the area was a very important factor in the decision regarding the connection, whereas the decision to use electricity was based mainly on the cost of other sources of energy like kerosene and/or the cost of wiring. b) The second micro-survey was about the benefits provided to rural industry; the main conclusion being that it helps reduce the cost of productive activities, not only because of the lower cost of electricity but the costs of the equipment needed (e.g. electric engines are cheaper than diesel ones). c) The third survey was to establish the factors affecting the choice of technology and location of the industries; the results revealed that most of the industries were established after electricity was available and the most important factor affecting the choice, other than electricity, was the cost of equipment.

The broad conclusions of this study are that the success or failure of rural electrification in a developing country depends much less on the specific institutional framework, but on others factors related to proper planning and existing prerequisites for rural electrification, which are: a) A clear rural electrification objective and a rural electrification master plan, broad strategy, selection criteria and others. b) Conditions of design standards and engineering practices appropriate to rural electrification. c) Proper financial arrangements for implementation as well as for running rural electrification (including tariffs). d) Proper demand evaluation, design and implementation. e) Quality control, operation and maintenance of the services.

Consequently, according to this study the main issues or factors mentioned in this study are: a) institutional framework is not important. b) Appropriate technical intervention during all phases demands evaluation, implementation, operation and maintenance and quality control, c) appropriate financial arrangements, which are related to appropriate management.

3) Uganda Rural Electrification Strategy Study: This report [ESMAP, 1999] shows a comprehensive study on the demand and supply of rural electrification in Uganda. It suggests that Uganda is one of the most interesting examples where small stand alone

energy systems contributed to rural electrification substantially, mostly set up by users themselves. It reveals that by the end of the study, Ugandan households and businesses have imported and used well over 60MW of private generating plants, representing about one third of the total installed capacity of the Uganda Electricity Board (UEB).

In rural and urban fringe areas, ten times as many Ugandans had been electrified through lead-acid batteries supplied by UEB, twice as many rural industries generate their own electricity as take it from the grid, ten times as many rural enterprises (from sawmills, rural hotels, shops, and other service establishments) supply their own electricity, taking it from the grid.

Efforts to obtain electricity were made despite the cost of energy; 94% of the rural population use dry-cell batteries, spending an average of US$ 72 per annum per family and paying about US$ 400/kWh. hundreds of thousands of households use lead-acid batteries paying US$ 1 per charge, spending around US$ 50 per annum, paying about US$ 3/kWh; there are hundreds of small diesel sets, paying an average cost of US$ 0.78/kWh; there are several thousand PV systems (most of them 24Wp systems) which had been installed during the 1990's at costs from US$ 6.0 to US$ 10.0/kWh, while the UEB sells electricity at US$ 0.10 per kWh with significant subsidies.

Despite poverty and inequalities regarding costs and opportunities, people were able to use their own initiative to obtain electricity with their own means, whenever there was a clear and important need; however it is worth pointing out that this occurred because at that time the grid in Uganda was only supplying electricity to about 3.4% of the total population; in fact, according to the study report of 1998, by the time the study was completed, there were only about 140,000 grid connections in Uganda[2],

In Uganda there are abundant renewable sources of energy, small hydro being one of the most important, although not exploited due to the lack of technical and financial capacity. The study points out that there had been several inefficiencies in the existing

[2] Of these, 77000 are in Kampala (the Capital), 49000 in other urban areas and only 14000 (10 % of the total) are in rural areas. Uganda is a country where about 85% of people live in rural areas and only 15 in urban areas.

energy systems, which were mainly due to the lack of reliable technical intervention during the implementation of the self-supplying services, aggravated by an inappropriate legal framework, which did not allow self-generators to sell their excess energy to the grid under free market conditions, despite the clear shortage.

This study strongly recommends that the most important and urgent activities should be to establish an appropriate legal framework, a better organisation of suppliers and accessible financial mechanisms to promote rural electrification; promote the use of the surplus installed capacity of self suppliers; capacity-building in order to establish the foundations for a fast growing supply. For the case of small hydro schemes and for village electrification in general, t suggests the promotion of mini-utilities using local capacity to reduce costs.

The methodology considered splitting the sector into two sections, the supply and the demand, choosing regions, sub-regions, and stratifying the villages. The data was collected using open ended questionnaires applied to different groups of users and suppliers.

4) Case study in Bolivia: "Beneficiary Assessment of the Mizque-Aiquile Subproject": The objective of this case study [NERECA, 1993] was to maximise the socio-economic benefits of the Mizque-Aquile rural electrification subproject[3] by consulting beneficiaries about costs, benefits, and delivery services. The information obtained was meant to have implications for project design and management and for managers of the utility implementing this subproject. The project itself was executed for a subproject comprising 3 large communities: Vacas, Mizque and Aquile (the three together with around 2000 connections), in the region of the Chapare. The study concentrated its efforts on studying the benefits of electricity and the difficulties and or problems arising from the electricity service. The main findings were that there are technical, management, financial and payment capacity issues, which influence the use and benefits of electricity.

[3] The Mizque-Aquile was a subproject of the "Electrification for Alternative Development Project (ADEP)" implemented by the National Rural Electrification Co-operative, funded by the USID with a total investment of US$ 5 Million, for a total of 15,000 connections.'

The main technical problems were: frequent outages and delays in repairs in places where the services were provided through the grid, and the same difficulties plus limited service hours in areas supplied by diesel sets.

Regarding management, the most important complaints were the long delays in providing the services required by people, which the management team justified by claiming that dealing with one or two cases at a time was too costly (therefore they had been waiting for a group of problems to solve). This was particularly the case in Vacas - managed by the regional utility – more than in the other cases. In Mizque (managed by a co-operative) the difficulties were related to bill collection, because users were given the alternative of paying their bill either in the office or at home, which caused confusion as sometimes they were even charged twice.

The financial problems for users where related to the investment in the connection, because its cost ranged from US$ 50 to US$ 120, depending of the administration (the utility was the most expensive), while an average family income was estimated at US$200 a year, therefore most of the connections were possible only when credit schemes were established. Regarding tariffs, most people considered electricity to be expensive. According to the study, the tariff structure was not favourable for productive and commercial uses, because the rates were higher than for households, while in most cases institutions did not pay for the service. Delinquency was reported to be an important issue; this term was used to qualify the illegal connection or manipulation of meters to avoid paying the bill or reducing the amount.

The methodology used was that of "Participant Observation", however some structured questionnaires, meetings and workshops were also used, because the study planners considered it important to go into the community and take part in the daily living in order to obtain information, particularly on households. Questionnaires and interviews were used for institutions and authorities. The authors argued that this methodology was similar to those used for social and anthropological studies, which they claim had not been used for energy or rural electrification before, although it had been used widely for agriculture, health and others.

5) Socio-economic and Technical Study of Existing Pico Hydro Schemes: (less than 5 kW power) [N. Smith, A Harvey, S. Kapali, D. Upadhyaya, 1998]; this study compared the implementation approaches in different countries (Sri Lanka, Colombia and Nepal), where Pico hydro dissemination has been successful, and carried out a socio-economic and technical assessment in Nepal.

The study shows that in Nepal, there were more than 400 peltrics[4] installed in different parts of the country by the end of 1997 and in Colombia, more than 150 units were installed between the late 1980s and early 1997. The fast dissemination in both countries was evidently due to: the low cost of the equipment, the easy implementation of the systems and the technical assistance provided by the manufacturers and agents in the villages. The agents were local people trained to promote Pico hydro in Nepal, capable of installing and providing technical assistance. Another clearly important success factor was ownership, which was mostly private. There were a few other small groups of villagers which were crucial for organisation, operation and maintenance purposes, as revealed by the purchase of equipment.

Financially, the government of Nepal and the Bank played very important roles, the first provided subsidies ranging from 30% to 50% of the total cost of Pico hydro schemes, and the second provided loans with payback periods of up to 6 years. An important issue that arose in this study is the fact that the people made every effort to obtain energy when the needs were urgent and the conditions present, the conditions being affordability and resources.

The most important social benefits of the Pico hydro schemes were: better lighting, which was well appreciated because it provided better conditions for children to study, and entertainment for adults, such as listening to radios and/or watching TV; the authors also pointed out that electricity did not have any adverse effect on women or minority groups.

The methodology used was mainly interviewing the main agents in the villages, placing emphasis on technical aspects related to manufacturing, installation, operation,

[4] Peltric is the name given to a small Pelton turbine coupled directly to an induction generator.

maintenance, repairs, technical assistance and the guarantees provided by manufacturers; social aspects were also considered important, hence the inclusion of a Social Scientist in the team, who was in charge of interviewing users and community leaders.

6) Energy Resources and the Role of Mini and Micro Hydro Power in Northern India [A. Doing, 1994]; This is a PhD Thesis aimed at investigating the need for and the viability of mini and micro hydro power (MHP) in the north of India, in the Himalayas Region.

It reveals that in the region in which the study was conducted, a need for alternative energy sources was perceived, especially to supply energy to isolated villages and communities in the Himalayas and in places with few services, mainly in the less developed areas of the region. Another important conclusion was that under the existing conditions MHPP had very limited success and in many cases had completely failed, and that within the Himalayan context of India the MHPP projects had neither been sustainable nor economically viable.

Chapters five, six and seven of this study describe the situation of the case studies conducted during the research work and the particular findings from the visits in each case. Although the reference points out other issues influencing the performance of the systems, there are strong suggestions that the main reasons for failure had been mainly technical: site selection, planning, design, civil works construction, operation and maintenance; it also points out that a more wide-ranging issue concerned the technical regulations, which were the same as for large hydro schemes. Very poor load factor had also been reported as an important reason for the failure of MHPP. Other factors suggested were the very limited participation of local people and long down times, among others.

As far as economic performance is concerned, the study reveals that bill collection was a great problem, as well as frequent breakdowns with high expenditure in repairs and in lower revenues when the plants were not running. The low load factor was mentioned as a reason for low profitability. It also mentions that among the visited cases, two had a 5% load factor, one had 12% and two had 20%. Tariffs were also considered a problem;

because on the one hand high tariffs are needed to cope with expenses and on the other hand poor people cannot afford such high rates.

In management terms, the most important issue mentioned was the bureaucratic delays in making decisions, for example for repair work, which in turn produces down time and economic losses to the systems.

The suggestions to overcome the poor performance of MHPP are: 1) Integrated development projects that MHPP would form part of, but not be the main objective; 2) Consideration of all other issues like load factor, productive uses and participation of local people; 3) the use of indigenous technology. 4) NGOs must lead the implementation of suggested programmes, because they are better qualified to do so, while bureaucracy prevents government agencies from doing so.

The research methodology is not very clear, either for the selection of case studies or for the collection of information. Early in chapter 1, page 12, the author states "*The RETAIN[5] programme for dissemination of energy technologies in developing countries identified "nine key issues" which must be considered for projects to be successful, as shown in fig 1.4 . This thesis considers each of these issues for the case study in North India, with particular emphasis on the first four*", there is no discussion or justification from the author about their possible influence. Such factors were: a) The role of the market and the state, b) Dissemination strategies and the user's role c) the performance of the technology, d) understanding user needs, e) the political economy, f) financial returns for the user, g) the macro policy environment, h) System overhead costs, scale and the provision of complementary inputs, i) monitoring and feedback. Nevertheless, there are no conclusions regarding those factors. Field data was collected from direct visits and discussions with authorities, utilities, and personal inspections of each scheme, civil works, equipment, electricity lines, load factor, etc.

7) Best Practices for Sustainable Development of Micro Hydro in Developing Countries: [S. Khennas and A. Barnett, 2000]. - The objective of the study was to rectify the neglected micro hydropower plants (MHPP) despite the advantages of their maturity as energy

[5] RETAIN , Rural Energy Technology Assessment and Innovation Network

alternatives for stand alone rural energy. A comparative analysis and best practices was obtained from four countries, Peru, Sri Lanka, Nepal and Zimbabwe, where important MHPP programmes had been implemented or were in progress. This study places emphasis on the economic performance of microhydro and the potential for replicability and scaling up, however it appears to be focused on successful cases only rather than on a wider scope of research and analysis of the reasons or factors for failure or success.

Among the key findings are: a) Micro hydro technology is a mature technology, however there has been limited success in widespread dissemination; b) micro hydro proved to be more profitable when used for mechanical uses; c) MHPP are more in demand for generating electricity than for mechanical uses; d) there are clear circumstances where hydro technology is most likely to be financially viable, the factors contributing to this being: high load factor, a financially sustainable end-use, costs contained by good design and management, effective management of installations, including the setting and collection of tariffs that keep pace with inflation.

The critical factors pointed out are: a) MHPP need clear objectives, b) financially self-sustaining MHPP have cash generating end uses, lighting only projects will have great difficulty in achieving financial sustainability, c) subsidies are necessary in MHPP especially to reach poorer sectors, d) Costs of MHPP are dependant on location and standards, although management can contain this, e) the form of ownership is less important than creating a business style management, f) good selection of equipment is important for the success of MHPP.

Methodologically, although the study provides interesting conclusions on a group of cases (16 in total) it seems too dispersed to be conclusive, especially when referring to countries, because there were only 4 case studies for each country. The sampling does not appear to be representative of the universe in each country. For example, in Peru the sample was taken from two privately owned MHP – one belonging to a co-operative (Atahualpa, 35kW) and another to a rural entrepreneur (Yumahual, 11kW) – and two government owned (Pucara, 400kW and Pedro Ruiz, 200kW); the first two are micro hydro for productive uses (which were designed for that purposes but not for rural

electrification), the other two are mini hydro for rural electrification purposes. Therefore it would appear that the choice was aimed at identifying the economic performance of the systems, rather than a wider context research. For Sri Lanka the choice took into consideration financing arrangements and end-uses, however in at least two cases, the functioning time appears to be too short to obtain conclusions on performance, since they had been commissioned shortly before the evaluation (1998, 1997, 1995 and 1985 respectively) and the study was published in year 2000.

8) Study on Critical Success Factors for Renewable Energy Projects and Programmes: [ETSU, 1995]. It was a wide-ranging evaluation study done by the British Group ETSU, the aim being to identify "Critical Success Factors" for successful renewable energy projects.

The study is based on a desk review of several renewable energy projects and programmes, implemented by various international co-operation agencies in several countries (a total of 28 projects and programmes in both developed and developing countries). As key findings, the study points out 53 critical success factors covering a very wide scope of issues; the case studies were grouped according to the objectives of the programme and project (renewable energy programmes, rural electrification, productive uses, development programmes). Only 14 (of the 53 critical success factors) were relevant for rural electrification, or more specifically for village electrification, which is the interest of this research, as follows: Autonomy from Government (1), identify markets and benefits (2), market pull (3), credible champion/entrepreneurial technical capacity (4), payment capacity and affordability (5), integration with wider development plans (6), develop the cheapest first (7), encourage competition (8), resource/fuel known to be available (9), consistent and predictable load (10), appropriate and flexible design(11), informed and appropriate selection(12), competent contractors/suppliers(13), job creation(14)

The methodology consisted of organising a network of agencies working in the related fields in order to obtain primary information about their different projects and programmes, selecting a group of countries in Western Europe and developing countries. In Europe the projects and programmes were located in the UK, Germany,

Greece and Spain, while in the developing countries in India, Southern Africa, and the Far East. These three regions spanned the spectrum of per capita GDP commonly found in the developing world. During the study they kept close contact with the World Bank and obtained its opinion.

The data was collected by visiting partner organisations and interviewing project leaders. The Critical Factors emanated from each interview. A structured discussion followed in each case, and the case study was constructed and the CSF identified: The format included five points: Description, macro environment, micro environment, critical success factors and relevant notes. Page 6 states *"Then on completion of each meeting a visit note was produced so as to record both what was said and the judgements of ETSU staff present. These visit notes were then used, along with professional judgement, to construct the case studies"*.

Although this study gathered information on several projects and therefore the spectrum to identify critical factors was good, its main weakness appears to be the little or no contact with users, hence no information was gathered directly from them; furthermore, interviewees used their own criteria to identify CF and were not necessarily prepared to provide a thoughtful opinion, since no previous analysis was requested.

9) Key Factors for the Success of Village Hydro-Electric Programmes: [N.P.A. Smith, 1994]. The main objective of this paper was to address the key technical, organisational and economical factors for successful village hydro-electric programmes in order to promote a wider and more sustainable use of small-scale hydro power for rural development.

The main key factors addressed are: 1) Community involvement, participation of the community with both labour and money is mentioned as very important, also ownership. 2) Well trained local operator and manager, good organisation and management is highlighted by the author as the main finding from field studies like the one conducted by the Pakistan Council of Appropriate Technology (PACT). 3) Well trained local micro-hydro energisers; the need for training micro hydro engineers at national/local level is highlighted; in this case, a micro hydro engineer must have multidisciplinary skills,

training is possible from both north-south or south-south. 4) Low cost, reliable, locally manufactured equipment; this issue is related to the need for national capability to manufacture equipment and spare parts and assess and install MHPP appropriately, which will provide not only easy access to equipment, services and spare parts but also low costs. 5) Detailed survey of hydro potential and demand; the author mentions that many MHPP had failed because of the poor assessment of hydro and/or resources or demand; the existence of simple and effective equipment and procedures is mentioned as a probable solution. 6) Good plant factor; low load factor is pointed out as the main reason for poor financial performance of plants, therefore encouraging productive end-uses is suggested as the main possible solution to this issue. 7) Dependable, local finance with reasonable terms; financial programmes considering credits and subsidies when necessary is pointed out as crucial for enabling people to contribute funds for an effective implementation of the MHPP; this issue is consistent with issue number one. 8) De-licensing to enable private sector involvement; the author points out the high cost of government only intervention in the implementation of MHPP, because of the higher administrative and bureaucratic costs; the private sector had proved to be cheaper and more reliable. 9) Strong Co-ordinating Organisation(s); the need for a co-ordinating organisation is highlighted; it is good for advice and exchange of experiences. 10) Concentrate on villages that are developing economically; this factor identifies the more urgent needs have more developed villages and also their payment capacity, while poorer ones may have other needs more urgent than electricity. 11) Co-operation with grid supply utility; the issue is related to the need for good communication with the utility in order to overcome possible difficulties due to promises made by the utility and/or its connection soon after or before the installation of the MHPP. 12) Integration with other development programmes; integrated planned use of water resources is suggested as an important issue in order to maximise the benefit of the MHP.

The methodology used was to review existing studies of different programmes or projects related to micro hydro plants in different countries, then organise the key issues in twelve of them (the most important ones); the methodology was also based on the authors' experiences with projects and programmes in different parts of the world.

4. 2 Review of case studies on rural electrification in Peru

10) Peru Rural Electrification Report [Wold Bank, 1999]:- This reference covers the study conducted by ITDG-Peru under an agreement with ESMAP (World Bank)[6]. The objective of the study was to identify the performance of isolated rural energy schemes, in order to learn the lessons of past installations and suggest appropriate approaches for the future rural electrification strategy. Thirteen case studies were carried out, ten of which were small hydro schemes and 3 were small diesel sets.

The main findings were that there are two levels of factors affecting the success or failure of the energy schemes, those requiring government intervention and those which can be solved at a local level, with community intervention and/or decisions.

a) Those requiring government intervention concern the following:

- Legal and tax aspects; the need for a rural electrification law, guidelines on the use of resources by local governments, tariff structures, concession, uses of local resources etc. were suggested as important issues, which need to be tackled by the central government.
- Finance mechanisms; it suggests the need for common implementation rules, clear subsidies when needed, since at present there is a mix of complete donation (government intervention) to few private intervention (especially those for productive uses, small producers).
- Institutional framework; the study suggests the need for an institution to conduct promotion activities and to monitor the performance of village electrification nationwide.
- Local technical capacity; according to the study there is an important national capacity to manufacture a range of equipment and spare parts for rural electrification, especially those related to small hydro equipment. This is considered a positive aspect for the sustainability of the schemes, because they can provide technical assistance and spare parts when needed.

[6] The fundamental objectives of the ESMAP programme in Peru have been two-fold: a) to focus the Government's attention and strengthen its capability to deal with key areas left out of the privatisation and reform process of the energy sector; and b) to demonstrate alternative institutional delivery mechanisms to design, implement and supervise these new areas.

b) Four important factors are pointed out to be important at a village level.

- Management service or organisation; the study suggests that it is one of the most critical factors for the success or failure of the schemes. It also mentions that five different management models were identified, all of which had failed in some way; these were managed by the national utility (government), privately, by the municipality, co-operative and community.
- Training, particularly related to developing the capacity of community members to operate, maintain and administrate the systems. The study shows that systems with appropriate training had a better chance of succeeding.
- Use of appropriate technology; this is related to two issues, the capacity of local people to handle the equipment properly and therefore run the system properly; the availability of spare parts and technical assistance.
- Tariffs; the study shows that the financial performance depends largely on the tariff structure and the ability to collect bills.

The methodology implies a careful choice of the cases, considering: a) Location (in the Andean region[7]; b) Political status "Districts" (which are the smallest geographical areas with political authorities elected by people); c) access to services, the distance from the province capital and the location of the services to be analysed (roads, fuel suppliers, etc.); d) Poverty, it was decided to evaluate places with different poverty rates: extremely poor, very poor and poor. Information was obtained from interviews with local leaders and managers of systems, but not from the users themselves.

Although an interesting methodology was used, there were clearly some gaps in the selection and data collection procedures, since the latter was limited to interviewing local leaders and visiting sites and there were no structured questionnaires for users. Clear emphasis was placed on management and technical and economic performance, but no information was obtained regarding the payment capacity and willingness to pay, or on the socio-economic impact in the village. With respect to the choice of the case studies

[7] The location in the Andean region was chosen because most rural people live in the Andean Region, where electricity services are limited.

mentioned above (location and poverty), the representative size of the researched technologies was not taken into account.

11) NERECA – a study carried out to design a rural electrification strategy for Peru- [NRECA, 2001]. The main objective of this study was to prepare the National Strategy for rural electrification in Peru. It basically involved a thorough desk evaluation of the existing information, with very few site visits, as simple observers. The study presents a picture of the rural electrification situation in Peru, the different needs and opportunities regarding sources of energy and costs.

It suggests the creation of a rural electrification fund, the issue of a rural electrification law and some possible structures for the delivery of electricity services. As a result of this study and the willingness of the authorities to raise the rural electrification coefficient, the government submitted a draft "Rural Electrification Law" and the Parliament approved it in May 2002. Unfortunately, this law was never enforced because another law[8] was issued soon after, which annulled all the effects and viability of the first one. This study does not mention any particular critical factor or issue that would be worth taking into consideration during any designing and/or implementation stages of the rural electrification programme in Peru.

12) Luz es Progreso? (Light is Progress?). Rural Electrification in Junin and Apurimac: A case study of 6 Micro Hydro Plants (MHP) in the Southern Peruvian Andes, departments of Junin and Apurimac [M. Glave, 1988]. The objective was to identify the main variables which explain the success or failure of micro hydro plants in two Andean regions. Junin and Apurimac were chosen, the former representing success and the latter representing failure.

The findings were that the MHPPs in Junin were managed by the communities themselves while those in Apurimac were run by the government utility[9]; in addition to the management models, there were other factors that contributed to the success of the

[8] The new law established the decentralization process, which gave local governments the power to implement all services, while the first was basically meant for central planning and central execution.
[9] The author reports that at the time, Apurimac was by far the department with the most micro hydro systems in Peru, with 34 units.

Schemes in Junin, such as a lower tariff and no connection costs, which provided better opportunities for people to gain access to electricity. However, the author points out that all cases in Junin failed to cover running costs.

The author suggests that in both cases, MHPP had not contributed to the development of the region, but were used mainly for lighting purposes. In the hydro schemes in Junin, there was better care of equipment but poor care of electrical wiring, whereas the opposite occurred in Apurimac. According to the study the main reasons for down times were landslides during the rainy season, in addition to the lack of technical skills in the communities.

A highlighted conclusion was that the communities studied in Junin had more access to both local and regional markets, implying that important factors for the success of the cases in Junin were the payment capacity and the use of energy for productive purposes. Regarding tariffs, the study mentions that although there were tariff schemes in the community, there were no power meters or any other measurement equipment, while in the cases of Apurimac users paid according to the metering systems.

The methodology used consisted of simple visits and interviews with management teams, leaders, authorities and operators. Data was collected in personal interviews with local people and there were no organised or prepared questionnaires. Cases were selected and considering the following important factors: degree of integration in the market, role of the community organisations, existence of hydro resources and management of the scheme. Therefore the methodology looks interesting for the purpose of purely comparing the schemes of the two departments "Success Vs. Failure" with pre-established factors. Finally the author strongly suggests that the possibility of success for future MHP would be part of integrated rural development programmes

4.3 Grouping possible critical success factors (PCSF).

The following table shows the different possible critical factors, extracted from the different references mentioned above. These are grouped according to social, financial/economical, technical, managerial and legal issues.

Table 4.1 Key Factors pointed found from literature review					
Reference	Social	Financial	Technological	Managerial	Institutional and legal
• Thailand case study	• Political interference • Local participation	• Financially viable Programme • Low cost of energy • Low connection cost • Effective bill collection	• Affordable connection cost	• Effective bill collection methods	• Institutional (Exclusive institution)
• Bangladesh rural electrification study	• Household Benefits are important	• Latent demand for equipment • Use in irrigation • Extension of working hours • Degree of village development		• Organised Bill collection	
• Uganda rural electrification study	• Clear energy requirements	• Financial mechanisms	• Local capacity-building	• Better organisation (Promotion of mini-utilities)	• Appropriate Legal framework
• Bolivia Beneficiary assessment of the Mizque-Aquile Subproject		• High cost of centralised management • Bill collection • Cost of connection • Cost of electricity	• Secure supply • Availability of repairs • Service hours (limited, due to diesel sets)	• Good service users • Good management	•
• Socio-economic and Technical study of existing Pico hydro	• Clear social benefits (like Better lighting and entertainment)	• Low cost • Affordability	• Easy implementation • Technical support • Good resources	• Ownership	
Energy Resources and the Role of Mini and Micro	• Participation of community	• Bill collection • Good load factor • Tariffs	• Good design for all components		• No bureaucracy

Hydro Power in Northern India		• Integration with other programmes	• Good load factor • Good quality of service (no breakdowns)		
Key factors for the success of village-electric programmes	• Community involvement & ownership • More developed villages first	• Low cost • Local finance, subsidies • Integration with other programmes	• Training for local operators & managers • Training for local Eng. • Reliable local manufacture • Good assessment of resources & demand • Good plant factor	• Co-ordination	• De-licensing • Co-operation with grid supply
Best Practices for Sustainable Development of Micro Hydro in Developing Countries	•	• End uses (self-sustaining) • Subsidies • Business creation	• Good selection of equipment	• Good management (suggest business style)	
Peru Rural Electrification Report	• Community participation	• Finance mechanisms • Tariffs	• National capacity (technology) • Training • Appropriate technology	• Good management (suggest private Service organisation)	• Proper tax for small scale schemes • Institutional framework
Strategy study	• Community participation	• Capacity to pay	• Technical support	• Service organisation	• Legal and institutional framework
Luz es progreso? (Light is progress?)	• Community participation	• Market connection • Better development	• Load factor • Local capacity	• Good management	•

4.4 Summary of the possible critical success factors (PCSF)

From the literature review the references that directly addressed the possible critical factors for the success or failure of stand alone systems [N. Smith, A Harvey, S. Kapali, D. Upadhyaya, 1998; ETSU, 1995], both of them referred to wide contexts; the first is a review of case studies (existing written data), the second is a field research study; other relevant studies for the purpose of this research work were the Impact studies concerning rural electrification related to programmes (Thailand, Bangladesh and Bolivia Case studies) shown above, which also have some important outputs which could help to identify the possible factors. At a national level there were two relevant studies, Carrasco (shown above) did a study aimed at identifying different issues regarding rural electrification in Peru and M. Glave (shown above) covered a particular region and a particular technology.

From the table above, it is clear that the different authors had different approaches and different outputs regarding the factors which they believed affected the performance of rural electrification. These PCSF can be divided into common groups related to social, financial, technological and managerial aspects, as stated in the main hypothesis of this research study.

However, there are some PCSF which are not relevant to each village, but to the wider context (national level), therefore for the purpose of the field data collection, the PCSF will be organised into two main groups, those which refer specifically to the village and those related to the national context.

4.4.1 Possible Critical Success Factors at a village level

4.4.1.1 Social factors

Benefits in households and better lighting can be grouped in one PCSF as "Benefits of electricity in households"; No political interference is an important issue on its own, therefore it is considered a PCSF; community participation is pointed out by most authors in different ways, therefore it is also considered a PCSF; the three PCSF mentioned above can be studied at a village level. Although delinquency is an issue which generally affects the village, it has not been considered because it is part of the management issues, also it is not a general issue suggested by the authors.

More developed villages can be considered under "degree of development of the village", however this PCSF affects a wider context (national) and will be studied comparatively taking poverty issues into consideration.

Consequently, the PCSF related to social issues to be studied at a village level are summarised as follows:

- Benefits of electricity in household
- No political interference
- Community participation

4.4.1.2 Financial/economic factors

Financially viable programme refers to a national programme, therefore it is not taken into consideration, because the research will study isolated schemes, which may or may not be implemented as a programme. Latent demand for end uses, use of electricity for irrigation, extension of working hours, will depend on the degree of development of the village; therefore this can be considered as part of the social issues (national context). Load factor and better development can be expressed as productive end uses. Cost of management can be well placed under the management and organisation group, while breakdowns can be considered under technical issues; local finance and subsidy refers to programmes (and are therefore left out). Market connection looks to be an important issue by itself however it will affect the degree of development of the village, therefore it will be analysed as part of it.

- Cheap energy
- Low connection cost
- Effective bill collation
- Tariffs sufficient to meet costs
- Payment capacity

4.4.1.3 Technical factors

Technical performance of the scheme, including no outages, no delay in repairs, 24 hour services, no limited service hours, long down times, is generally associated to the

technical assistance available and also to the source of energy (diesel sets sometimes have no fuel supply, MHPP may have problems of no access to technical assistance or spare parts); therefore access to technical assistance and source of energy are two PCSF in technical terms. Easy operation and maintenance implies the existence of local capacity, but also suggests the existence of appropriate technology; it is generally possible through training of local operators and managers, then local capacity will be considered as another technical PSCF. Load factor and end uses can include good plant factor and be considered a PCSF. Easy implementation is not necessarily an important issue for the sustainability of the schemes, because installation is generally carried out by implementing agencies or organisations; however, easy operation and maintenance is relevant, therefore it will be used instead of easy implementation.

National capacity includes design aspects, resource assessment, training of local Eng., reliable local manufacture, good selection of equipment. However, this cannot be identified in a village survey; it will be analysed with information collected from existing national industries in the field of isolated energy schemes and it is considered an issue related to the National context.

- Local capacity
- Good load factor/end uses
- Easy operation and Maintenance (appropriate technology)
- Access to technical assistance
- Source of energy

4.4.1.4 Management factors

Some of the issues mentioned under managerial aspects are related to good bill collection (which is considered under financial issues). Better organisation, type of organisation and good organisation can be all considered under type of organisation, the purpose of which is good management; therefore good management by itself can stand for all the previous issues mentioned. Good local management capacity is also an issue which can be enclosed under good management. Ownership is a separate issue from good management, because the owner can either hand over the electricity services to a manager or manage his own property (the electricity service).

Local capacity is already considered under technical issues, so it is not necessary to repeat it under managerial issues. Co-ordination can go as part of institutional arrangements. Therefore, managerial issues are reduced to two:

- Ownership
- Good management

4.4.1.5 Institutional and legal factors

Exclusive institutional refers to the implementation of rural electrification programmes, therefore is not included in the village level study; also it cannot be studied or referred to under national context because no such programmes have been implemented in Peru (it is worth bearing in mind that two of the references have conflicting thoughts: while it is mentioned as very important in the Thailand study, the Bangladesh study says the opposite). The same occurs with de-licensing, co-operation with the grid and clear objectives.

The legal framework is also a general issue related to the whole nation rather than a village level, so it will be referred to as a national context PCSF. Bureaucracy and Proper tax frame are also issues which are related to the national context, therefore all the Institutional and legal PCSF will be considered under the wider context (national).

Table 4.2 Summary of possible critical factors at village level

Social	Financial	Technical	Managerial	Institutional and legal
• Benefits of electricity in household • No political interference • Community participation	• Cheap energy • Low connection cost • Effective bill collection • Tariffs sufficient to meet costs • Capacity to pay	• Local capacity • Load factor/end uses • National capacity • Easy implementation • Technical assistance • Source of energy	• Ownership • Management	• No bureaucracy • Proper tax frame

The great majority of these PCSF can be studied by interviewing the different groups living in the village and are considered as factors at a local context; see table 4.3. However, a few of them can only be identified from other sources of information, i.e. bureaucracy; degree of development and national capacity and are considered are factors of wider context; see section 4.4

With respect to financial issues, low cost of energy and affordable tariffs take into consideration the same concept; however payment capacity includes both, since they are relative to the family's ability to pay. A tariff can be affordable if the family has enough money to pay, but the same one can be not affordable if the family is unable to pay, therefore the possible critical factor to be included is payment capacity.

Table 4.3 Possible critical success factors (PSCF) at local level (village) considered for the field study

Theme	Possible critical success factor
Social	• Benefits of electricity in households • No political interference • Community participation
Financial	• Low connection cost • Effective bill collection • Payment capacity • Cost of energy
Technical	• Local capacity (in the village) • Load factor/end uses • Technical assistance • Source of energy
Managerial	• Ownership • Management

Regarding ownership, the two most important types in Peru are Municipal ownership and government owned and managed, (see Appendix A), Municipalities sometimes manage their plants directly, but they often prefer to give the responsibility to committees; the same occurs with governments. However, there are also some

communities who claim that they own a certain scheme because the implementing agency gave them that impression.

4.4.2 Summary of PCSF of wider context.

From the above analysed information it comes out the presence of some factors which may be relevant for the success of the small isolated energy schemes and therefore can be considered as possible critical factors, but those can not be talked from the local prospective, instead they require government and other external intervention or are influenced by external agents to the villages, see table 4.4

Table 4.4 Possible critical factors at wider context
• Degree of development of the village
• Market connection
• National capacity
• Legal framework
• Bureaucracy
• Proper tax frame

Although the present research study will mainly focus on the local context factors, attention will also be put on possible factors of wider context during the collection and analysis of the field data.

CHAPTER V
FIELD RESEARCH METHODOLOGY

5.1 Research methodologies

This chapter focuses on the field data collection methodology, so as to efficiently and effectively determine the critical success factors for isolated energy schemes in Peru. The required data will be collected from the different people involved in village electrification: beneficiaries, local leaders and authorities, operators and administrators of the systems. Therefore, social research methods should be used.

Social research methods are based on the belief that social regularities do exist. In his text describing the various types of social research, (E. Babbie, 1990) page 23, states, "*The fact remains that social norms do exist and that we can observe and explain those norms. When norms change over time, we can observe and explain the changes. Ultimately social regularities do persist because they tend to make sense for the individuals involved in them*". In this research, therefore, the regularities that occur in the villages will explain or confirm the degree of importance of the Possible Critical Success Factors (PCSF). According to the above mentioned author, the following six are the most important methodologies for social research work:

a) Controlled experiment. – It limits its attention to the before/after design with a controlled group; it represents a clear example of scientific experiment. However, in this case the isolation of the control group is extremely important and it is the primary advantage of this methodology; the controlled experiment represents an artificial test of the hypothesis, therefore the relevance to the real world is subjected to question, but the results of this sort of experiment may not be generalized in other segments of the population (E. Babbie 1990).
b) Content Analysis. - This is based on the systematic examination of some topics, such as novels, poems, government publications, speeches, songs, etc. For example, to know or understand the change of attitudes of government criticisms, or the opinion of groups under certain policy measures; the analysis of specific speeches of politicians or leaders. This is purely a qualitative analysis.

c) Analysis of existing data. - Some scientific research can be examined through the analysis of exiting data, (E. Babbie, 1990) states "*Scientific research work should not be equated with the collection and analysis of original data. In fact, some research topics are examined through analysis of data already collected and compiled*". An important advantage of this method is its economy. However it has important restrictions: 1) It is limited to data collected and compiled, which might not adequately represent the variables of interest; 2) Whenever you correlate variables generated from aggregated data, it is difficult to determine whether the same relationship between the variables holds true at the level of individuals.

d) Case study. - A comprehensive description and explanation of many components of a given social situation. (D. J. Casley, 1981) in page 62 states *"The essential methodological feature of a case study is that it provides in-depth detailed analysis, this is its strength and it means that the enumeration is usually carried out by a professional*". For example, the impact of an education programme in an isolated village, the impact of the installation of a rural electrification system. The case study focuses its attention on the understanding of specific aspects of the studied group rather than looking for generalization purposes, therefore it differs from the previous methods, which all look at the generalization of results. Although some results may appear to be generalized, there is no way of proving it, unless other similar studies are conducted in other communities.

e) Participant observation. - The researcher becomes part of the social event or group under study, for example he/she might join a demonstration as a method of obtaining data from other participants, or join a religious group to study it; like in the case study; with this method, the researcher is able to obtain a great deal of in-depth information on the subject. According to Earl Babbie, however, it is subjected to certain biases, because taking part in certain events can influence the researcher, and there is a constant dilemma of whether or not to tell the members of the community the truth about his/her real intention in the community under study.

f) Survey research. – It is applied to a large variety of topics and designs; this methodology is based on the study of samples for the purpose of describing a larger population from which the sample was taken and in order to examine the relative importance of the different variables that can later be generalized. It enables essentially qualitative data, for example people's opinions, to be

quantified, e.g. as a percentage of people within a sample that agree with a particular statement. It also allows the rigorous, step-by-step development and testing of logical explanations; the survey format permits a clear and rigorous elaboration of a logical model and helps to clarify the deterministic system of cause and effect. The survey research method involves the collection and quantification of data that becomes a permanent source of information. The same survey can be repeated at a later date in order to analyse changes in the measured data.

5.2 Choice of methodology to identify Critical Factors that affect stand alone energy generation systems in Peru

The most important features of this research are the national scope of the study and the large number of small villages spread out in the country[1] with access to electricity from stand alone energy schemes. The research work is expected to be representative of the country, i.e. representative of a wide geographical area with different topographic, social and economic conditions; for such conditions, the chosen methodology should allow sampling and generalising the results later.

Therefore, the most appropriate methodology to be used for this research study is the "Survey Research", whereby a sample can be chosen from where the data collection will take place. The data will be analysed and conclusions will be drawn and generalised, considering the limitations of the study.

The information to be collected from a sample of villages spread out in the country, will be related to each of the 13 Possible Critical Success Factors (PSF) shown in Table 4.3 grouped in four categories (Social, Financial, Technical and Managerial). It was assumed that some of that information may exist in written records, for example data concerning the number of users, tariffs, income and expenditure; however, it is likely that a large part of the information has not been recorded in writing, especially that referred to the opinions or behaviour of users. Consequently, the best way to gather such information was thought to be through interviews with the different stakeholders of the systems in each village.

[1]Although the proportion of electrified villages is small compared to those without access to electricity, the actual number of villages with electricity is large for a research study.

5.2.1 Universe

The universe of this study is formed by all people living in isolated villages in the rural areas of Peru, who have access to electricity.

5.2.2 Study unit

Since there were two sampling levels (Village and consumers), the study unit in the first level was the village in which the sample system is located. For the second level (data from consumers) the study unit was the family or household.

5.2.3 Data collection

Data was meant to be collected by a team of two enumerators, who were briefed on the purpose of the research work and had previous experience in data collection; nevertheless, they received training on the procedures of the interviews and the need for careful interviewing. The questionnaires were prepared and provided to the enumerators by the researcher.

5.3 Sampling frame

This research is a cross section survey[2], applied to rural villagers with access to electricity from small stand alone energy systems.

The sampling frame consists of all official and non-official information about small isolated villages with stand alone energy generating systems in isolated rural villages in Peru. Among the most important institutions providing the information are the Ministry of Energy and Mines, the Ministry of Agriculture and NGOs involved in the field of rural electrification and renewable energies.

Although there is no precise definition of a village (in terms of size), it was considered advisable to analyse and consider as a primary sampling frame all schemes below[3] 500kW, for both hydro schemes and diesel sets, since systems above this size are likely to be for larger towns or groups of villages.

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[2] In cross-sectional surveys, data are collected at one point at one time. Such a survey is not only for description purposes, but also for determining the relationship between variables at the time of the study (Earl Babbie, 1990). Other sorts of survey are longitudinal surveys (done at different times).

[3] The convention within the energy sector in Europe and USA is to use the term small hydro for the range from 1MW to 10MW, in Latin America from 0.5MW to 5MW

As mentioned in chapter 3, the options that have been playing an important role in decentralised rural electrification are small diesel sets and small hydro electric schemes. Diesel sets have become popular because of their "low implementation costs" and short implementation period; hydro energy schemes have also become popular in the Andean and upper jungle areas, where resources are available. Solar PV is a relatively new technology being introduced as a rural electrification alternative.

According to available data, there are 197 diesel sets and 138 small hydro schemes below 1MW, of which 158 diesel sets and 121 hydro schemes are below 500kW. There are also 37 villages which have been electrified using solar PV with more than 10 (systems), all of them for lighting and TV purposes, Wind energy schemes are not considered since they have not been used for village electrification, also most of those installed have failed drastically.

> *Therefore for the purpose of this research work, the sampling frame is made up of 159 diesel sets, 121 small hydro schemes below 500kW and 38 small villages electrified with solar photovoltaic systems (PV); see appendix A.*

5.4 Survey population

The survey population is a shortened list of villages taken from the sampling frame, after eliminating those inappropriate for the research sample; the appropriateness refers mainly to the homogeneity of the survey population, which should be as homogeneous as possible. The following considerations have been taken into account to shorten the list of villages for the survey population.

5.4.1 Technology options considered

As mentioned in Chapter 3, small hydro schemes and diesel sets have been contributing to village electrification for a very long time, reaching quite a few isolated villages spread out in the country and providing electricity services. Therefore these two technologies were considered straight forward to be part of the survey population.

Regarding solar PV, although it is one of the alternatives the government has been focusing on in recent years, the total number of families serviced with this technology

is bellow 1500[4]. There are 38 villages with Solar PV systems as a source of electricity with 10 or more than 10 families (users), and only 9 of them have 40 or more users (see appendix A). All solar PV systems were installed between 1999 and 2003.

An interesting feature of solar PV is that the SHS (Solar Home Systems) have been installed independently on a one unit per family (or user) basis and do not require common wiring within the villages like diesel sets and hydro schemes do, therefore PV systems face different social problems regarding the administration and management of the systems.

Therefore, from the point of view of technology options, several issues like the number of users (in total), age of the systems, administrative and management issues, determine that solar PV is not yet a representative technology in rural electrification in Peru and therefore it has been excluded from this research work.

Regarding wind and biomass for rural electrification, neither of these two technologies have been used for rural electrification and are therefore excluded from this research study.

5.4.2 Size of the systems considered for the survey sample

For hydropower schemes and diesel sets, organising the data of the sample frame by ranges of power in hundred units, it was found that there is a high concentration in the lower ranges for both technologies. For diesel sets, 74 (46%) out of the registed159 units below 500kW are in the lowest range (0kW to 100 kW), while for small hydro schemes 73 (nearly 60%) of 121 are in the lowest range – see figures 5.1a) and 5.1b).

Also, for both technologies hydropower schemes and diesel sets the second largest group is the one ranging from 100kW to 200kW – see figures 5.2a) and 5.2b). Since the interest of this research work is to look at the CSF for small isolated villages, the most relevant information seems to be related to the smallest ranges. Consequently, it was considered important to limit the size of the systems to a maximum of 200kW

[4] This information was obtained in a personal interview with officials of the Ministry of Energy and Mines in July, 2004.

in order to keep the similarity between the villages and the size of the energy systems.

Fig 5.1a) Diesel sets bellow 500kW

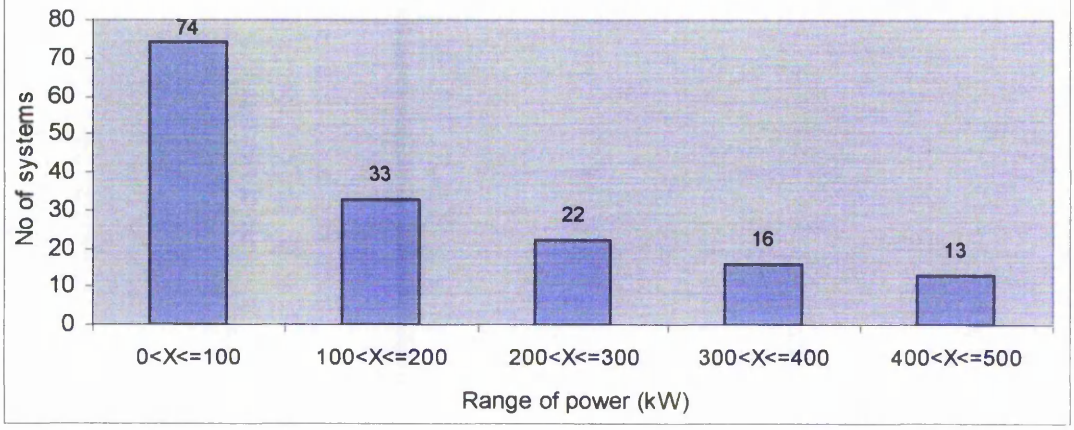
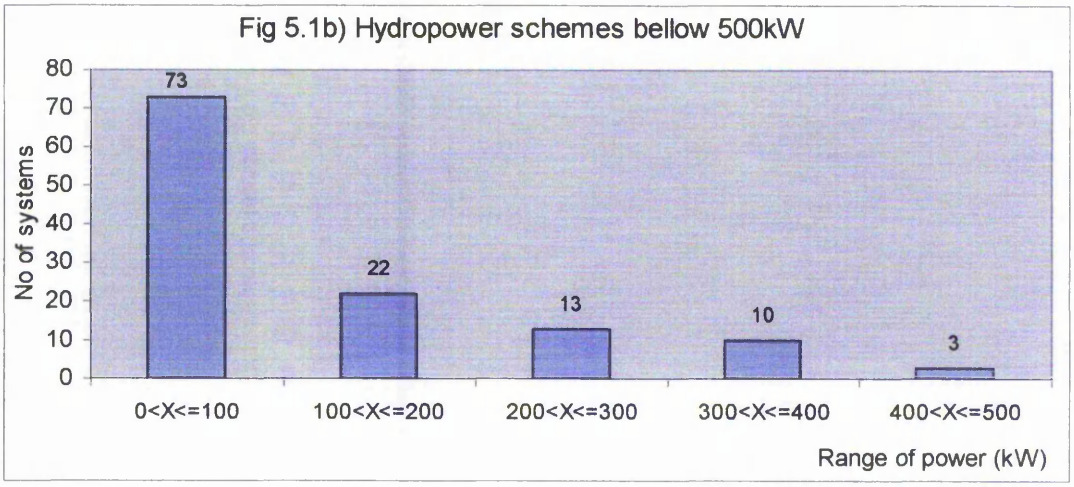


Fig 5.1b) Hydropower schemes bellow 500kW



Regarding the minimum size to be considered for the study, it is important to notice that there are very few diesel sets below 20kW; if fact, there are only 5 diesel sets below 20kW and 2 of 20kW; for hydro schemes, an important issue is that the smallest hydro plants have mainly been used for productive purposes rather than for village electrification; in fact from the sample frame, the schemes of Trinidad, Polulo, Tinte, Hucataz, Yumahual, Tambomayo, Tingo (see Appendix A), all below 20 kW power, are exclusively used for productive purposes; therefore only 8 schemes below 20kW have been used for village electrification. This fact shows that the lowest range of hydro schemes for electricity generation are attractive for small private businesses, rather than for village electrification.

There are also quite a few hydro schemes above 20kW which have been installed for productive uses on a private basis, among them: Toraya (25kW), Manatial Eterno (25kW), Porcon (35kW) and Monte Salvado (60kW). Again, these schemes have not been considered for the survey population because the electricity is not used for village electrification.

Fig 5.2a) Diesel sets bellow 100kW

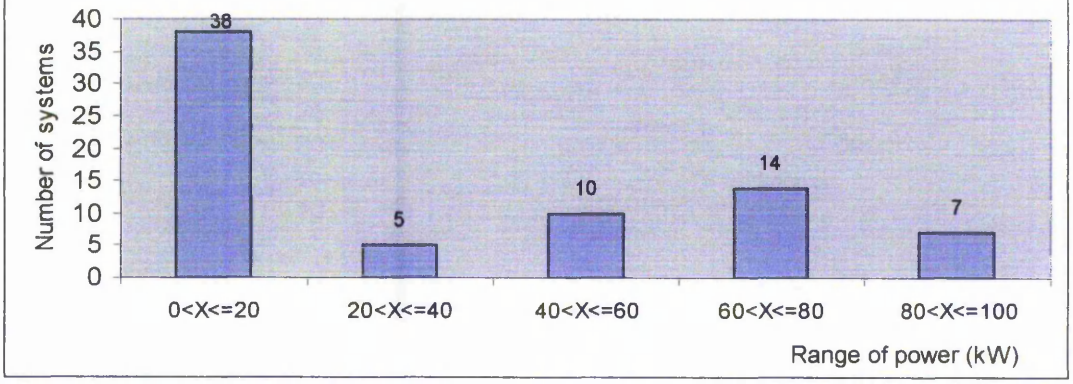
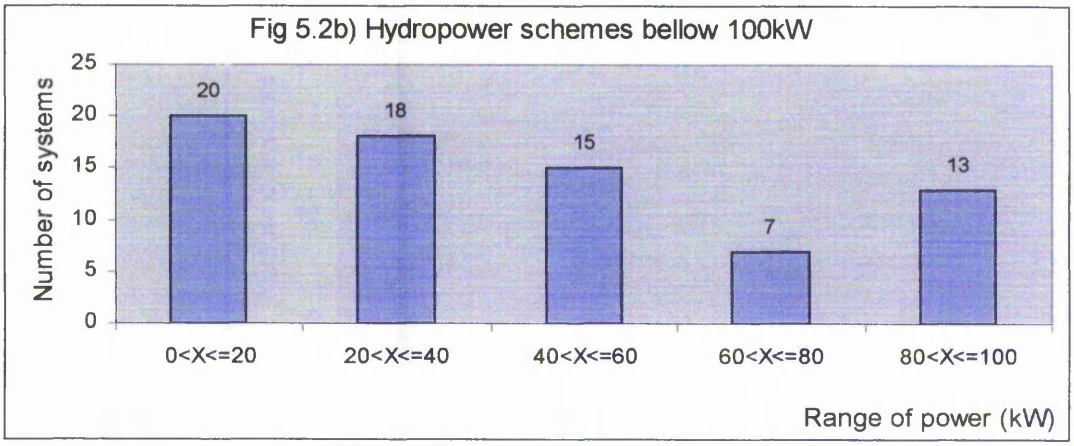


Fig 5.2b) Hydropower schemes bellow 100kW



Due to the reasons explained above, it seems reasonable to exclude from the survey population all diesel sets and hydro schemes below 20kW, and also those hydro schemes used for other applications than for village electrification.

Therefore, regarding size, the survey population is restricted to the range from 20kW to 200kW for both diesel sets and hydro schemes; which include 75 hydro schemes and 102 diesel sets.

5.4.3 Regions of intervention

In the Coastal region the rural electrification coverage is high compared with the other regions; also, the great majority of villages have been electrified through grid connection and only a few (more isolated villages) have access from isolated stand alone diesel sets. In fact, the sample frame reveals that only 11 200kW diesel sets in this region are providing electricity to the same number of towns.

Also, due to the flatness of the land and the shortage of rain, hydro resources do not exist in this region; furthermore, villages in this region without access to electricity will sooner than later be connected to the grid, not only because of their location close to the grid, but also because of the relative low investment required due to the good topographic, transport, weather and other conditions; The exception are the very few villages located in fishing communities along the Pacific coast, which may have to wait for a long time because they are relatively more isolated than the others in this region.

Regarding the Amazon region, for the purpose of this study it was considered convenient to divide it into two sub-regions (Andes and Upper Jungle)[5]. In the lower Jungle only 30 diesel sets ranging from 20kW to 200kW were identified, which means that there are a larger number of diesel sets in the Andes and in the Upper Jungle regions. It therefore seems reasonable to exclude the Lower Jungle sub-region from the survey population.

Therefore, subtracting the 30 diesel sets in the Lower Jungle and the 11 on the Coast, we are left with 61 diesel sets for the survey population. With respect to hydro schemes, the official information does not show evidence of any system in the Lower Jungle, because despite the abundant number of rivers, there is no hydro potential due to the flatness of the land. Existing hydro schemes are therefore concentrated only in the Upper Jungle and the Andes.

Therefore as far as geographical areas are concerned, the survey population will be restricted to the Andes and Upper Jungle, since most of the isolated schemes (hydro and Diesel) are located in these two regions.

[5] Although according to the main geographical classification there are only three regions (Coast, Andes and Jungle), the Jungle is generally subdivided into two important sub-regions, i.e. upper and lower jungle.

5.4.4 Ownership

According to official figures (MEM), it was discovered through sampling that of the 75 hydro schemes bellow 200kW (the scope of the research study), 40 were government owned and "Managed", 32 were Municipality owned and managed and only 3 were community owned and managed; according to the same information source, only one diesel set out of all the systems were government owned and "managed". Therefore the initial sample for hydro schemes consisted of 4 government managed and 3 Municipality managed, while for diesel sets, all 6 cases considered were government owned.

According to (ESMAP, 2001) "Peru Rural Electrification", the following are the types of ownership of rural electrification schemes in Peru:

- State owned. - Generally promoted, installed and run by central government agencies, the Ministry of Energy and Mines or through ELECTROPERU. Although the sample frame shows that almost all the list of schemes are administrated by utilities[6], in practice, most diesel and hydro schemes are administrated by municipalities.
- Municipality owned. - Schemes run by the local governments (Municipalities), installed by central government (Ministries and decentralised organisations), aid agencies, or sometimes by co funding of state and private organisations plus the villagers.
- Community owned. – This category includes all schemes promoted and developed by communities; these were mostly installed by external agencies with the participation of community members, but there are also an important number of schemes built by the government and left to be managed by the community, in which case the community adopted the ownership.
- Privately owned. - Schemes installed, owned and run by peasants whose main activities are agriculture and/or cattle. These schemes are generally used to provide services for the transformation of a variety of local products, like milling, sawing, etc. These schemes are hardly used for village electrification. Sometimes they may sell electricity to a couple of neighbours because of friendship with the owner, but that is all.

[6] This is because the diesel sets or small hydro plants have been installed by the government within the concession areas, therefore they leave the installations under the responsibility of utilities; in most cases, however, and utilities still leave the administration in the hands of municipalities.

- Co-operative owned. – Installed by local co-operatives[7], these schemes had been implemented as part of the activities of agricultural cooperatives; they are not for village electrification purposes, but generally to process products from the cooperative to place in the market.

The above clearly reveals that the most common types of ownership of small energy schemes in isolated rural areas in Peru are Municipality owned and State owned, followed by privately owned (to a much lesser extent), community owned and finally, co-operatively owned schemes.

> *Therefore, from the point of view of ownership, in order to maintain the homogeneity as much as possible, the survey population will include only municipality and state owned schemes.*

5.4.5 System age

For the purpose of this thesis, the systems to be studied should have been in operation for several years in order to collect information of people's experience regarding their performance. It is worth noting that in most cases, many agents intervene during the first years of operation, including installers, government (either local regional or central); in some cases the systems may be under guarantee conditions for the first years of operation. Therefore, in order to have enough evidence of the different facts under the villagers' administration, the choice is to consider systems that are at least 5 years old in both cases, i.e. small hydro schemes and diesel sets, which are the technological alternatives chosen for this study.

> *Therefore the survey population is taken from the list of existing village electrification schemes (sampling frame), meeting the following characteristics.*
>
> - ***Technology**: diesel sets and small hydro*
> - ***Range**: from 20kW to 200kW (including the extremes)*
> - ***Geographical Area**: Andes and Upper Jungle*

[7] The cooperatives where created by the agricultural reform in Peru back in the early 1970's, the reform was a failure and extremely few co-operatives remain at present.

- ***Ownership**: Municipality, community and government owned and/or managed; private owned schemes are excluded because officially there are no private owned schemes with the range size of the study.*
- ***Age**: 5 or more years in all cases*

In view of the above, the survey population is comprised of 61 diesel sets and 75 hydro schemes, both technologies ranging from 20 kW to 200kW, located in the Andes and Upper Jungle. For more details of the survey sample see Appendix A

5.5 Sample design

There are two main types of sampling; non-probability and probability sampling, and various techniques in each of these. Non-probability techniques are generally simpler and inexpensive but accuracy suffers [Weisbergg, Krosnick and Bowen, 1996]. Therefore probability sampling was chosen for this study, in order to ensure as much accuracy as possible.

The following are probability sampling techniques: Simple random sample, Systematic selection procedure, stratified sample, cluster sample and multistage area sample. However when the survey research is complex, a combination of techniques may be necessary.

This particular case is a complex one, as the study was to be conducted in a group of villages spread across the country and with different socioeconomic contexts. Each village has different groups of people (household energy users, business people, and operators) involved in different activities; the main two types of administration of village electrification are government and municipalities. Therefore, the sampling process had to take place at two levels. The first level referred to as "Village sampling" consists of a group of villages selected from the survey population, taking the chosen technologies (strata) and the type of administration into consideration. The second sampling level referred to in this study as "interviewees sampling", consists of groups of people from each village (the interviewees).

5.5.1 Village sample (national scope)

For large survey populations, (E. Babbie, 1990) the stratification technique provides the best representativeness of the three most well-known sampling techniques[8]: the same reference states in page 84: *"simple random sampling and systematic sampling are important in that they ensure the degree of representativeness and permit an estimate of the error, stratified sampling is a method for obtaining a greater degree of representativeness and thus decreasing the probable sampling error".* Taking into consideration these criteria, the following steps were taken to sample the villages to be surveyed.

- Organise the two technological strata (diesel sets and hydro schemes) and sample each strata independently, because technology is an important parameter for the analysis of results.
- List the technology strata in order according to the poverty level of the corresponding village, starting at the poorest level and using the poverty map [MEF, 2001][9]. This was expected to provide a sample which includes villages with different poverty levels; so that conclusions can be reached, taking the different socioeconomic conditions into consideration.
- Placing the villages in that order was expected to give a mix of government and municipal administration.

The Survey population was thus made up of 61 diesel and 75 small hydroelectric plants, appropriately stratified.

The sample consisted of 10% of the total number of villages; that is, 6 diesel sets and 7 hydro schemes; therefore the number of villages to be surveyed was 13. The procedure for choosing the villages was the systematic sampling method, as follows:

- The two strata of survey populations were treated separately and in both cases split into groups of ten elements, 1 to 10, 11 to 20 and so on until the

[8] The other two are simple random, which is the basic sampling method in statistical survey computations, and systematic sampling, where every kth element in the total list is selected for inclusion in the sample, for example if the total list is of 1000 elements and you want to select 100, the sample will include every tenth element.

[9] The poverty map was designed with the objective of assigning economical resources according to the severity of the poverty rate, whereby poorer sectors should receive more resources [MEF, 2001].

total number of each technology was included. The sample will be composed of one element of each group.

- For each of the technology strata, the selection process for the sample starts by picking randomly one element from the group (1 to 10), to which end ten pieces of paper were prepared beforehand.

- The second element was chosen from the second group (11-20), but this time the choice was done by adding then units to that chosen from the previous group (for example if the first chosen element in the first group was 5, the second element was 5+10=15).

- The process for the choice of the following elements were obtained by adding 10 each time, at which point an important consideration was introduced, which was to ensure a similar number of government and municipal administrated schemes, since jumping by tens would hardly provide the ideal case (government, followed by municipal, followed by government and so on, or Municipal followed by government followed by municipal and so on).

- In order to obtain a good combination of government and municipal, the procedure was such that if the first village was government managed and the second (obtained by adding ten) was also government managed, the solution was to skip to the following village in order to get municipal one; after adding ten to obtain the third element, if the result was a Municipal one then again we would skip to the following to get a government one; this procedure was repeated as often as necessary to complete the selection and obtain the good combination mentioned above.

- The result of the sampling selection process appears in table 5.1, which shows the village survey sample, including both technologies hydro and diesel. It also includes the poverty index of the village, the power and the sort of management of the system and its location within the country department (presently region) and the province and district.

Table 5.1 Village Survey Simple						
Hydro schemes						
Poverty Index	kW	Management	Plant	Department	Province	District
0.08661	25	Community	Las Juntas	Cajamarca	Jaen	Pomahuaca
0.07275	90	Government	Chaviña	Ayacucho	Lucanas	Chaviña
0.06215	40	Municipality	Mayorarca	Ancash	Recuay	Pampas Chico
0.05791	30	Government	Oxahuay	Piura	Ayabaca	Montero
0.04715	20	Municipality	Soloco	Amazonas	Chachapoyas	Soloco
0.04344	80	Government	Huyunguita	Cajamarca	Cajabamba	Cajabamba
0.01792	200	Municipality	Tialango	Amazonas	Bongara	Jumbilla
diesel sets						
	kW	Management	Plant	Department	Province	District
0.10404	100	Government	Masocruz	Puno	El Collao	Masocruz
0.07737	100	Government	Chipao	Ayacucho	Lucanas	Chipao
0.05969	50	Government	Cuñunbuque	San Martin	Lamas	Tabalosos
0.05318	100	Government	Pomacochas	Amazonas	Bongara	Florida
0.04027	50	Government	Moquegua(SIA).1	Moquegua	Mariscal Nieto	Calacoa
0.02500	182	Government	Moquegua (SIA).10	Moquegua	Grl. Sanchez C	Ubinas

5.5.2 Interviewees sampling (local level)

5.5.2.1 Stratification of the interviewees

In each village there are different groups (Strata) of people who can provide different information for the purpose of this study. These are described briefly below. Therefore, like for the first level, stratification was needed in order to achieve a more effective survey, although the stratification also helped to shorten the questionnaires.

a) Administrators/Operators- Administrators are the people in charge of the administration of the systems in the sample villages, who are a good source of information regarding the financial performance of the schemes, billing, tariff structures and others. It was expected that in some villages, written information regarding the above mentioned issues would be found; the sort of information we expected to collect included written records from existing files, although it was also considered to apply questionnaires regarding the performance of the scheme and the relation between the administrators and the users. In villages that did have written records, the questionnaires were applied to gather information.

Operators are the people in charge of the technical operation and maintenance of the systems, who could provide technical data about the operation of the plants, down time, repairs, costs and others related to the technical performance of the schemes; as in the previous group, the existence of some registered data was expected. Consequently, prepared questionnaires and interviews would be used to collect data. For the technical information, a review of all sorts of possible sources of information was considered, e.g. instruments (energy counters). Observation and evaluation of the technical characteristics and conditions of the equipment, instruments, design characteristics and other technical aspects were also considered and carried out.

In practice, however, administrators and operators of small schemes are usually the same people, therefore for the purpose of this research work, the two groups were considered as one stratum.

b) Local authorities and leaders. - This includes Village Mayors, teachers, nurses and doctors and community leaders. A questionnaire was prepared to collect information from this group through interviews. In this case, it was expected that no written information would be available, however this group of people was expected to provide important comments about the schemes, people's behaviour, needs and others.

c) Business people. – This includes families who run productive units, small shops or both. A questionnaire was prepared to obtain information from this group of people through interviews. The main idea was to gather information regarding the economic and financial benefits obtained from the energy schemes.

d) Domestic energy users. – For the purpose of this survey, domestic users are those who use energy exclusively for household purposes; although the other groups also use energy for household purposes (leaders business people, etc.), the information provided by this group would help provide an understanding of the capacity and willingness to pay, the benefits of electricity, the people's perception and opinion regarding costs, efficiency of the administration and operation of the schemes. A questionnaire was prepared for a sample of domestic energy users in each village.

5.5.2.2 Sampling the interviewees within each stratum

The sampling was different for each stratum. In all villages the groups of administrators, operators, leaders and authorities consisted of only a few members, whereas the number of business people varied according to the size of the village; however the number of household electricity users was generally large compared to the other groups. Therefore the following considerations were made for effective data collection purposes:

a) For household energy users, the sample was expected to be consistent with the population in the villages; in small villages, it was planned to consider up to 20% of the total number of families living in the village, whilst for larger villages the sample was limited to about 10% of the total number of families. Due to the lack of available information in advance, it was also planned to conduct the sampling itself upon arrival in each village.

The process was to start by meeting the community leaders and if possible the whole community, then do simple sketches of the villages as a first step and then count the number of the streets and the number of blocks of each street. The total number of the sample would be divided into the number of blocks.

The systematic sampling method would be used to select the interviewees for each block, to which end the number of houses on the block was divided into the number of interviewees; for example, if there are 12 houses in one block and 3 people were to be interviewed, then for purpose of choosing the interviewees, three groups of 4 houses each were considered; the first group consisted of the first 4 houses from one corner (the starting point), the second group was comprised of the next 4 houses and so on. The first interviewee would be selected at random, using four numbered pieces of paper from which one would be chosen. For example, if number 3 was the chosen house, the next one was would be number 7 (first group + 3= 4+3), the next interviewee would be number 11 (group one +group two + 3=4+4+3).

It was expected that two small problems would arise with this method: a) the number of houses in each block may not be the same; b) the number of houses would not be a multiple of the number of interviewees. It could therefore be argued that the sampling was not fully consistent, however issues of this kind were noticed in the literature and they are not considered dangerous.

b) For the other strata it was considered to interview all the members of that group, since each group usually had a small number of members, except for business people, which was expected to vary -- the larger villages, the larger number of business people expected. For such cases, it was considered interviewing a maximum of 50%.

5.6 Preparation of the questionnaires

The preparation of the questionnaires for data collection was a long process, including the review of the questionnaires used in other research work done by different researchers, looking at the extent of coverage of the different issues to be studied in this research, then preparing sets of questions for each PCSF and field testing tests before the actual data collection. The following were among the most important considerations for the questionnaires:

a) Duration of the interview. - During the preparation, there was a dilemma between having a large number of questions to obtain as much information as possible and the quality of the information, based on the understanding that the larger the number of questions, the more information can be collected from the field and more accuracy can be expected in the research; however, it is also true that the more questions a villager is asked, the more boring and uncomfortable the interview could become, especially when villagers do not perceive an immediate benefit of the exercise, which could severely influence the quality of the information and, therefore, the quality of the research results. Consequently, an initial set of questions was prepared aimed at approximately 30 to 40 minute interviews.

b) The reliability of the information. - Most of the information to be gathered was about people, economy, production, sales, behaviour, perception, which is generally not found in writing; therefore the questionnaires had to be prepared in such a way that the risk of obtaining biased information would be reduced to a minimum. It is also important that the interviewees had to be completely aware of the situation so that the interview would be friendly but obtaining as much accurate information as possible.

To overcome that fears and minimize the effects of the situation pointed out in the previous paragraph, the solution was to rely on the memory of the interviewees

regarding actual facts, so the questions asked were related to previous activities, for example regarding the agricultural activities of the previous year (size of potato plantations, number of animals sold and others of this kind); in this way the researcher could collect facts about the previous year's economy of the families[10].

c) The organisation of sets of questions. - To facilitate the work analysis after the data collection, it was important to organise the PCSF in sets that had common sources of information (interviewees), avoiding duplications or omissions. A group of PCSF was assigned to each stratum (household users, management and operation team, local authorities and local leaders, business people), and then a set of questions was prepared for each PCSF. See the questionnaires in appendix C

d) Type of questions. - The questionnaires mainly consisted of close-ended questions in order to obtain quantifiable results. Also, formats were prepared to organise and quantify the collected information according to each question. In all the questionnaires the wording was kept as simple as possible in order to obtain simple, straightforward answers.

5.6.1 Review of some questionnaires of previous field research studies

A variety of questionnaires applied to rural energy studies were found: purely technical, a combination of technical, social and financial issues, impact evaluation, including the following:

a) Energy Resources and the Role of Mini and Micro Hydro Power in Northern India [A. Doing, 1994]. The researcher used a so-called "site proforma", a questionnaire with 11 questions. It was designed basically to collect technical data, containing a total of 7 questions regarding the location, size, technology, power, breakdown periods; 1 question on running costs, 1 question on investment costs, 1 question regarding the type of load of the plant, and finally 1 on additional notes and comments. It is clear that this questionnaire had no intention of obtaining social and/or financial information, neither was it aimed at obtaining deep insights of technical issues. It was clearly addressed to the technical person in charge of running the scheme.

[10] This practice is used for sociologists in rural areas of Peru, for socio-economic studies [World Bank, 1999], refers to this method of building the facts of last years by questioning the interviewee about its activities of the previous year.

Although the above mentioned reference considered some technical issues, which were also part of this study, the information needed for this research work is much wider and therefore the questionnaire clearly had to be very different.

b) Bangladesh Rural Electrification Preliminary Assessment Final Report. [De Lucia Associates, 1989]. This study includes three important sets of questions: i) Addressed to domestic consumers, aimed at understanding the capacity and willingness to pay for electricity; it includes 13 questions (some sub-questions within them) about benefits, difficulties, energy shortages, use of other sorts of energy sources, amount paid, willingness to pay for better services (if these were available); ii) 5 Addressed to people not connected to electricity, which included questions about the reasons for not being connected and their interest in electricity; iii) A third questionnaire is addressed to the rural industry; including 7 questions regarding the sort of business, energy consumption (size of the engines), cost of operation, reliability of the operation, selection of technology and markets.

This research is particularly interesting to confirm the strategy of splitting into groups of users. It also contains some issues which have been of much interest to the researcher, which are in some way common to this Thesis, especially issues like operating costs, willingness to pay, costs of energy, reasons for not being connected and energy use.

c) Electricity Power Utility Improvement Study (EPUEIS) [J.A.K. Kandawire, Jean Davison, Graham G. Mills and P.R.T. Ntata, 1992]. This study was aimed at improving the utility efficiency in Malawi. The procedure used to collect information from the villages was organised in three steps: Step one, meetings with leaders and authorities from the communities[11] (in each village). Step two, the researcher conducted a Rapid Urban Assessment (RUA), drew a map with details of streets, roads, walkways, houses, huts, and other residential accommodation, as well as all sorts of shops, businesses, churches and institutions; also listed and described all sorts of formal associations. Step three, contact people and establish friendly links with them.

[11] This questionnaire shows an interesting method of starting data collection, a step-by-step procedure, when the researcher does not know the situation of the village.

Then three sets of questionnaires were used for present energy users, former energy users and non-users. i) The set for energy users consisted of 25 questions including socio-economic profile of the interviews, business, energy use and benefits, people's opinion about electricity, reasons for using electricity, way of paying for the electricity connection (existence of loans), and suggestions to improve electricity services. ii) 16 questions to former users of energy, including socio-economic profile, problems found with electricity, their attempts to solve the problems, also what the utility can do to help them and whether they will use electricity again. iii) The set of questions for non users had 14 questions regarding the socio-economic profile, knowledge about electricity and possible uses, capacity to pay, their opinion about the most important uses of energy, and others.

The sort of questions used in this research was of great interest to this one, because it has common issues such as the socio-economic profile of the users, benefits of electricity and people's opinion of the electricity service.

d) A preliminary Analysis of Residential and Productive Uses of Energy Based on Quantitative and Qualitative Methodologies [J. Etcheverry, 2000]. The study was aimed at clarifying the residential and productive uses of energy in the region and identifying viable energy alternatives. Most of the energy used in that region is based on small isolated diesel sets.

The questionnaire designed for this study was made up of 87 questions, which were organised in a continuous list. The first 21 were related to the identification of the interviewee and the entire family living in the house; 34 related to the economy of the family, income, expenses, properties and business and the source of energy used; 11 questions on household energy, types of equipment and/or appliances, quantity of energy used, cost of energy and ways of paying for it. Finally, 21 questions related to the families' intentions of purchasing more equipment and/or household appliances, including equipment for water pumping and businesses.

Although the questionnaire seemed to be comprehensive form the point of view of the coverage of subjects, it appeared to be improvable from the point of view of the way the questions were organised in order to avoid possible duplications.

e) Electrification and rural development, Electrification Project in the rural areas of Cusco, Peru [Carrasco Alfonso, Kimmo M. Juves, Maija Seppo, 1990]. This is a comprehensive impact study in the south east of the country (Cusco). The main objective of the study was to evaluate the changes due to electricity in the local production and to consider the coordination of the electrification project with the regional development plans.

The authors used a questionnaire of 89 questions, divided into 8 sections: a) general data of the interviewee (13 questions), b) household electricity (16 questions); c) the economy of the family (6 questions); d) the cost of energy (12 questions); e) participation of the interviewee in power at village level (5 questions); f) agriculture (9 questions), g) cattle (4 questions); h) business people, craftsmen and small entrepreneurs (24). All questions were close ended.

This questionnaire looks interesting from the point of view of coverage of all required aspects: family income, resources, household energy, production, small businesses and costs of energy. However, there was only one questionnaire for the interviewees, there was no grouping or stratification and the report does not include any explanation about the sampling methodology. An interesting issue is the use of questions about the past (last year), for example *"Last year how much did your family earn from temporary work outside the village"*, such questions rely on the people's memory regarding the actual facts that occurred in the immediate past instead of asking about planned activities, because it is common practice in rural areas not to keep records or plan in advance.

5.6.2 Questionnaires

The design of the questionnaires involved various steps; after the review of several questionnaires used for past studies, a first draft was prepared and then two field tests were conducted, followed by the necessary adjustments, taking into consideration the lessons learned.

The final result was a questionnaire with 4 sections, one for each stratum: Household energy users, Business people, leaders and authorities, and operators and administrators. Each stratum was assigned a PCSF group.

The first group of household energy users were asked about 5 PCSF (capacity to pay, affordable tariffs, benefits from electricity, community participation and connection cost), including 23 questions in total. The second group of operators and administrators was asked 6 PCSF (management of the system, bill collection, local capacity to operate and administrate stand alone schemes, access to technical assistance, load factor and political interference) including a total of 41 questions. The third group of business people was asked about (affordable tariffs, connection cost and benefits from electricity), including 15 questions. The fourth group of Leaders and Authorities was asked about 3 PCSF (political interference, community participation, and local capacity), with 13 questions.

As shown in appendix C, the most extensive section of the questionnaire was for operators and administrators, because this is the only group that could provide first hand information about the performance of the system and its operation and administration. The second longest list of questions was for household energy users, who provided information about different social and economic issues like capacity and willingness to pay, among others. The questions for leaders and authorities were important for understanding the history of the scheme and people's participation during the execution of the project.

This PCSF grouping according to different stratum helped to obtain as much information as possible from direct agents on the one hand (operators inform about operation, leaders and authorities abut policy issues, etc), but on the other hand it allowed more selective sets of questions.

5.6.3 Field-testing and adjusting questionnaires.

Testing the questionnaires was considered part of the methodology used to identify lessons and weaknesses that could be corrected. Two field tests were conducted at different times, each in two small hydro schemes. Hydro schemes were chosen because these systems have a wider scope of technical issues than diesel sets (hydro schemes generally involve large civil work compared to diesel sets).

The first trial took place in two small villages located in the north of Peru, Conchan and Paccha, with 80kW and 130 kW power respectively. The most important lessons learned from the first field test were:

The number of questions.- Several of them were considered unnecessary or irrelevant, the reason being that when the questionnaires were first designed, there was great enthusiasm for obtaining as much information as possible, to which end a large number of questions were needed. In practice (in the field trial) it was found that some questions were related to trivial issues or known issues; sometimes the questions had only one possible answer, e.g. the legal status of the schemes, which is generally known beforehand, or the fact that schemes installed by the government energy sector are registered, whereas other systems are not registered.

Repetition of questions.– During the testing it became evident that the same questions were repeated in various PCSF; for example a question about cost of energy can be easily considered in at least two PCSF (capacity to pay, capital and running costs, tariffs, and others). Therefore a careful review of all questions was necessary in order to avoid any kind of repetition.

Organisation of the team of enumerators.- The results of the tests conducted in Paccha and Conchan also revealed that, whenever there is more than one enumerator, it is important to organise and split the team and the strata to avoid duplicating efforts (for example by interviewing the same family twice).

Order of the PCSF. – The testing revealed that listing the questions in order by PCSF could be useful for shortening the questionnaire and making it more specific. Consequently, it was decided that each stratum should cover a PCSF group and each PCFC should have a group of questions, as shown in section see 4.0.

5.7 Organising the PCSF and questions according to stratum

The information to be obtained from this group is related to all the social PCSF and part of the financial ones. These are:

a) Domestic energy users

- Benefits from electricity in household (economic, health education, communication, others)
- Community participation (opinion about their participation opportunities and importance)
- Cost of connection (importance of the decision to connect)
- Capacity to pay (family income and electricity rates)

- Political interference (information about political interference and its effects on the performance of the scheme)

b) Administrators/Operators

- Effective bill collection
- Local capacity to operate and administrate
- Technical support (existence nationally, locally)
- Load factor (plant capacity and use of energy, productive uses)
- Management
- Political interference

c) Business people

- Low connection cost (how it affects the business)
- Benefits from electricity
- Cost of energy (effects of the energy cost and use of energy)

d) Leaders and authorities

- Political interference (opinion about political interference, both local and external and its effects on the scheme performance)
- Community participation
- Local capacity

CHAPTER VI
DATA COLLECTION AND ANALYSIS

This chapter contains information about the data collection, survey sample, poverty index and the analysis of the different PCSF related to social, financial, technical and managerial issues that happen within the village context affecting the system's performance, and the PCSF of wider context that may affect the performance of the system.

6.1 The survey sample and sampling conditions

The data was collected during the period November 2004 to May 2005. As considered in the methodology the villages studied are located in the Andes and the Upper Jungle regions of Peru. It was necessary to change some villages originally sampled, because some of the initially chosen villages had been connected to the grid[1]. The changes were done bearing in mind the need to keep a spread of the poverty index as wider as possible as well as location, technology, age and ownership.

An additional change was on the number of schemes; the initial sample was made of 13 villages, 7 with hydro and 6 with diesel sets, however the actual collection was made from 14 systems, 7 hydro schemes and 7 diesel sets; the main reason was to include a private system (which originally was turn down because the official information does not show their existence). The final sample and the location of the systems can be seen in table 6.1

Before the field data collection, two field visits were done for testing the questionnaires; the villages visited were Conchan and Mayorarca; during the visits it was found the need for small changes in the questions, most changes related to the wording, to make them the simple and straight forward to facilitate the replay of the interviewees.

During the first field visits evidence was found that there are many more community-managed hydro schemes than those registered in the official information, also quite a few Municipality and community managed diesel sets and few private diesel sets.

[1] There are quite a few cases, which had already been connected to the grid; however they still remain as served with isolated energy schemes.

Table 6.1 Survey samples (initial and final)

Initial sample				Final sample			
Systems	Poverty Index	Andes	Upper Jungle	Schemes	Poverty Index	Andes	Upper Jungle
Oxahuay (H)	0.0579	X		Shitariyacu (H)	0.0596		X
Mayorarca (H)	0.0621	X		Mayorarca (H)	0.0622	X	
Chaviña (H)	0.0727	X		Chaviña (H)	0.0728	X	
Las Juntas (H)	0.0866		X	Las Juntas (H)	0.0866		X
Soloco (H)	0.0472		X	Maria (H)	0.0552	X	
Huayunguita (H)	0.0434	X		Santa Catalina (H)	0.0756		X
Tialango (H)	0.0179		X	Longuita (H)	0.0785	X	
				Totora (D	0.0711		X
MoqueguaSIA-10 (D)	0.0025	X		Limabamba (D)	0.0598	X	
Cunumbuque (D)	0.0597		X	San Roque (D)	0.0597	X	
Chipao (D)	0.0774	X		Tambo Quemado(D)	0.0728	X	
Mazocruz (D)	0.0963	X		Mazocruz (D)	0.0963	X	
Pomacohas (D)	0.0532		X	San Martin (D)	0.0438		X
MoqueguaSIA-1(D)	0.0403			La Coipa (D)	0.0782		X

H, means hydro energy schemes
D, means diesel set

The most important reason for the existence of systems not registered looks to be the fact that the regulation requires neither licence nor permission to install electricity generation systems bellow 500kW, the owners only need to inform to the authority about the installation; but in practice none (or very few) of the systems installed by NGOs, Churches, communities, municipalities or privates have been reported to the authorities. Those few registered are because government representatives have noticed the existence of them and registered them.

Table 6.1 shows the initial and final composition of the survey sample, which was made of: 1 Government owned, 3 Municipality owned and 3 Community owned

hydro schemes, while for diesel sets it was made of 4 Municipality owned 1 Government owned, 1 Community owned and 1 private owned.

For easy of the identification and the preparation of tables and graphs, an (H) is added to the names of the villages with hydro schemes and a (D) to those villages with diesel sets.

6.1.1 Main features of the final survey sample

Table 6.2 shows the final composition of the survey sample. Although the intention was to preserve the initial considerations as much as possible, some changes were unavoidable or were convenient to be done.

Table 6.2 Main features of the sample surveyed

Village	Poverty index	Rated Power (kW)	Scheme age	Owner	No of interviewees	Number of Users
Maria(H)	0.0552	20	10	Community	28	149
Shitariyacu(H)	0.0596	120	5	Municipality	40	450
Mayorarca(H)	0.0622	40	9	Community	15	60
Chaviña(H)	0.0728	90	26	Government	25	346
Santa Catalina(H)	0.0756	90	7	Municipality	25	99
Longuita(H)	0.0785	40	7	Municipality	22	210
Las Juntas(H)	0.0866	25	5	Community	12	55
San Martin(D)	0.0438	50	6	Private	16	120
San Roque(D)	0.0597	60	6	Community	24	250
Limabamba(D)	0.0598	50	8	Municipality	21	60
Totora(D)	0.0711	50	7	Municipality	18	60
Tambo Quemado(D)	0.0728	40	5	Government	21	88
La Coipa(D)	0.0782	90	20	Municipality	25	250
Mazocruz(D)	0.0963	120	7	Municipality	45	350

The most important changes being: increasing the number of the survey sample from 13 to 14 systems and widening ownership and management to 4 categories

(Government, Municipality, Community and Private owned and/or managed) in stead of the 3 initially considered: Government, Municipality and Community owned.

Very few private owned hydro schemes all of them below 20kW[2] and used for productive uses were found in the official information and none during the field visits, therefore it was not possible to add a private owned hydro scheme to the survey sample as it was for diesel sets.

6.1.2 Poverty index

This indicator was developed by the Peruvian Government early in the1990s to be used as the main variable for the allocation of financial resources to FONCODES (The National Fund for Social Compensation). This programme was implemented to compensate the impact of the structural adjustment on the poor[3]. This indicator has similarities with the Human Development Index, but was done specifically for Peru, it was developed considering three levels: national, regional and district; 11 socioeconomic variables were used for the National and regional and other 8, the variables were weighted differently, more weight was given to the variables of infant mortality and malnutrition because it was understood that such variables are more related with the capacity for purchasing food; therefore it is believed that this indicator matches with the purpose of the present study, since the financial indicators of this study are related purchasing capacity of the people.

Figure 6.1 shows the poverty index for the sample survey ordered from less poor to the poorest, the first 7 in the left are the hydro schemes, the 7 in the right are the diesel sets; the size of the bars show the average dimension of poverty of each village, the higher the bar is the poorer the village is; the spread of the poverty indexes within the sample ranges from 0.04376 to 0.09627. While the whole national poverty index ranges from 0.0002 for the richest District[4] (San Isidro, located in the region of Lima) to 0.14243 for poorest District (Anchonga, located in the Region of Huancavelica) in the south Andes.

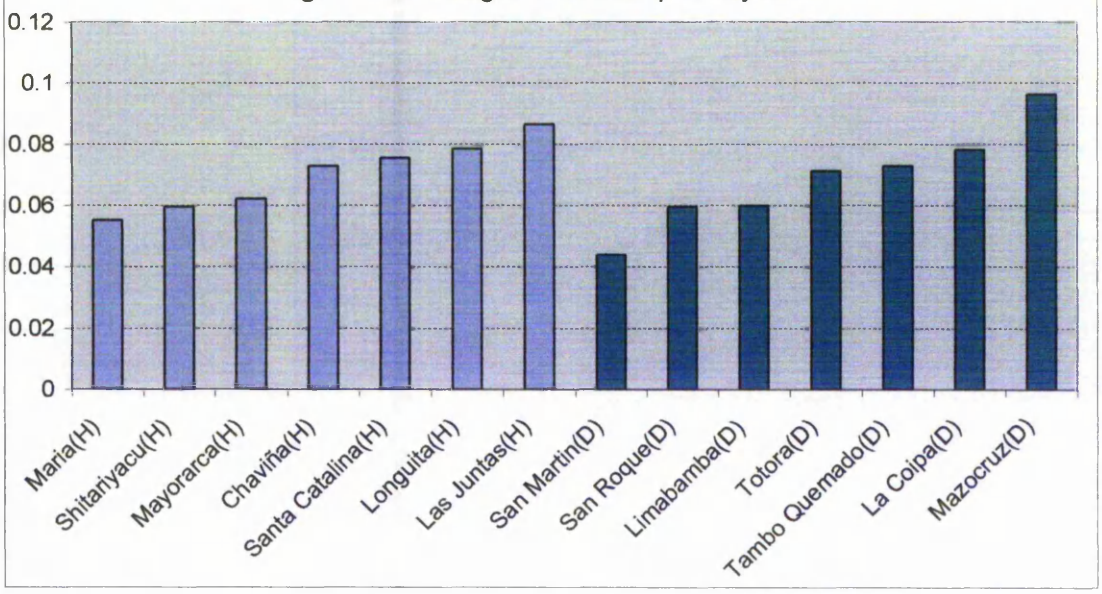
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[2] The range of the survey sample was made of stand alone energy systems for rural electrification from 20kW to 200kW

[3] The structural adjustment was mainly the privatization of the public assets, which happen in the nineties. See http://www.inei.gob.pe/biblioineipub/bancopub/Est/Lib0070/5-2.htm

[4] Within the political organisation of the country, District is the smallest geographical space recognised a representative from the central government (the order from largest to smallest is: Region, Province and District).

Fig 6.1The Villages and their poverty index



It was not possible to have a wider range of the poverty index for the sample survey because in the extreme of the poorest, quite a few villages have been connected to the grid during the decade of the 1990's as a result of the implementation of the programme of FONCODES, which was meant to reduce the poverty nationally, and therefore the expenditure was mainly in the poorest regions (especially in those considered in extreme poverty). In rural areas much of this programme was on the implementation of basic services like drinking water, electricity (with grid extension), basic roads, foot pathways; schools and health centres. In the other extreme, the richest villages or districts have already been connected to the grid, because they are located in urban areas in the larger cities like, Lima, Arequipa, Trujillo and others in the different parts of the country.

Although there is small difference in the maximums and minimums of the ranges for the two technologies studied, hydro schemes (0.0552 to 0.0886) and diesel sets (0.0438 to 0.0963), the average for each group separately is very similar, for hydro 0.0709 and for diesel sets 0.0705.

6.1.3 Size of the system

The chosen range for the study was from 20kW to 200kW; within this range the most popular systems are the smaller sizes, the sample includes two schemes of 120kW, and the others are spread within the range from 20kW to 100kW. The average for

the whole sample is 63.21 kW, but the averages for the hydro schemes is 60.71kW and the average for the diesel sets is 65.71kW

6.1.4 System age

For the most cases the scheme age was not known in advance (before the visit to the site), because it is information of public domain. The final survey sample was made of systems ranging from 5 to 26 years of age, although the majority of the schemes are within 5 to 10 years from commissioning. The average age for the whole sample is 9.14 years, with very similar average for both groups, for the hydro schemes is 9.86 years while for the diesel sets it is 8.43 years.

6.1.5 Ownership

The survey sample was made of 7 systems owned by Municipalities, 2 owned by the government, 4 owned by the communities and 1 private owned (see table 6.1).

6.1.6 Location

Regarding location of the systems the distribution was: 4 hydro schemes and 4 diesel sets from located in the Andes, 3 hydro schemes and 3 diesel sets located in the upper Jungle.

6.1.7 Sampling in the villages

Four strata of people were considered for the data collection in all the villages: domestic users, operators and administrators, business people, and leaders and authorities[5]; for each village the sample of users was made of about 6 to 20% of the families; the lower percentages were taken from those villages with larger populations.

The interviews were always made to adults, preferring the mother or the father, however in few cases it was necessary to interview another adult member of the family (in the absence of one of the fathers), for operators and administrators the interviews were done to either an administrator or operator; for business people the sample was made of at least 3 families of this strata in each village, and finally for leaders authorities at least 2 people either authorities or leaders were interviewed.

[5] Leaders and authorities were considered in one stratum because they are few leaders and few authorities in each case.

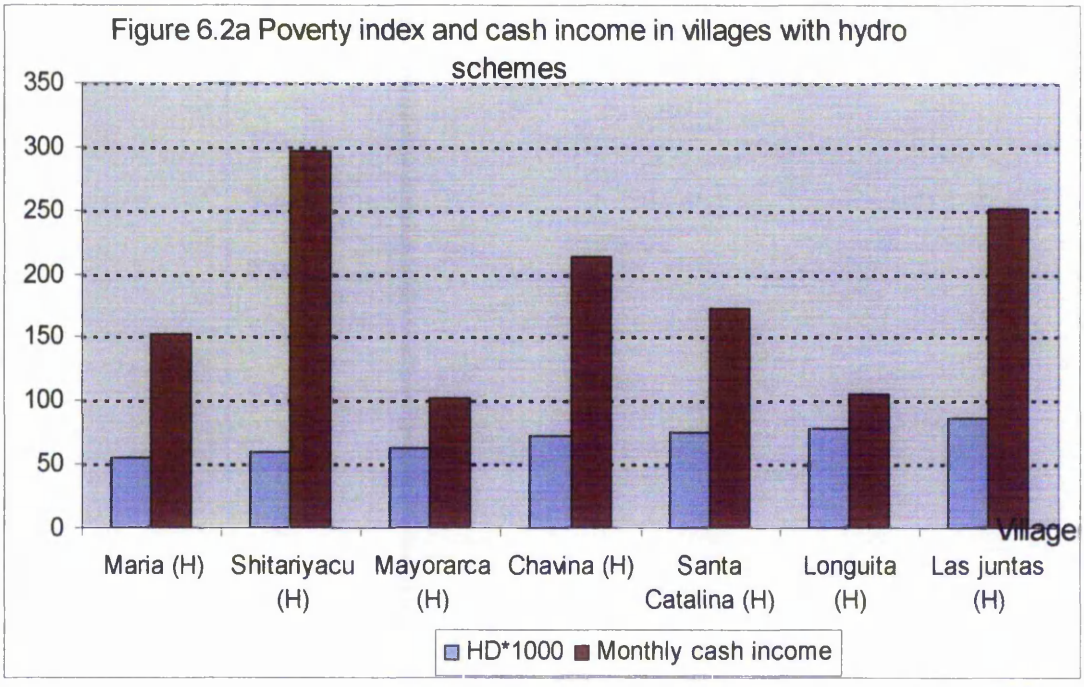
The methodology of data collection in each village was as described in chapter four; before the interviews it was important to meet the authorities and/or leaders and ask for their permission to do the study; for all cases the leaders and authorities accepted in first instance, but the consultation of the community members was also necessary, who in all cases accepted pleasantly.

6.2 Possible critical success factors (PCSF), trends and anomalies

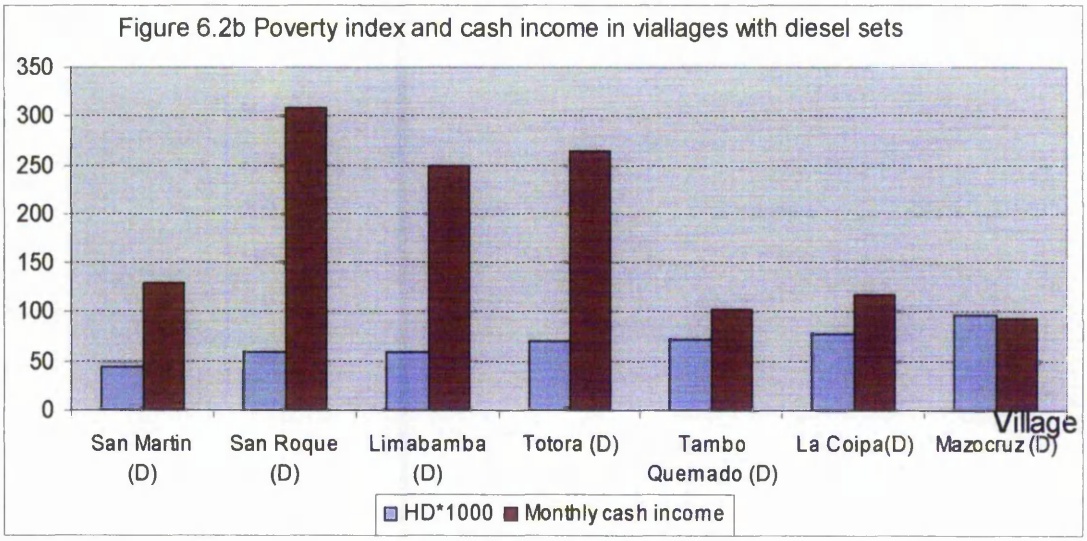
Financial factors

6.2.1 Capacity to pay

This PCSF refers to the financial situation of the customers in the different villages, their cash income from the different activities and their expenses in energy. The strata interviewed for this PCSF were the household energy users. Fig 6.2a and Fig 6.2b show the poverty index[6] and the average cash income per family for villages with hydro and villages with diesel sets respectively.



[6] The poverty index was multiplied by 1000 in both 6.2a and 6.2b figures in order to have a simple graph with one scale in the "y" axis.



For villages with hydro schemes there is not clear trend on the average cash income in relation to the poverty index, see figure 6.2a; but for diesel sets there is a more clearer trend, the higher the poverty index of the village is the lower the average cash income is, see figure 6.2b.

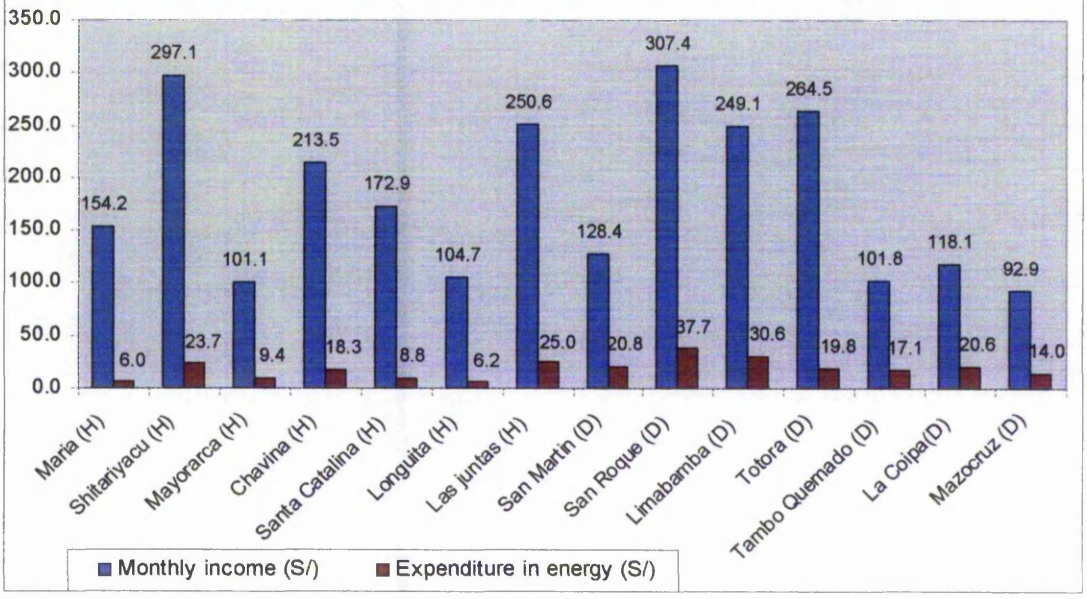
However the trend for hydro appears to be affected by Las Juntas (see Fig 6.2a at the extreme right of the figure), which appears as a clear anomaly, because it has the highest poverty index, but has the second highest cash income among the villages with hydro schemes. The reasons for that anomaly are not clear, however; among possible reasons are: Las Juntas is located next to the largest penetration Coast –Amazon [7] road, the installation of a the electricity scheme by the end of 1999 has had an important impact in the village, especially on the creation and/or improvement of small businesses and services, like cafes, food and shops which passengers, satellite telephone and others. However such high poverty index could also be due to errors in the estimation of the poverty index.

The average cash income for the samples of villages with hydro schemes and those with diesel sets is very similar, the 7 hydro schemes of the sample is S/. 184.6 (US$ 56.81) and for the villages with Diesel sets is S/180.3 (US$ 55.48)

[7] Penetration road is called to those, which connect the Towns along the Pacific Ocean (the cost) with those in the Amazon.

As shown in figure 6.3, the average monthly cash income per family ranges from as little as 92.9 Soles (US$ 28.6) to as much as 307 Soles (US$94.5)[8] monthly; The poorer the families are the lesser agricultural products they sell to the markets, Mazocruz being the extreme case, where almost 100% of the agriculture is for self-consumption, and their cash income comes from the sale of small domestic animals like chicken, guinea pigs, sheep, and in much lesser proportion from the sale of cattle, although some income also comes from remittances of one or more members of the family living out of the village.

Fig 6.3 Average monthly cash income and expenditure in energy (Soles)



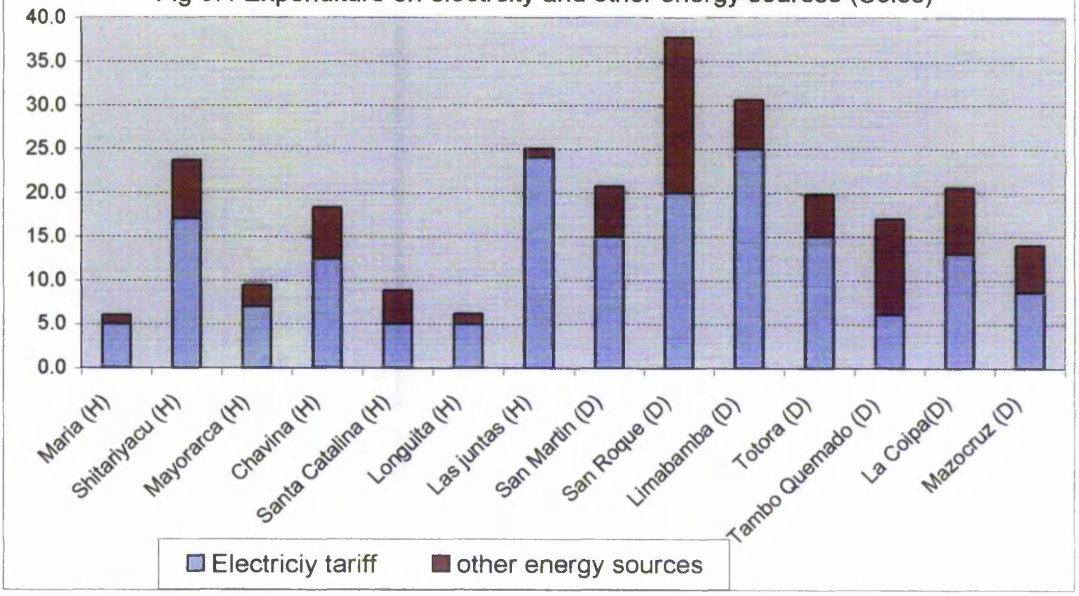
The results reveal that the location and isolation of the villages have some influence on the cash income of the families, the higher in the Andes the village is located the poorer the families are, and also the most isolated the village is the poorer the families are. For example for the villages with hydro, Mayorarca is located in the high Andes and Longuita in the Upper Jungle but very isolated; Las Juntas have very good connection with large towns. For those with diesel sets, Mazocruz is in the very high Andes, but Tambo Quemado and La Coipa are isolated villages in the Upper Jungle, see Table 6.1 and Fig 6.3.

[8] It is important to bear in mind that these figures could be not compared with the figure of 1US$ per day for those considered to be in extreme poverty, because these figures do not count their food, which is produced by themselves.

As shown in figure 6.3, families living in villages with diesel sets expend more in energy[9] than those living in villages with hydro by an average of 40%, similar situation happen for electricity alone; although this average figure is in some way twisted by three of them with much higher tariff (Las Juntas, Shitariyacu and Chaviña).

Figure 6.3 also shows that, within the villages with hydro schemes, those better off in terms of cash income have a higher monthly expenditure on energy, see the case of Shitariyacu, Chaviña and Las Juntas; similar situation happens for the villages with diesel sets (see San Roque, Limabamba and Totora)

Fig 6.4 Expenditure on electrcity and other energy sources (Soles)



As shown in figure 6.4 the total monthly expenditure on energy ranges from 6.0 Soles (US$1.85) to 37.7 Soles (US$ 11.6), considering both electricity and other sources; but the expenditure on electricity ranges from 5.0 Soles (US$ 1.54) to 24.0 Soles (US$ 7.38), and the expenditure on complementary sources of energy ranges from as little as 1.0 Soles (US$ 0.31) to as much as 17.7 Soles (US$ 5.20). The most common complementary sorts of energy being wax candles, kerosene, dry batteries and exceptionally wet batteries, these complementary sources are only for lighting at home and/or for torches at night.

[9] For this study energy includes electricity and complementary sources such as kerosene, wax candles, dray and wet batteries.

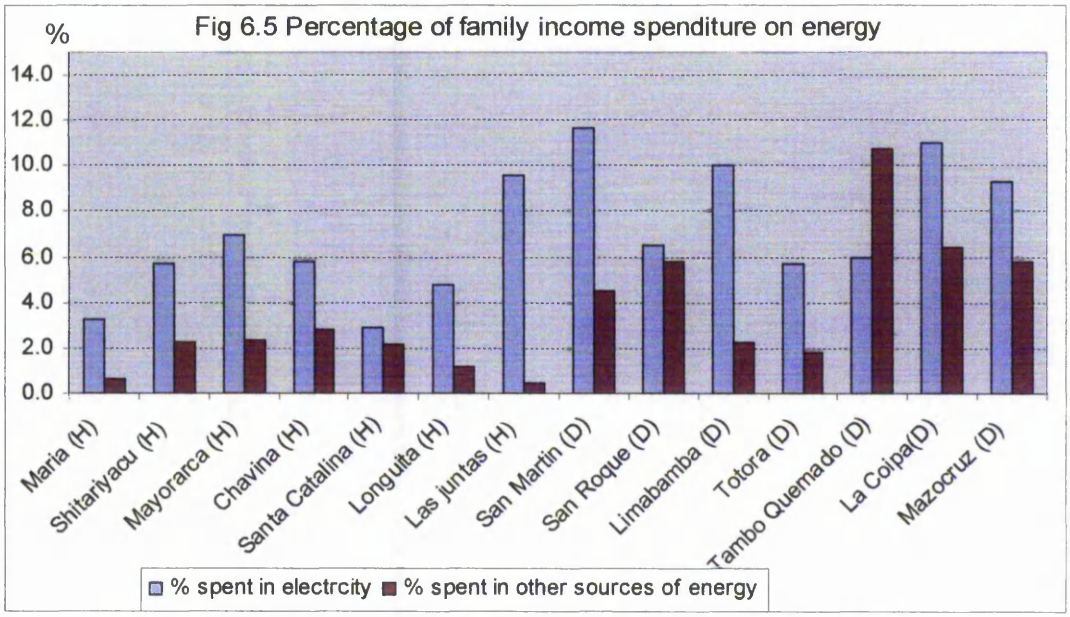


Figure 6.5 shows that families living in villages with diesel sets expend a much higher percentage of their cash income in energy (including both electricity tariffs and complementary energy sources); looking at the complementary energy sources only, it also happens that families living in the villages with diesel sets expend a larger proportion of their cash income on complementary sources of energy. It was found that villages with hydro schemes expend an average of 7.25% of their income on energy, while villages with diesel sets expend an average of 14% of their cash income on energy. The main reasons for the purchase of complementary energy sources is that diesel sets provide only few hours of electricity service daily, and also because most diesel sets have a considerable number of down time days during the year.

The smallest average expenditure on complementary sources of energy happens in Las Juntas, according to the comments of the interviewees, such a low expenditure is mainly on dry batteries for torches for occasional use on visits their farms by night or early mornings to do specific activities like irrigation, they do not use torches for home lighting or radio, because they have a reliable electricity services the whole year round.

Figure 6.6a) and 6.6b) show a linear trendline regression of energy expenditure as a percentage of their income Vs poverty index separately for hydro schemes and for diesel sets; although the correlation coefficients (R-squared) are low for both cases,

both indicate upward trends. These figures also show families with diesel sets generally spend a higher percentage of their income to purchase energy.

Fig 6.6 a) Correlation expenditure on energy and povety index, villages with hydro schemes

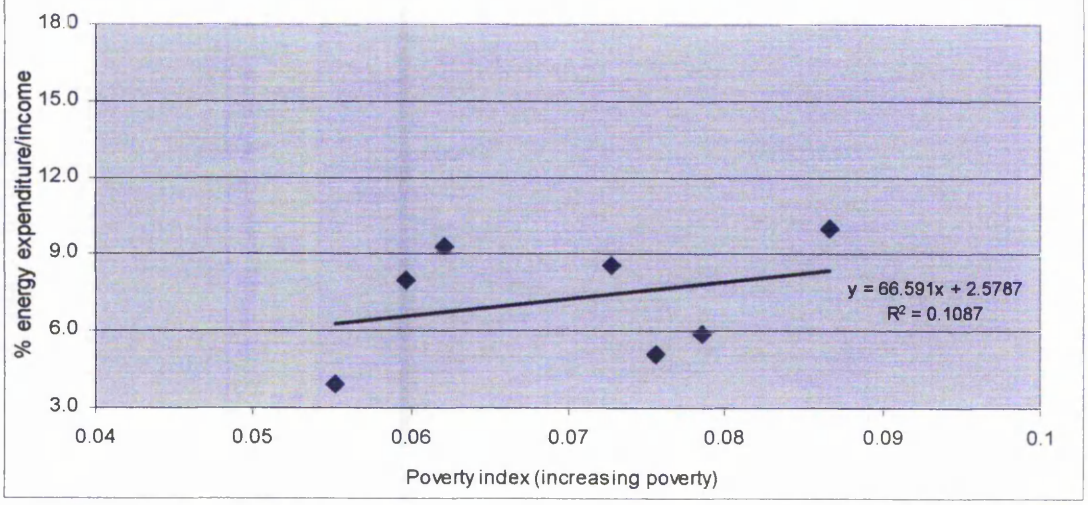
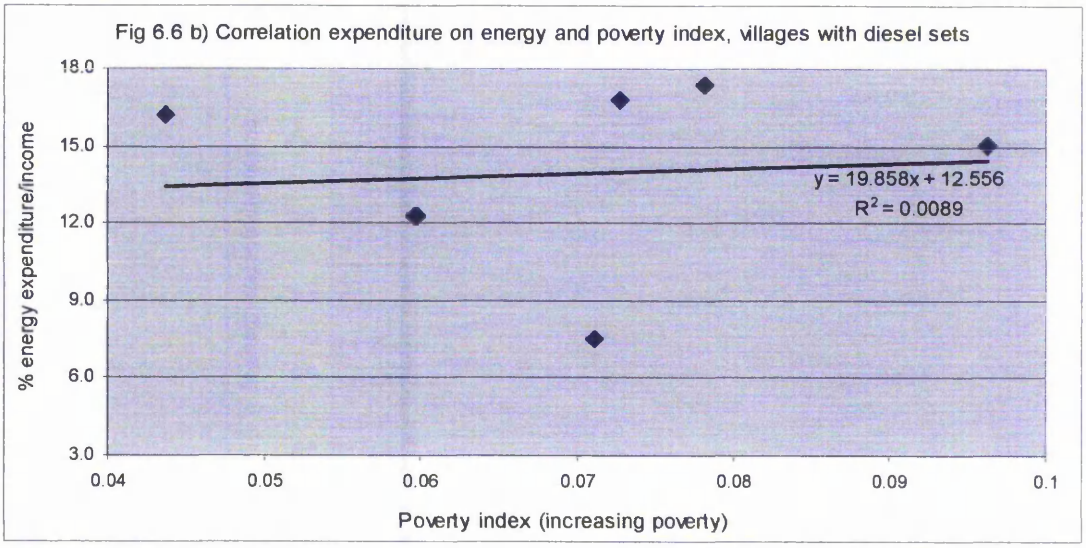


Fig 6.6 b) Correlation expenditure on energy and poverty index, villages with diesel sets



6.2.2 Cost of energy

Two strata were interviewed regarding this PCF: domestic users and owners of small businesses.

6.2.2.1 Cost of energy for domestic users

a) Tariffs. - Three types of tariffs where found: 1) One hydro scheme and one diesel set- use the government regulated tariff[10]; 2) One hydro scheme and one diesel set-

[10] The National Body for tariff regulation is OSINERG (The National Office for Energy Regulations and Tariffs). The present regulated tariff for rural electricity is 0.52 Soles per kWh

use a metered tariff but not regulated, the hydro scheme is Community owned and the diesel set is Municipality owned; 3) Ten systems have flat tariffs. Table 6.3 shows the sort of tariff used in each village and the average monthly payments for electricity service.

Important disparities have been found in both hydro schemes and diesel sets regarding tariffs. The highest average pay for electricity service among hydro schemes happens in Las Juntas – with a descending block metered tariff[11], followed by Shitariyacu and in third place Chaviña; the other 4 hydro schemes have very low flat tariffs.

Table 6.3 Tariff structures and monthly average payments

Village	Tariff	Payment (S/)
Maria(H)	Flat	5
Shitariyacu(H)	Flat	17
Mayorarca(H)	Flat	7
Chaviña(H)	Regulated*	12.4
Santa Catalina(H)	Flat	5
Longuita(H)	Flat	5
Las Juntas(H)	Metered not-regulated (Descendant block)	24
San Martin(D)	Flat	15
San Roque(D)	Flat	20
Limabamba(D)	Flat	25
Totora (D)	Flat	15
Tambo Qemado(D)	Regulated*	6.1
La Coipa	Flat	15
Mazocruz(D)	Metered** 1.0 Soles per kWh	8.6

*Have regulated tariff (from the national body of tariff setting, Soles 0.52 per kWh)

** Charges according to consumption at a rate of Soles 1.0 per kWh

Similar disparities happen for diesel sets; the village with regulated tariff –Tambo Quemado – has the smallest monthly average tariff of all the villages with diesel

[11] The descendant block tariff of Las Juntas uses 3 blocks; the first block from 0 to 20 kWh of consumption costs Soles 0.52 Soles per kWh, the second block from 20 to 60 kWh costs 0.40 Soles per kWh, while from 60kWh onwards costs 0.10 Soles per kWh.

sets, the second smallest tariff is in Mazocruz (despite having a very high metered tariff), the other five villages have different flat tariffs and they all pay a higher monthly amount for the electricity service.

The above findings show that the poverty index has not been taking into consideration for tariff setting in the villages of the survey sample; each village had set its tariff using their own criteria, without coordination with other villages and without supervision and/or advice of any kind (except for special cases)[12], except for government owned systems.

b) Cost of energy. - Figure 6.7 shows that families living in villages with diesel sets clearly pay a much higher amount per unit of energy consumed; while the average energy cost for the survey sample of hydro schemes is 0.18 Soles (US$ 0.055) per kWh, the average cost for diesel sets is 1.61Soles (0.49 US$) per kWh; in other words, families living in villages with diesel sets pay about nine times the amount paid by families living in villages with hydro schemes.

In the villages with diesel sets, where electricity is metered, despite the apparently "high unit energy cost" (0.52 Soles in Tambo Quemado and 1.0 Soles in Mazocruz), in both cases the average monthly pay of the families is low compared with those systems with flat tariff rates (see figure 6.7). Tambo Quemado uses a regulated tariff while Mazocruz simple uses an agreed tariff (the agreement is between the Major and the users). It is interesting to notice that people can easily refuse high cost per unit for metered tariff, because they can compare that with regulated tariff of the closet town[13]. Therefore from the administrative point of view (income), it will be simple and convenient for the management to use flat tariffs.

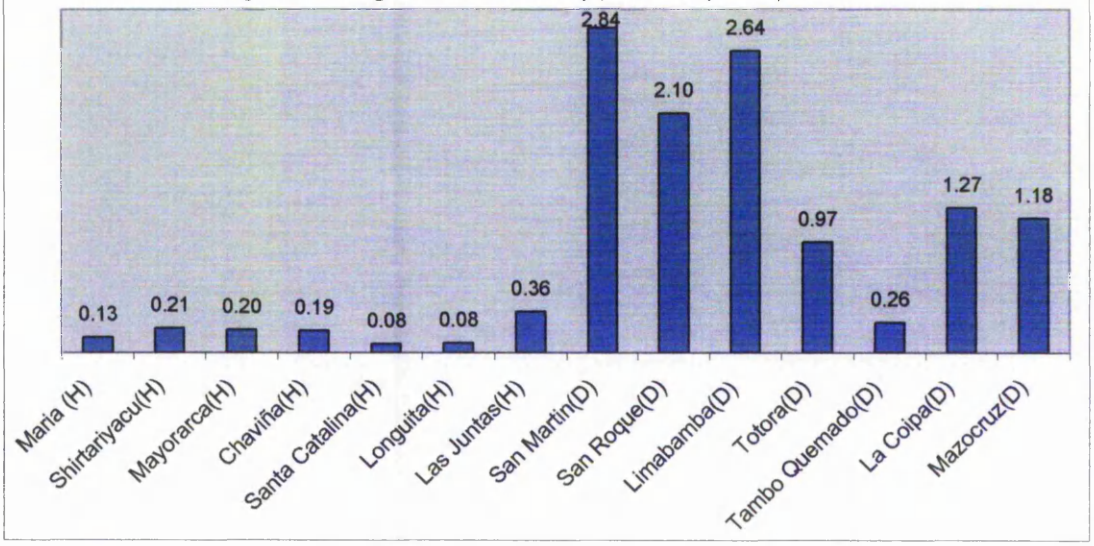
Despite to the fact that Tambo Quemado has a regulated tariff of 0.52 Soles per kWh, the actual average cost of energy is only 50% of that amount (0.26 soles), this is because people only pay metered in their home, they do not pay public lighting neither any losses. According to the data collected the total energy generated is about twice the total energy metered.

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[12] Schemes installed by NGOs, Churches and other development agencies generally have had some sort of advice and/or supervision when the tariff scheme had been set, such as the case of Las Juntas.

[13] In Mazocruz for example the major explained that he could not increase the cost since 2003 because people compare with the unit cot of the regulated tariff which was about 0.48 Soles.

Fig 6.7 Average cost of electrcity per kWh (Soles)



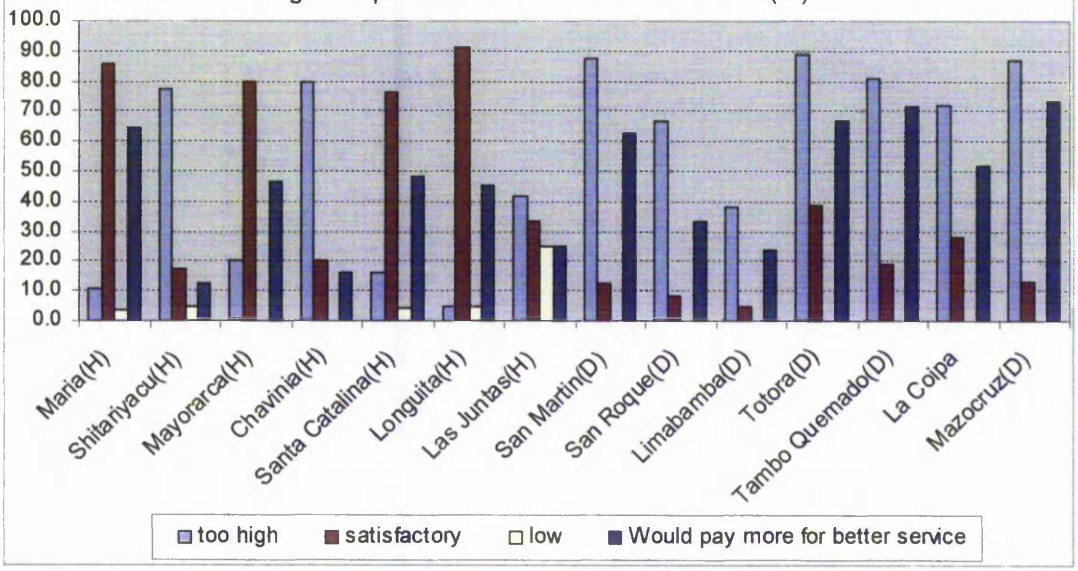
c) Opinion of the users about the cost of energy and willingness to pay more. - The amount paid for electricity does not necessarily influence much on the opinion of domestic users about the appropriateness of the tariff; for example in Chaviña (with very low average monthly pay), about 80% of the interviewees said that the tariff is too high; while in Las Juntas with tariff about twice higher than in Chaviña people have a better opinion about the appropriateness of their tariff, also in Las Juntas there is a split of too high, satisfactory and low (see figure 6.8).

Few users of the hydro schemes express their willingness to pay more for electricity provided they have a better service; while most of the users with diesel sets say that they would pay more for better electricity service, despite to the fact that they are already paying a large amount.

The understanding about good or bad service is not uniform; in Mayorarca most of those who would pay more for the service, express their interest in 24 hours service, but there is no other complain, implying that for them a better service means to have electricity 24 hours service instead of the 12 hours they have now. In Chaviña, most of those who express their willingness for paying more think that they are ignored by the management that they have not been asked for opinion of any type, implying that a better service means better attention from the management of the scheme. In Las Juntas most of those who expressed their willingness to pay more believe that they have a too small scheme, implying that a better service means a larger scheme. In the villages with diesel sets, the idea of better service is basically related to the hours

of service and the number of days of service per year, since most of them has large number of down time days and few hours service per day.

Fig 6.8 Opinion of the users about the tariffs (%)



6.2.2.2 Cost of energy for other groups of the population

The only group that has a different tariff are those families that hold small business activities; this section includes the tariffs and cost of energy for this particular group and their opinion about the cost.

a) Tariffs for business people. - In all the villages of the survey sample the tariffs for business people is slightly higher than for the domestic users (for either with metered tariff or with flat tariff), see table 6.4. As for domestic use, the tariffs are set in different ways, and basically depend on the management of the system.

b) Cost of energy. - Apart from those systems with metered energy, it is not possible to establish the cost per unit kWh for business people, however it is possible to figure out that in all villages with flat tariffs, the unit energy cost for business people is cheaper than for domestic users because business people generally pay either the same or slightly higher amount than domestic users, but they use energy much more intensively, they have more appliances and more lighting bulbs.

Table 6.4 Average monthly pay for business people		
Village	Tariff	Average monthly pay
Maria (H)	Flat	10.00
Shitariyacu (H)	Flat	25
Mayorarca(H)	Flat	10
Chaviña (H)	Regulated*	18.3
Santa Catalina(H)	Flat	5.00
Longuita(H)	Flat	5.00
Las Juntas(H)	Metered not regulated (Descending blocks)	34
San Martin(D)	Flat	15
Roque(D)	Flat	35
Limabamba(D)	Flat	25.00
Totora(D)	Flat	15.00
Tambo Quemado(D)	Regulated*	9
Copia(D)	Flat	26
Mazocruz(D)	Metered** 1.0 Soles per kWh	9.67
*Uses the a tariff regulated by the national body of tariff setting, Soles 0.52 per kWh ** Charges according to consumption at a rate of Soles 1.0 per kWh		

c) Opinion of other groups of people. - The opinion of the operators and administrators about the amount paid for electricity is justifying the existing tariff and the criteria they apply (if any). When the tariffs are low, as happens for most hydro schemes, they argue that "people are poor in the village", however most of them recognise the need to raise the income of the system via increasing tariffs. In those systems where customers pay more, as in Las Juntas (within hydro schemes) and in most of the diesel sets, leaders and authorities have a better understanding of costs and financial issues, and they feel that such high amounts are needed in order to keep the schemes running.

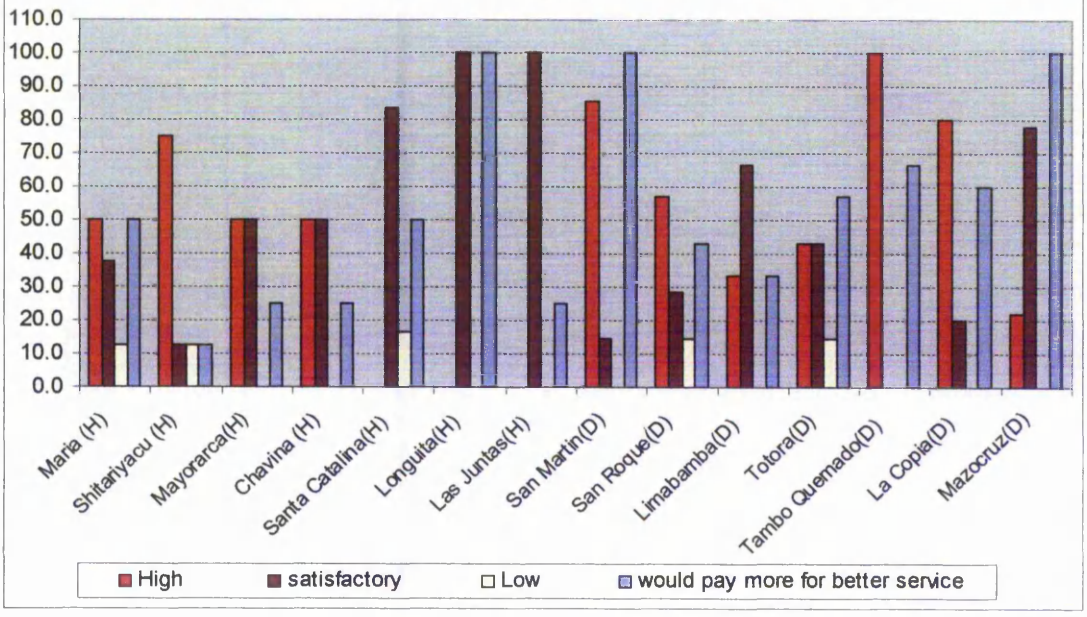
The opinion of the group of business people is shown in figure 6.9. In most villages with hydro schemes the majority think that the tariffs are satisfactory, but a significant proportion of these strata think that the tariffs are high, only a small percentage thinks that the tariffs are low. In villages with diesel sets the majority think that the

tariff for their group is high, some think that it is satisfactory and very few (only in two villages) think that it is low.

Comparing villages with hydro schemes with those with diesel sets, more people in the group of business holders express their willingness to pay more for better service.

As for domestic users, the understanding of better service is different for the different villages, for example in Shitariyacu, they understand that a better service would provide more days of energy during the year; in Las Juntas people think that they could have a better service (despite that most of them recognise that their service is good) if they had a larger scheme. Business people from villages with diesel sets generally complain about the short time service, they understand that with more hours service they could do more business, especially those who sell food or have shops, hence they express they willingness to pay more for a better service.

Fig 6.9 Opinion of business people about the electrcity tariffs (%)



6.2.3 Connection cost

6.2.3.1 Domestic users

As shown in table 6.5; out of the 14 villages surveyed, in 12 of them the average connection cost has been low, between 10 to 50 Soles (US$3.08 to 15.38); only in 2 villages it had been much higher, Las Juntas 100 Soles (US$ 30.77) and Chaviña

350 Soles (US$ 107.70). In Las Juntas, the leaders explained that connection cost had been agreed among the users early in the process of installation and it had been the amount needed to pay for the hooks, while in Chaviña the connection cost was just informed by the utility.

Table 6.5 Connection costs to domestic users (in Soles)			
Hydro schemes	(S/.)	Diesel sets	(S/.)
Maria (H)	50	San Martin (D)	20
Shitariyacu (H)	20	San Roque (D)	6.8
Mayorarca (H)	20	Limabamba (D)	50
Chaviña (H)	270	Totora (D)	30
Santa Catalina(H)	50	Tambo Quemado (D)	20
Longuita (H)	10	La Coipa (D)	30
Las Juntas (H)	100	Mazocruz (D)	20

It was also found that in 5 systems, 3 hydro schemes (Shitariyacu, Chaviña and Mayorarca) and 2 diesel sets (San Roque and Mazocruz); the amounts paid for connection have been random. In Chaviña the users had been charged from as little as 10 Soles to as much as 510 Soles, almost half of the interviewees said they do not remember how much they had been charged and the administrators did not know about the past charges, especially those that happened at the beginning of the operation of the systems.

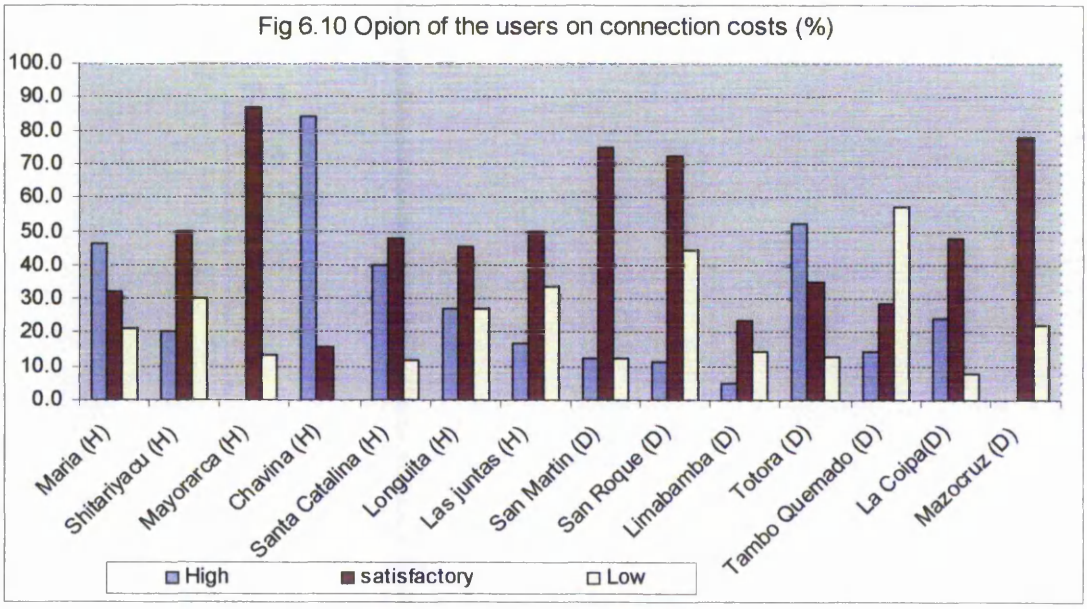
Table 6.5 shows that if Chaviña is excluded from the hydro schemes, it comes out that the average connection cost in villages with hydro and villages with diesel are pretty similar to each other.

Regarding opinion about the connection cost, as shown in figure 6.10, those living in villages where connection costs had been low, they said that it had been satisfactory; the exception being the case of Las Juntas, where despite the relatively high charge for connection most people said it had been satisfactory and a large proportion of the interviewees said it had been cheap.

6.2.3.2 Connection costs for other groups.

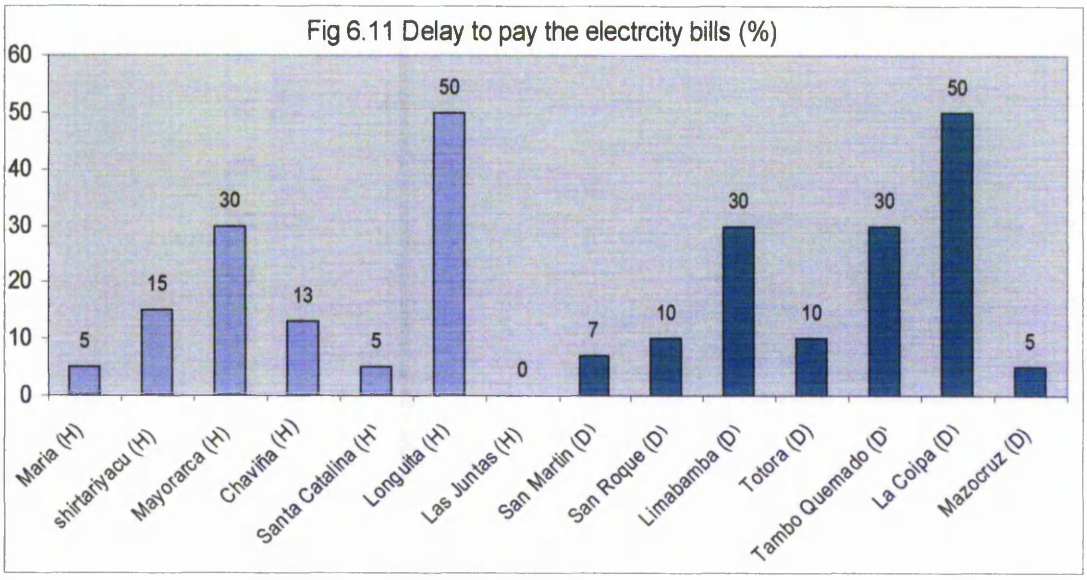
Regarding the other sectors of the populations, their connection costs had been much the same as for domestic users, except for the case of Las Juntas, where for

businesses had been double (200 Soles), and in Mazocruz where the connection cost for the business sector varied case by case, averaging 26 Soles.



6.2.4 Effective bill collection

As shown in figure 6.11, most systems have considerable delays on bill collection; however it is more frequent and with higher percentages for diesel sets than it is for hydro schemes.



The results reveal that the size of the tariff does not influence the level of the delays in paying the bill; for example, La Coipa has the lowest tariff among villages with diesel sets, but it has the highest delays on bill collection (about 50%), while San Martin has slightly higher tariff but has only 5% of delay. In Las Juntas despite that it has the highest average pay per family of all the systems, the delay to pay remains very close to "0" every month.

The above findings imply that the size of the tariff paid for electricity has little or no influence over effective bill collection, but the sort of administration influences it, in fact in both systems under private administration (Las Juntas and San Martin) the bill collection is good.

The reasons for delay to pay were found to be: lack of money, quality of service (hours of service), relation customer – administrator (in that community managed systems people generally felt that they have better elation with the administrators), lack of rules to enforce commitments of the users. Nevertheless in 7 out of the 14 villages it was found that the delay is equal or below 10%. It was also found that in average, villages with hydro have a better bill collection.

Table 6.6 Information records of administration team

Villages with hydro schemes			Villages with diesel sets		
Village	Have list of users	Have accounts books	village	Have list of users	Have accounts book
Maria (H)	Yes	No	San Martin (D)	Yes	No
Shirtariyacu (H)	Yes	Yes	San Roque (D)	Yes	Yes
Mayorarca (H)	Yes	Yes	Limabamba (D)	Yes	No
Chaviña (H)	Yes	Yes	Totora (D)	Yes	No
Santa Catalina (H)	Yes	No	Tambo Quemado (D)	Yes	Yes
Longuita (H)	Yes	No	La Coipa (D)	Yes	No
Las Juntas (H)	Yes	Yes	Mazocruz (D)	Yes	No

From the interviews to administrators and operators, it was found that all villages have a list of users, but only six of them have account books, the others have simple written notes were administrators register the date of the pay and the amount (see table 6.6). The lack of proper accounts or records generates confusion and contributes to the delay to pay.

Most administrators claim that they have penalties to apply to those that fail to meet the rules (like paying late, unauthorised connections, and others). Three types of penalties were shown cut of the service, fine, or both; in fact all of them claim that they apply at least one of the penalties; see table 6.7.

Table 6.7 Penalties for delay to pay

Villages with hydropower schemes			Villages with diesel sets		
Village	Cut service	Fine	Villages	Cut service	Fine
Maria (H)	X		San Martin (D)	X	
Shirtariyacu (H)		X	San Roque (D)	X	X
Mayorarca (H)			Limabamba (D)	X	
Chaviña (H)	X	X	Totora (D)	X	
Santa Catalina (H)	X		Tambo Quemado (D)	X	X
Longuita (H)	X		La Coipa (D)	X	X
Las Juntas (H)	X	X	Mazocruz (D)	X	

Although most villages consider the cut of service as a penalty in practice they hardly use it, except for those systems managed by the utilities (government owned) and San Martin (private scheme). For example in Longuita, the penalty is the cut of service, however this village shows one of the two highest delays to pay of all the survey sample; In La Coipa, they decided to apply both penalties, yet this village is also among the two with highest delay to pay.

In Mayorarca, they have not considered penalties, however they are the fifth highest delay to pay (but not the worst). In Las Juntas they have considered the two sorts of penalties and have an effective bill collection, the operators and administrators interviewed said that they have applied the rules in few occasions.

It was found that in the systems owned and managed by Municipalities, the application of rules is more difficult than in the other cases, that is because of the concern of the Majors about possible negative impacts on their image, which evidences the political interests of these authorities of using the services as political tools keep their power.

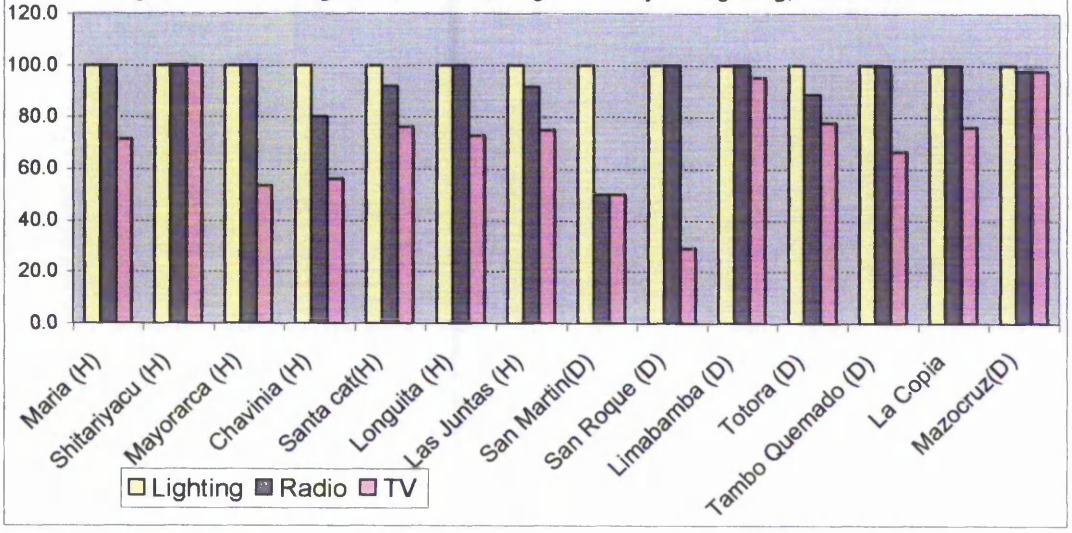
Social factors

6.2.5 Benefits from electricity on household

6.2.5.1 Use of electricity

a) The most popular uses of electricity in the villages. - Figure 6.12 shows that lighting; radio and TV are the most popular (or primary) electricity uses by far in all the villages; 100% of the interviewees said that they use; an average of 93.5% use it to play small radios and 75% to play TVs. Figure 6.12 also shows that the technology for electricity generation does not make much difference in the preference for the use of electricity for lighting, radio and TV; in fact 94% and 74.5% of people living in villages with hydro schemes use radio and TV respectively; while in villages with diesel sets 93% and 74.5% use radio and TV respectively.

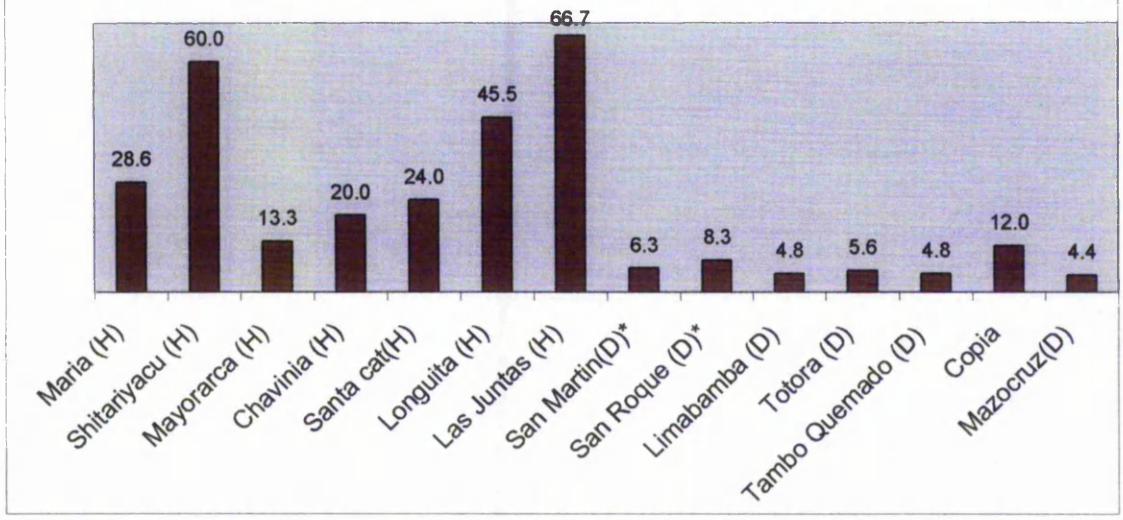
Fig 6.12 Percentage of families using electrcity for lighting, radio and TV



The use of appliances in rural areas is small; and in this cases the technology maters. Only 75 electrical appliances were found within the whole survey sample, 64 of them in villages with hydro schemes and the remaining 11 in villages with diesel sets. The most important reason for such inequities is the number of hours of service per day; while hydro schemes provide 24 hours service, except for Mayorarca[14], those for villages with diesel sets provide only few hours, ranging from 2 and 5 hours during the night.

[14] There is no technical reason to use the hydro system for 12 hours per day, however it make sense for them, because all their members spend most of the day on farming.

Fig 6. 13 Number of appliances per each 100 families



Another factor that influences on the number of appliances in the villages is their weather conditions. A total of 15 refrigerators were found, 14 in villages with warm weather (Upper Jungle), and 1 in an Andean village[15] all these in the villages with hydro schemes. It is important to point out that 2 kerosene refrigerators were found in villages with diesel sets located in the Upper Jungle.

The fourth most popular appliance was found to be the VHS systems, after lighting, radio and TV in both villages with hydro schemes and diesel sets, this is because VHS are generally used for short periods of time, which fits with the supply time even in the villages with diesel sets (1 to 2 hours); nevertheless those villages with hydro schemes tend to have more VHS than those villages with diesel sets.

Despite the isolation of the villages and their situation of poverty, there are some people (generally those better off) who can access to other modem appliances like DVDs and computers, see table 6.8

Figure 6.13 shows the number of appliances per each 100 families in the different villages of the survey sample. The results show that there is no influence of the poverty index on the use of appliances. The four villages with hydro schemes that have more appliances are those in both extremes of the poverty index; Shitariyacu

[15] The Andean Village with a refrigerator is Santa Catalina, which is in relatively lower altitude than the other Andean Villages with hydro.

and Maria with the lowest poverty index and, Las Juntas and Longuita in the extreme of the highest poverty index.

Table 6.8 shows all the appliances found within the villages of the survey sample. It should be noted that most appliances are for recreation activities, for example 32 out of the 75 are either VHS or DVD. Therefore if we consider that the use of radio and TV has connection with recreation, it comes out that recreation appliances are those largely preferred by people. Although the understanding of villagers is that radio and TV are used to get access to information rather than for recreation.

Table 6.8 Appliances used in the different villages

Village	No of appliances used							
	Refrigerat.	VHS	DVD	Comp.	Mixers	Irons	Fans	Hair dryers
Maria (H)	0	3	2	0	1	2	0	0
Shitariyacu (H)	8	4	3	0	0	3	6	0
Mayorarca (H)	0	1	0	0	0	0	0	1
Chaviña (H)	0	2	0	0	2	1	0	0
Santa Catalina(H)	1	3	1	0	0	1	0	0
Longuita (H)	3	2	1	1	0	0	3	0
Las Juntas (H)	2	0	0	0	2	0	4	0
San Martin(D)*	0	1	0	0	0	0	0	0
San Roque (D)*	0	2	0	0	0		0	0
Limabamba (D)	0	0	0	1	0	0	0	0
Totora (D)	0	1	0	0	0	0	0	0
Tambo Quemado (D)	0	1	0	0	0	0	0	0
La Copia	0	2	1	0	0	0	0	0
Mazocruz(D)	0	1	1	0	0	0	0	0
Total	14	23	9	2	5	7	13	1

* A refrigerator operated by kerosene was found in each of these two villages

b) Opinion of the interviewees about benefits of electricity services. – For this particular issue, the whole set of questions were applied to 100% users sample; therefore each answer is compared against the total (100%).

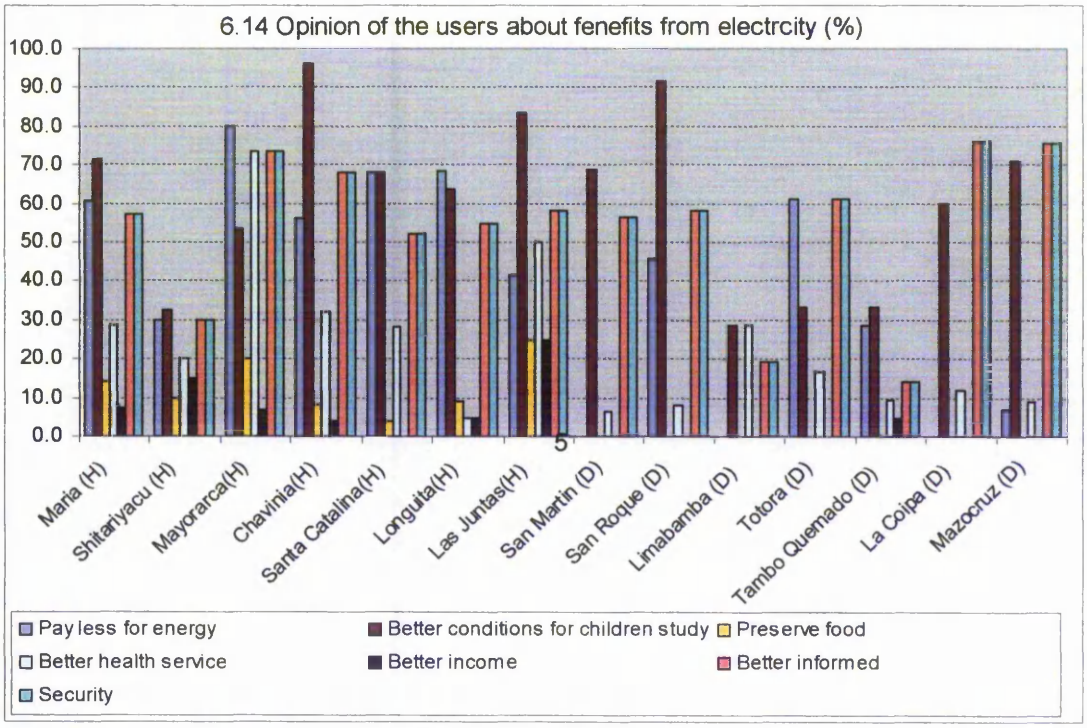
Both villages with hydro schemes and those with diesel sets consider that better conditions for children to study, access to more and better information, and security are the three most important benefits they get from electricity; other benefits like paying less for energy[16], preserve food and income generation apply on a lesser extent for villages with small hydro, see figure 6.14

Among the services highlighted by the interviewees are lighting for health centres, use of electricity in schools (basically for lighting) and security in the streets during the nights, which can only be possible with 24 hours electricity service, therefore only possible in villages with hydro schemes.

In all villages with hydro schemes, a significant number of interviewees consider that electricity play an important role on getting better health services; while only in four villages with diesel sets there were some users that that consider electricity is playing a role on better health services.

Despite the fact that none of the household interviewees use electricity for income generation activities, in villages with hydro schemes people are more optimistic about opportunities for productive uses and income generation activities using electricity, this is because they learn by viewing from other villagers (those with small business) about the use of electricity for small business or services in their own villages.

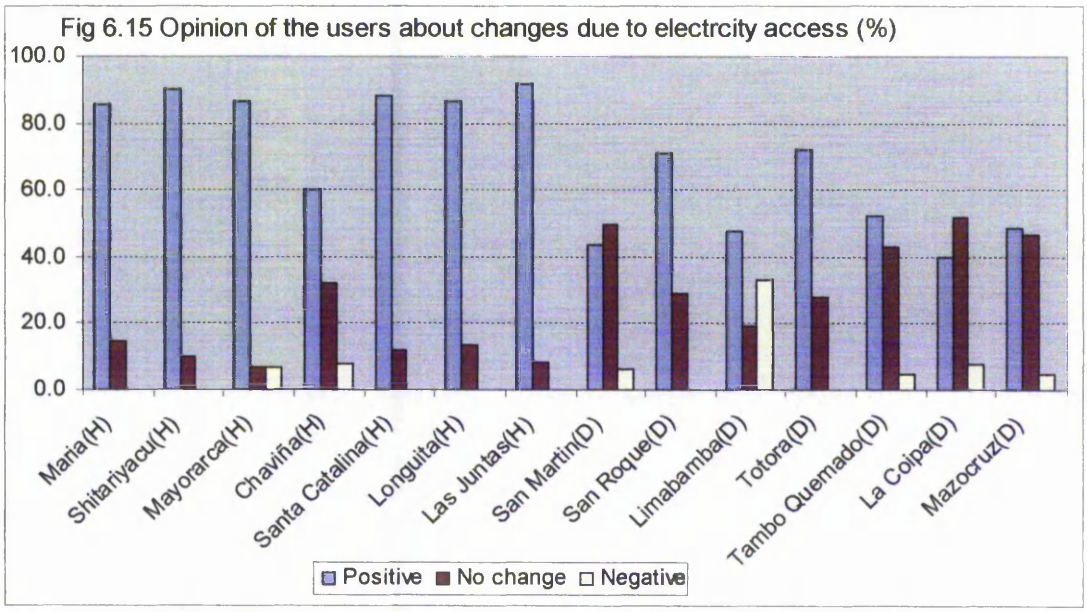
[16] The amount paid by electricity was compared with other kind of energy sources, which could be used when electricity is not present.



c) Opinion of users about changes due to access to electricity. - Figure 6.15 shows that users from villages with hydro schemes are more optimistic regarding the good impact of electricity; in fact between 80% to 90% of the users recognise that electricity have brought positive changes; except for Chaviña where only 60% think in a similar way. In villages with diesel sets, in two of them about 70% of the users think that electricity brought positive changes; in the others only about 40% to 50% think in the same way.

An important proportion of the users think that electricity has not brought changes to their villages; such proportion is higher for the villages with diesel sets than for those with hydro schemes. And finally a very small proportion of users think that electricity brought negative changes.

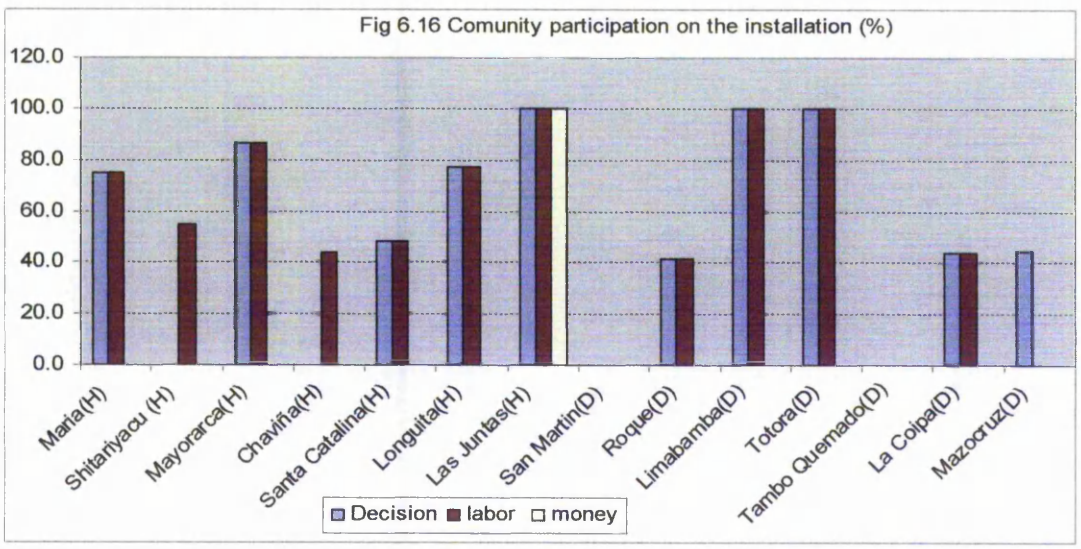
Users that claim negative impacts from electricity argue that the use of TV spoils their culture, their moral and/or religious principles. Among the examples they mentioned the changes on clothing, lack of respect for elder people, and others mainly related to the behaviour of young people.



6.2.6 Community participation

a) Community participation in the installation of the systems

The questions on community participation were aimed at finding out weather people have taken part in the implementation of the systems and weather they take part in the running of the systems. It was found difficult to establish the actual participation extent of the users in the process on implementation, because among other reasons, with time the number of users has grown differently for each system, and those users that got access to electricity after the first year of operation of the system had not taken part in the installation. The most relevant findings are as follows:



For hydro schemes, those installed by NGOs, Church and Municipalities had more participation in the decision making for the installation, with a relative higher participation in those systems where management had been handed over to communities (case of Las Juntas, Mayorarca and Maria); while for those systems installed by the government (see figure 6.16 and table 6.9) there had not been participation of the community – those had been installed very much under a top-down approach.

In villages with hydro schemes the most common way of participation had been through contribution with labour, only in one case –Las Juntas- there had been actual contribution of the villagers with money.

As for villages with diesel sets, in two cases there had been no community participation of any kind, these were Tambo Quemado – government owned -, and San Martin - private owned-. However in San Roque -also government owned- there had been participation of the community in both decision-making and labour for the installation. This facts show that government used different approach for each case. According to the authorities of San Roque, the reason for active participation of the community had been the commitment of the government to hand over the ownership to the community once the system is installed[17].

In the other four diesel sets installed by the Municipalities there had been community participation in decision-making; in three of them there had also been participation with labour. In Mazocruz it was found that had not been community participation because the implementing organisation (municipality) had not considered it necessary or convenient, there is not a clear reason for such consideration.

b) The investment.

As shown in table 6.9, from the studied sample it comes out that the most frequent investors on electricity is small isolated villages are the municipalities, the second is the central government, NGOs in third place and, the church and private appear with one case each out of the total of 14 villages. However it should be pointed out that Municipalities have got the financial resources from central or regional governments, either the total or partial.

[17] The decision of handing the scheme over the community once it is installed had been told to the community since the very beginning.

The study also reveals that NGOs and the church prefer to invest in hydro schemes rather than in diesel sets, while municipalities prefer diesel sets. The preferences of the municipalities for this technology appear to be the short duration period of a Major (according to constitution local authorities used to be only 3 years[18]

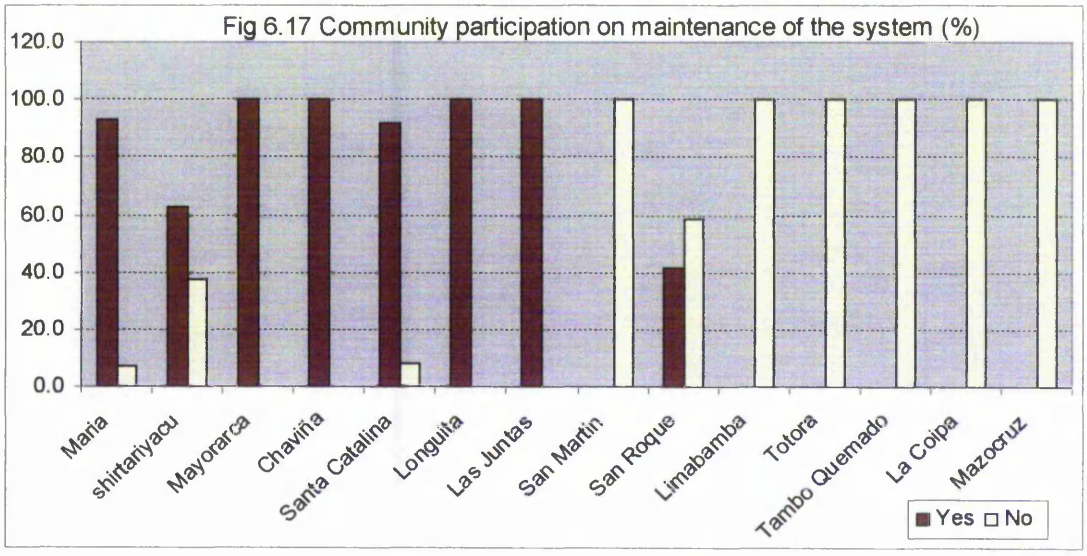
Table 6.9 Who paid the investment?	
Village	Paid
Maria	Church
Shitariyacu	Government
Mayorarca	NGO
Chaviña	Government
Santa Catalina	Municipality
Longuita	NGO
Las Juntas	NGO
San Martin	Private
San Roque	Government
Limabamba	Municipality
Totora	Municipality
Tambo Quemado	Government
La Coipa	Municipality
Mazocruz	Municipality

c) Community participation in the maintenance of the schemes

Figure 6.17 shows that in villages with hydro schemes there is clearly a high participation of the users in maintenance activities, except for Shitariyacu (where almost 40% do not take part in such activities). In villages with diesel sets there is no participation of the users in maintenance activities, except for San Roque where community participation reach about 40%.

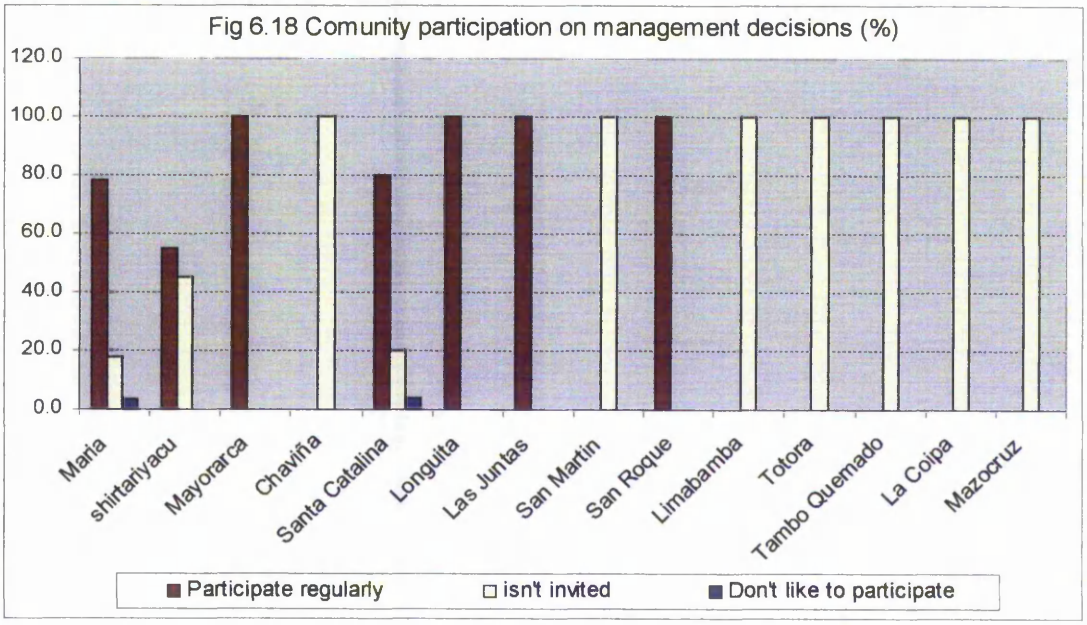
In villages with hydro, the participation of the users is mainly in the maintenance of civil works that require non-qualified skills, but they participate little in the maintenance of the equipment, this is only because it requires qualified skills. These finding explains that the little or non-participation of the users in the maintenance of diesel sets is not only a social reason (of lack of interest of the users or lack of interest of the installer) but it is also the fact that diesel sets require skilled labour, which is not found within the villages.

[18] The local government duration period was changed through changes in the constitution, from 3 to 5 years from 2001 onwards.



Regarding participation in the maintenance of electrical wiring, it is found that users take part only in activities like painting and/or changing poles, for both hydro schemes and diesel sets where non- skilled labour is required.

d) Community participation on the decision about maintenance activities



In all hydro schemes there is good community participation in the decisions on maintenance activities, except for Chaviña, which is operated by the regional concessionaire. Most of those not taking part on decisions on maintenance activities said that they had not been invited, only in two cases a small proportion of users said

that they do not take part because they do not like it (they do not consider it important), figure 6.18.

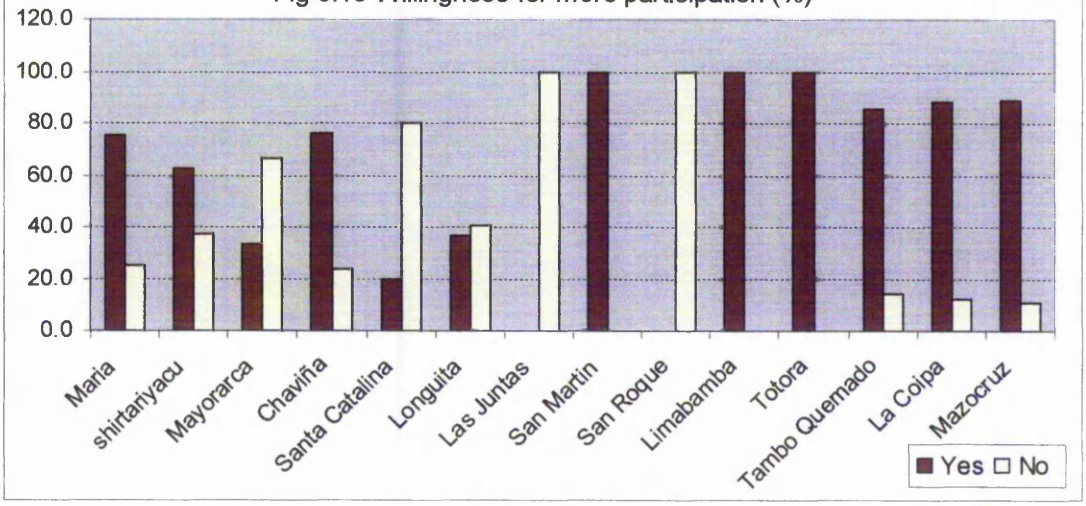
As for diesel sets, there is no participation of the community in the decision taking for the maintenance activities, except for San Roque, where there is a good participation of the users, the most important reason appear to be the ownership, in fact those community managed show more participation of people in decisions on maintenance activities (both for diesel and for hydro).

e) Willingness for more participation

In the villages with hydro schemes the willingness for greater participation ranges from 20% to 75% of the interviewees, while in all villages with diesel sets the percentage of interviewees with willingness for greater participation is above 80%; see figure 6.19. The most likely reason for such a difference is the existing degree participation at present, those communities with little participation now, they show interest for grater participation, while those with more participation at present show satisfaction and consequently are not interested on greater participation.

The case of Las Juntas and San Roque interesting to look at, since in bother cases there are good stories of community participation, however when they were asked about their willingness for more participation, they all said no; the reason being that they feel that they have had enough participation, see figure 6.19.

Fig 6.19 Willingness for more participation (%)



6.2.7 Political interference

The research survey reveals that there is frequent political interference in the electricity services in isolated rural villages; such interferences come mainly as promises from politicians who look for people's votes to get a positions either in the National Parliament or in the local government (Major); at less extent it comes from politicians who are already in power, but want to keep their popularity to be re-elected for another period whenever next election come.

Table 6.10 shows the main sorts of promises done by politicians from the capital or from large towns when they visit villages; except for the cases of Mayoraca and Chaviña, domestic users and business people say that politicians approach to villages to offer improvement of the electricity services every time that there is an election campaign, and similar offers are done by candidates to Majors.

Table 6.10 Main political offers from politicians

Village	New system	Extend the grid	Improve the existing system
Maria		X	
Shitariyacu		X	
Mayorarca			
Chaviña			
Santa Catalina		X	
Longuita		X	
Las Juntas			X
San Martin		X	
San Roque	X		
Limabamba		X	
Totora		X	
Tambo Quemado		X	
La Coipa		X	
Mazocruz		X	

The most common offer from politicians regarding electricity services is connection to the grid[19], and in occasions they also offer new and bigger systems.

[19] Sometimes the grid may be hundreds of km away from the village, but they take advantage of the lack of knowledge of people about the viability or not, however most of the time it is because of their own ignorance about the viability of their promises.

The non-political interference in Mayorarca appears to be because that community enjoys the existence of strong local leadership[20]; and in Chaviña the reason appears to be the ownership and management of the electricity services. In Tambo Quemado, despite to the fact that it is government owned system, the interviewees said that they have had promises about grid extension, and among the main remarks of politicians when they visit the community are "too few hours of service" or "too small systems".

However there is some awareness among communities about the behaviour of those politicians looking for votes to get positions in the central government or Parliament, also about their appearance during the election campaigns, but once the campaigns pass, they rarely come back until there is a new election campaign. While for local politicians (candidates to Majors), when campaigning, they generally offer cheap or free electricity for all, but also they generally do not meet their promises, although sometimes they will reduce the cost in a small proportion, or simple they do not update the tariff in order to keep in good terms with his/her voters.

Technical Factors

6.2.8 Local capacity

6.2.8.1 Education and training

All surveyed systems except for Tambo Quemado have operators, but only 5 of them have administrators; this confirms the lower importance given to administration comparing with operation of the electricity services. In Tambo Quemado, the regional concessionaire (responsible for running the system) hired an administrator instead of an operator, but this person does both administration and operation.

Specific questions where prepared for the interviewees in order to understand about the existing capacity in the surveyed systems, these were related to education and training, the results reveal the following:

a) Education. – The level of education of operators was found to be low; out of the total of 15 operators (working in 13 systems), 5 have elementary education, including

[20] This community has had representatives in the National Association of Peasants (CCP-Confederacion Campesina del Peru), which has been the strongest national organization of peasants at national level since early 1970s, when was created with government support.

one with incomplete elementary education; 6 have high school education, but one of them has incomplete this education level; and in 2 cases operators have technical education[21] (Shitariyacu and San Roque).

Administrators have better education than operators; as seen in table 6.11, administrators have at least some high school education and one has technical education in accounts. The reason for that slight difference in education between administrators and operators is not clear; because in the one hand most systems have operators (which gives the impression that owners care more about operation than they administration), but in the other hand administrators have more education,

Table 6.11 Training and education of operators and administrators of the systems

SYSTEM	OPERATORS			ADMINISTRATORS			BOTH (ADM & OP)
	No	Education	Training (days)	No	Education	Training (days)	Occasional training
Maria (H)	2	Elementary E*	15	0			2 days (once)
Shitariyacu (H)	2	Technical	1	2	High school	1	None
Mayorarca (H)	1	High school	5	0			1 day (twice)
Chaviña (H)	1	High school	1	1	High school	1	1 day (per year)
Santa Catalina (H)	1	High school*	5	0			None
Longuita (H)	1	Elementary E.	5	0			None
Las Juntas (H)	1	Elementary E.	15	1	High school*	10	2 days (per year)
San Martin (D)	1	Elementary E.	3	0			None
San Roque (D)	1	Technical	3	1			1 day (3 times)
Limabamba (D)	1	High school	2	0			None
Totora (D)	1	Elementary	2	0			None
Tambo Quemado (D)				1	Technical		1 day (per year)
La Coipa (D)	1	High school	5	1	High school**	1	None
Mazocruz (D)_	1	High school	5	1		1	None

Elementary E*. - Have elementary education incomplete

High School*. - Have high school incomplete

** The Administrator is a formal employee of the Municipality.

[21] The technical education in all cases is a one-year education in a Private Institute generally done in a particular subject, which is done after the high school.

b) Training. – It was found that operators from all systems have had some training immediately after installation of the systems; however the training periods reported show to be insufficient for the requirements; except for Maria and Las Juntas, which have had 15 days training after installation of the systems, and they also have had 1 or 2 days training regularly every year, see table 6.11 (both systems had been implemented by NGOs); for the other systems the training periods have been very short, they only lasted from 1 to 5 days per in each case. The training for administrators has been even scarcer than for operators, Las Juntas being the most extensive with 10 days; the other 4 cases with administrators have had 1 day training.

For both operators and administrators, only in 6 systems there has been occasional training. Within those 6, only 3 have this training every year, Chaviña, Tambo Quemado and Las Juntas; the other 3 have had different number of days; while for the other 8 systems there have had not been occasional training.

6.2.8.2 Maintenance and repairs

a) Equipment. – The operators of 4 hydro schemes and 3 diesel sets claim that they have preventive maintenance programmes (see table 6.12), however only those operated by the concessionaries show evidence of having preventive maintenance programmes, the others only have irregular checking activities. All the systems have some sort of activities related to the preservation of equipment such as regular greasing, regular check and tying bolts and nuts and cleaning.

In the systems managed by Communities or Municipalities, except for Shitariyacu, operators said the repairs of the equipment are done by consultants coming from cities and mostly from the capital –Lima-. In the systems managed by Concessionaries, the experts mostly come from other systems (larger ones) belonging to the Concessionaire.

Regarding the pay for maintenance and repairs, it was found that "maintenance activities" have been part of the routine duties of the operators and they have a monthly income to perform operation. Small repairs are generally faced using the income from the electricity services for all the cases; however for large repairs the cost of the spare parts and consultant are generally paid by the local authorities or central government, except community owned systems (where it is paid by the

community either from the electricity services income or using other funds) and private owned systems (where the entrepreneur have to face the costs).

b) Electrical wiring. - Operators are capable of repairing small failures like changing wirings and fuses (for all systems). In most cases operators are capable of lifting and installing poles with the support of the users, either for maintenance purposes or to extend the wirings; but in all the systems there is lack of skills to review equipment or instruments, such as transformers, generators and load controllers; the expertise for these sorts of repairs is only found in Lima and at less extent in other large towns.

c) Civil works. - It was found that in all systems operators were clear about the maintenance tasks required for civil works like cleaning the screens of forebay tanks, channel; and generally they do such tasks. However none of the systems have shown preventive maintenance for the civil works (except for those operated by the concessionaires), the others react whenever any damage happens. The maintenance of civil works is mostly done with community participation with labour; the operators feel that they rarely need external support for repairing or maintaining civil works.

Table 6.12 Preventive maintenance and repairs

System	Has preventive maintenance programme	Who does repairs equipment	
Maria(H)	Yes		Outsiders
Shitariyacu(H)	No	Team	Outsiders
Mayorarca(H)	Yes		Outsiders
Chaviña(H)	Yes	Concessionaire	
Santa Catalina(H)	No		Outsiders
Longuita(H)	Yes		Outsiders
Las Juntas(H)	No		
San Martin(D)	No		Outsiders
San Roque(D)	Yes		Outsiders
Limabamba(D)	No		Outsiders
Totora(D)	No		Outsiders
Tambo Quemado(D)	Yes	Concessionaire	
La Coipa(D)	Yes		Outsiders
Mazocruz(D)_	No		Outsiders

6.2.9 Load factor

It was found that the patterns of down time days, demand curve, energy consumption, and other characteristics of the systems are different for hydro schemes and diesel sets.

a) Down time days. - Most systems have a large number of down time days per year, except for Las Juntas that has an average of only 3 days per year, which happens when they stop for the annual technical check, and occasional stops of few hours for different reasons like maintenance of civil works or wiring; the system with the second lowest number of down time days happens in the hydro scheme of Chaviña, with an average of 10 days, and in third place is Tambo Quemado with 13 down time days. The main reasons reported by the interviewees are: lack of resources, lack of spare parts and/or experts and lack of money.

Figure 6.20 shows how down time days have happen in the different systems (averages reported by the operators); such averages are not accurate by any mean, but are informed guesses of operators and administrators.

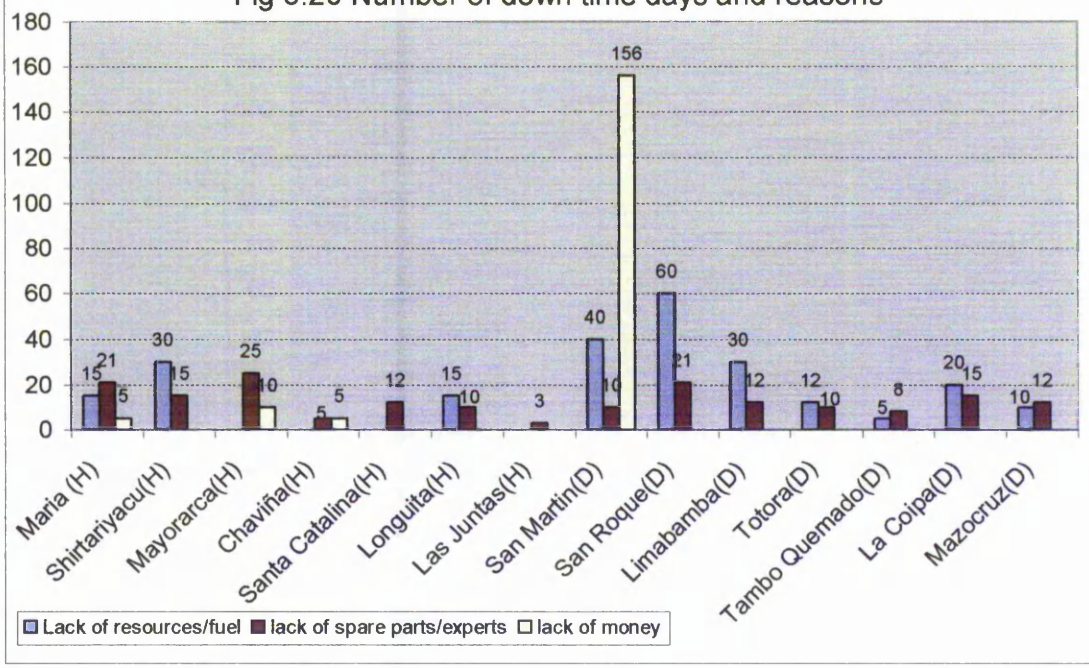
Community managed systems show the longer periods of down time days due to lack of spare parts/lack of experts, which generally happen due to lack of information about where to find experts, but also because communities use complicated procedures to get the approval for any purchase or contract; furthermore in communities there are also internal issues which most of the time contribute to delays on the decisions, an issue is the fact that the number of community members is generally much larger than the number of users of the electricity, therefore repairing a failed electricity system is generally not priority for all the community members.

Looking at it from the prospective of the technology; for hydro schemes, see Fig 6.20, there are three cases of down time days due to lack of resources, that happens once a year during the dry periods (from August throughout the end of September); the reason for all three cases look to be the poor planning and design of the schemes, and the optimistic estimates of minimum river flow (all the schemes are run-off the river schemes) and/or the poor hydrological studies.

As per the diesel sets, most cases have a significant number of down time days during the year due to lack of resources (fuel), the main reasons are either the unreliability of the roads (especially during the rainy season) and/or the lack of money to purchase fuel. The worse case of lack of resources happens for San Roque where the system has an average of 60 down time days per year due to the lack of fuel.

San Martin is the exception with a extremely high number of down time days, the reasons given by the entrepreneur to the users are lack of money and lack of resources (fuel), but it is also the fact villagers have agreed with the entrepreneur for the provision of only 4 days per week (Thursday, Friday, Saturday and Sunday). The entrepreneur also explained that for him, the only way of making sensible business without losses is actually providing few hours of electricity and the minimum number of days per year.

Fig 6.20 Number of down time days and reasons



b) Village energy consumption (load diagram). - There is a large difference in energy consumption between villages with hydro schemes and villages with diesel sets, the most important reason by far is the fewer hours service that diesel sets provide each day, varying from 2 to 5 hours, while hydro schemes provide 24 hours,

except for Mayorarca[22], where the community decided to run their hydro scheme for 12 hours per day.

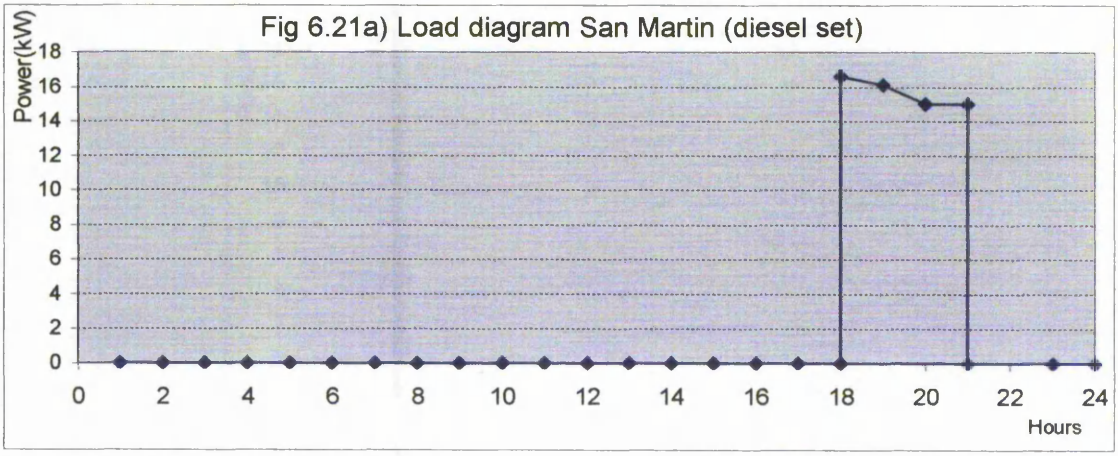


Fig 6.21a) Load diagram San Martin (diesel set)

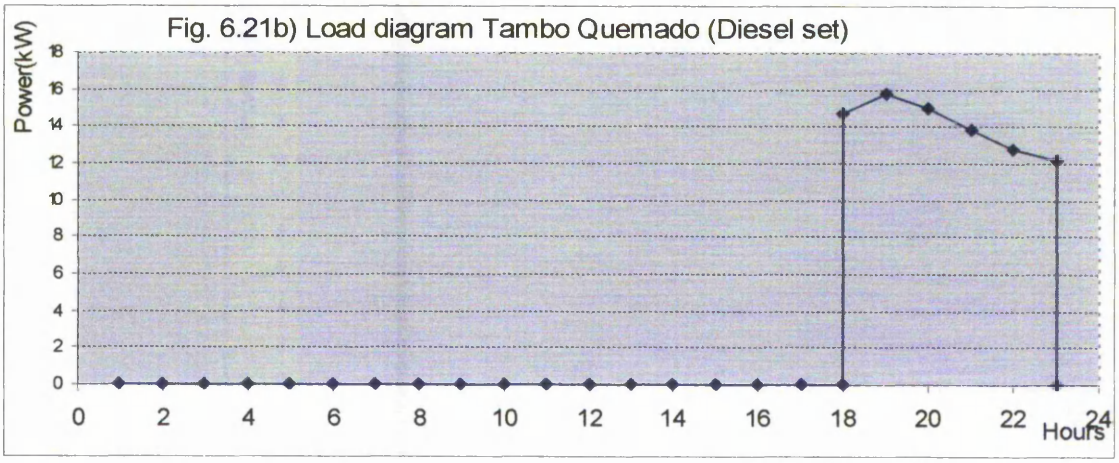


Fig. 6.21b) Load diagram Tambo Quemado (Diesel set)

As for the diesel sets surveyed, the system providing the least number of hours of all is San Martin (2 hours), and that one providing the largest number hours of electricity is Tambo Quemado (5 hours).

The typical load diagrams for diesel sets have little demand variation during the few operation hours, see examples in figures 6.21a and 6.21b for San Martin and Tambo Quemado respectively; hydro schemes have typical demand diagram curve with a high peak during the first evening hours, and low power demand during most of the day hours, see examples in figures 6.21c and 6.21d for Shitariyacu and Las Juntas

[22] In Mayorarca the community decided to run the hydro scheme for only 12 hours a day, they think that it will help them to preserve their system.

respectively; the peak demand for hydro schemes happen between the 18 to 22 hours, when lighting and TV is used the most; however Shitariyacu also shows a small hump from 6 to 8 hours, which is due to the use of small electrical resistances for heating water for breakfast in the mornings[23]. The diagrams for hydro schemes also show that the valley hours of the night consumption are higher than those of day hours; this is because of the public lighting during the night.

Fig 6.21c) Load diagram Shitariyacu (hydro scheme)

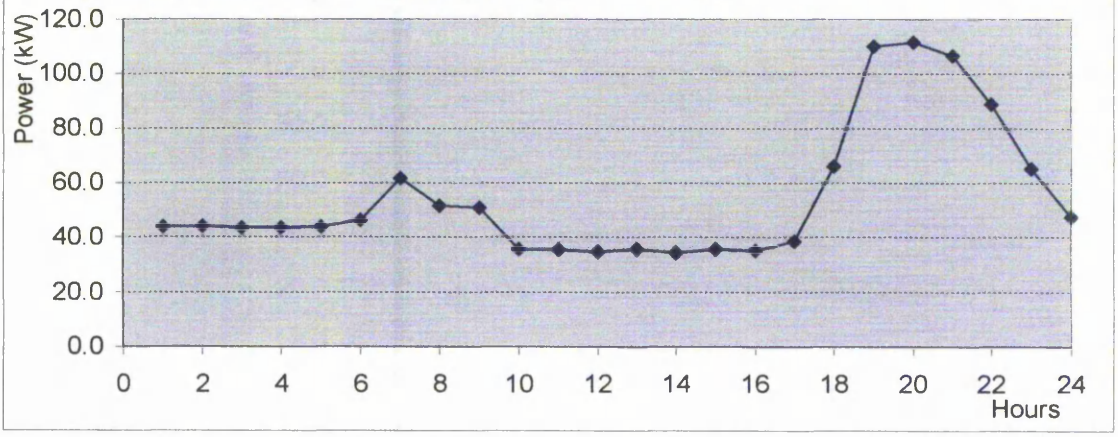
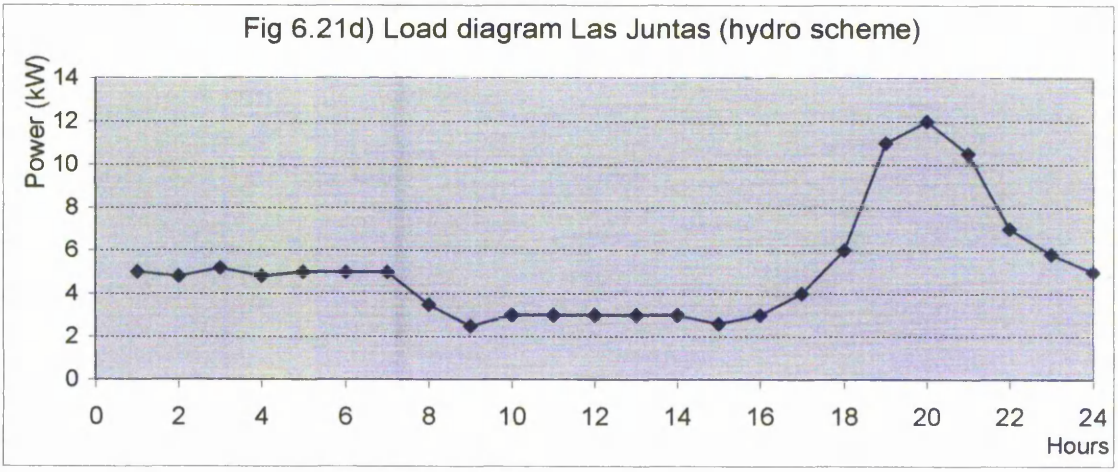


Fig 6.21d) Load diagram Las Juntas (hydro scheme)



c) Family energy consumption. - The average energy consumption in villages with hydro schemes ranges from 55kWh to 79kWh per family monthly; except for Maria and Mayorarca which show lower energy consumption[24] (about 35 kWh monthly); while in villages with diesel sets most have an average energy consumption bellow

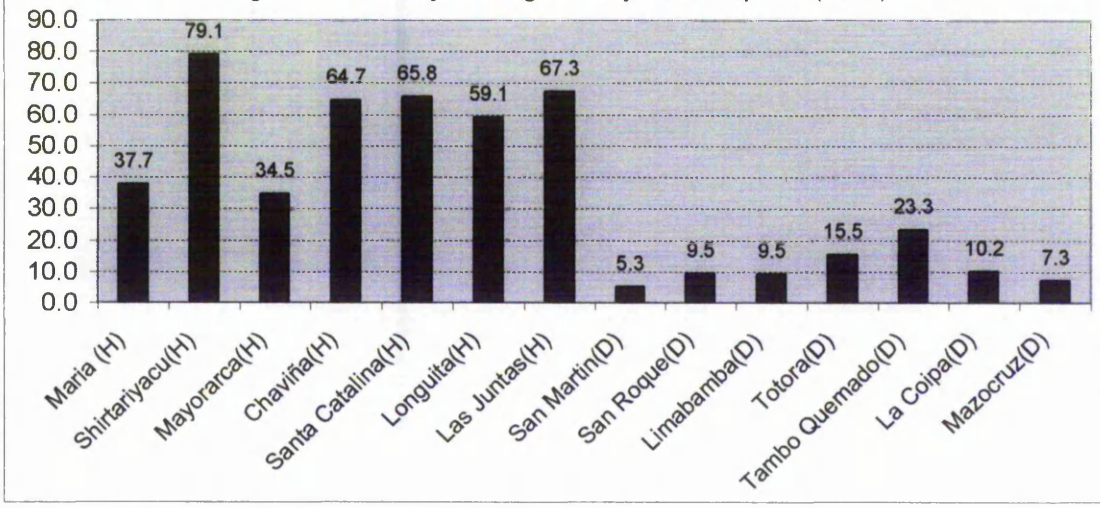
[23] This sort of humps may happen for electricity systems with flat tariffs, because there is no incentive for saving electricity.
[24] The total average is that found by dividing the total energy consumption of the village into the number of families.

10kWh per family monthly, except for Totora and Tambo Quemado where the consumption is higher.

It is estimated that in villages with hydro schemes about 15% of the total energy consumption is for public lighting[25]; for diesel sets it is difficult to estimate the power demand for lighting, because the demand curves do not provide any indicator as it happens for hydro schemes. However it is assumed that diesel sets and hydro schemes have approximately the same public lighting. Except for San Martin where they have only few public lights.

Among hydro schemes, those with the lowest average energy family consumption are the two communities owned and managed schemes, Maria and Mayorarca. But the third case community owned and privately managed –Las Juntas- shows a different picture with nearly double the consumption of the previous two cases, see figure 6.22.

Fig. 6.22 Monthly average family consumption (kWh)



The low energy consumption in Mayorarca happens because it is operated only 12 hours a day and has 10% of down time days (see down time days); the demand is basically for lighting since they do not have appliances of permanent energy demand like refrigerators or others. The case of Maria, with the second lowest energy consumption among hydro schemes, an important reason is the large number of down time days per year (average 45 days or 12.3% of the total time), but another

[25] The public lighting demand is estimated by subtracting the night off-peak power supply less the day off-peak power supply.

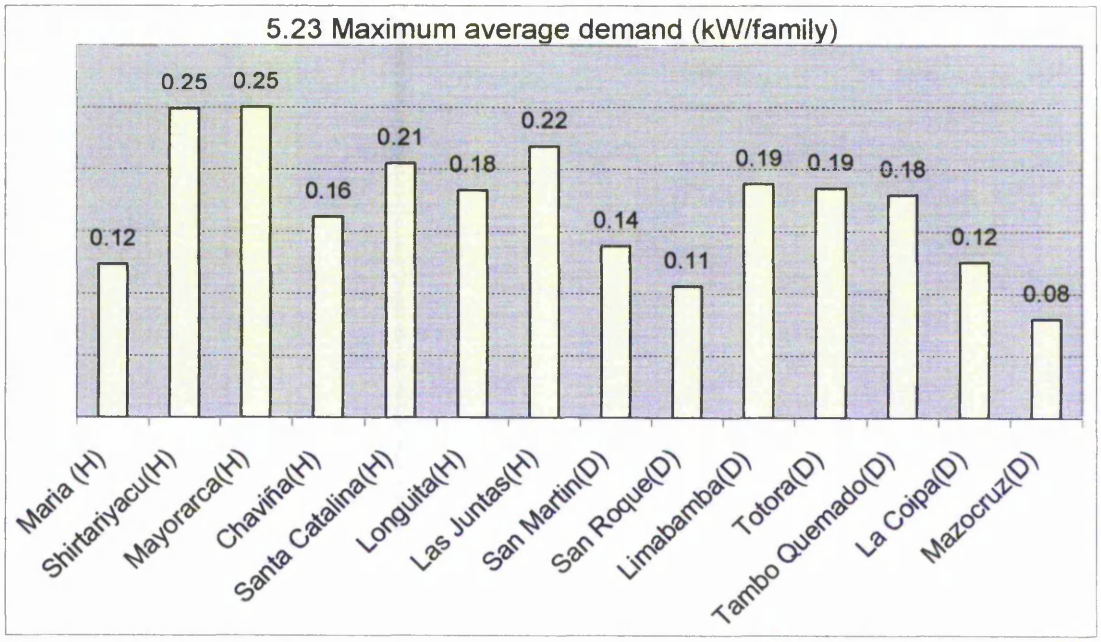
reason is the energy savings that they do, because they are conscious of the limited power capacity of the system (the scheme is close to saturation, their peak demand is 18.5 kW and the capacity of the scheme is 20 kW). Therefore they have raised awareness among the community to use low wattage lighting lamps.

Shitariyacu is the scheme with the highest energy consumption per family monthly; among the main reasons are: the flat tariff that does not promote energy savings, the lack of awareness of the users about the limited installed capacity for the present demand (they think that they have a large hydro scheme), but also it is due to the fact that the users feel like they are paying a "high tariff" and therefore they have the right to use as much electricity as they want, some interviewees said that they sometimes use small electrical resistances to heat water for hot drinks (coffee, tea), also in many cases families use more lighting than necessary during the night.

Diesel sets show low family consumption for all cases, the most important reason being the very few hours of service, which happens mainly because of the cost of fuel; but also for other reasons like the large number of down time days.
The highest energy consumption in the diesel set of Tambo Quemado is because it provides the highest number of energy supply (5 hours per day) and has the lowest down time days per year. The second highest consumption among diesel sets happen in Totora, the main reasons appear to be the lowest number of down time days per year (following to Tambo Quemado), but also the large installed capacity comparing with the actual present demand.

For the other 5 diesel sets the family energy consumption range from 5.3 kWh to 10kWh per month; the lowest consumption happens in San Martin because of the few days of electricity service per year and few hours daily. The second lowest happens in Mazocruz, the reason appears the fact that most of the users have meters, but it is also a cold region and therefore people tend to sleep earlier than in regions with warmer weather.

d) Maximum average power demand per family (at peak hours) .- Both technologies (hydro and diesel) show a wide range of peak demands; for hydro schemes the peak demand ranges from 0.12kWh/fmily to 0.25kW/family, while for diesel sets it ranges from 0.08kWh/family to 0.19kWh/family. The average family peak demand for hydro is 0.20 kW, while for diesel sets the average is only 0.14 kW (see figure 6.23).



The main reasons for the difference in energy consumption and peak demand within hydro schemes is the sort of tariff they use, when the tariff is flat, they have no incentive to save energy, therefore they use big and inefficient bulbs lamps for lighting and they generally use as many as they like; those that have a proper measured tariff prefer to save energy (which is the case of Chaviña and Las Juntas). For hydro schemes peak demands is also increased a little bit because of the larger number of appliances used comparing with diesel sets (see Las Juntas and Shitariyacu).

It was found that the size of the scheme has an important influence in the behaviour of people towards consumption; in Maria for example, where they have limited spare power, they are using a large number of saving energy lamps in order to coupe with their present demand.

The behaviour of the users in villages with diesel sets is much the same as those of villages with hydro, but they have important limitations due to the cost fuel and the difficulties to get fuel in isolated areas, the main limitations being: few hours of operation and many down time days per year.

6.2.10 Technical support

6.2.10.1 Support services

In the 12 non-government owned systems, operators and/or administrators interviewed said that there is need for technical assistance (see table 6.13), in the other two (government owned) they said that they do not need technical support because they get it from the utilities in charge of the management, who send technicians (from other systems) to do regular inspections, because utilities have in house technical expertise.

Regarding the degree of difficulty to find technical support, in 6 out of the14 systems surveyed, interviewees said that it is difficult to find technical assistance, in three cases the interviewees said that it is very difficult, and only in other three they said it is easy (see table 6.13). The two governments owned do not need technical assistance from outside.

It was also found that the most isolated villages have more difficulties to get technical support, however the sort of management also has important influence in the degree of difficulty to get technical service, such is the case of Santa Catalina, Longuita and Limabama, all three very isolated and all three owned and managed by municipalities. In San Martin a private system, despite its isolation, the owner explained that he knows where to find technical support for his system and that it is easy for him.

Regarding the opinion of interviewed operators or administrators about the cost (see table 6.13), in 9 out of the 12 requiring technical assistance, they explained that the cost of the technical service is expensive, only in other 3 expressed that cost is satisfactory.

There is evidence that the quality of management influences in the availability of information in the village. It was found that only in three Systems (Shitariyacu, Las Juntas, San Martin), operators or administrators, keep records on consultancy

services, manufacturers and product sellers (who can provide the services or assistance to them).

Table 6.13 Technical support

Village	Requires technical support	Finds Tech. Support	Cost		
			Expensive	Satisfactory	Cheap
Maria (H)	Yes	Difficult	X		
Shitariyacu (H)	Yes	Easy	X		
Mayorarca (H)	Yes	Difficult	X		
Chaviña (H)	No				
Santa Catalina (H)	Yes	Very difficult	X		
Longuita (H)	Yes	Very difficult	X		
Las Juntas (H)	Yes	Easy		X	
San Martin (D)	Yes	Easy	X		
San Roque (D)	Yes	Difficult		X	
Limabamba (D)	Yes	Very difficult	X		
Totora (D)	Yes	Difficult	X		
Tambo Quemado (D)	No				
La Coipa (D)	Yes	Difficult		X	
Mazocruz (D)	Yes	Difficult	X		

6.2.10.2 Sizing the systems

Most systems show a random sizing, because they do not match with the growth of the population (see table 6.14). However in some surveyed villages it might have happen large population immigration[26] after the installation of the system, which had not been foreseen at the planning stage.

In Shitariyacu a 120kW hydro scheme was built for an initial demand of 450 users[27], the number of connections remains the same after 7 years of operation, but this

[26] During the last four decades there have been important socioeconomic or political events, which had impact on the immigration rates: High immigration from the Andes to Upper Jungle looking land, from the Andes to the Cost looking for job opportunities, the terrorism of the 1980s and early 1990s, and others.

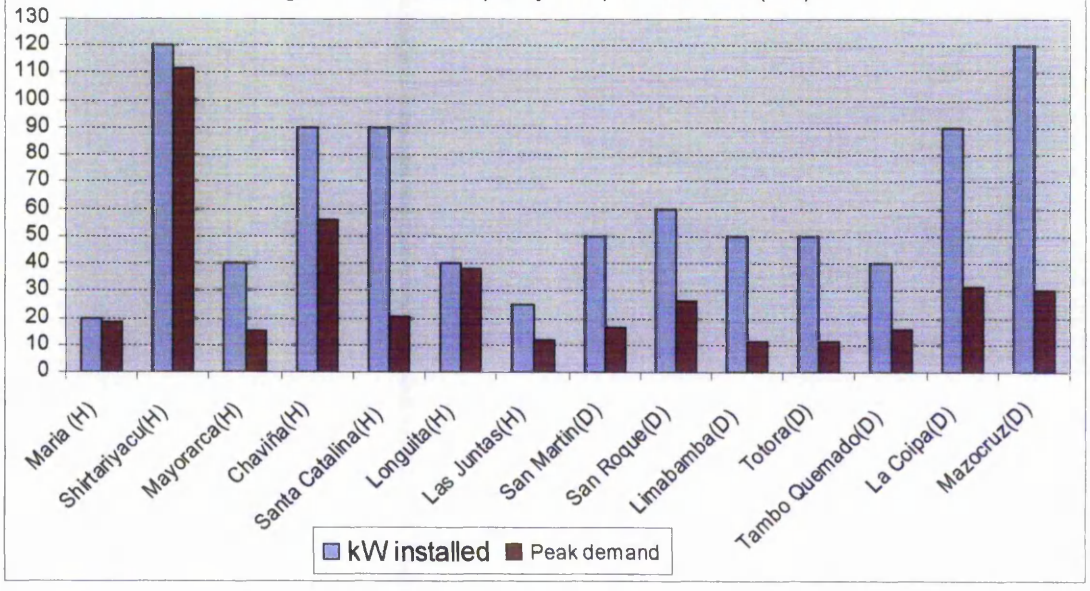
[27] It looks like during the design phase the sizing of this scheme was just for the existing demand (450 families).

village has now a waiting list of 700 families that are not connected due to the insufficient power; its present peak demand is very close to its full design capacity. In San Roque, another fast growing village, in 8 years of operation there is a number in the waiting list twice bigger than number of the present users. In the other extreme, there are villages where the demands have decreased because the population have decreased, as are cases of the diesel sets of Limabamba, Totora and Tambo Quenmado.

The results suggest that the reasons for such a disparity in the demand grow is basically the location of the scheme, those schemes in the Andes have experimented a small grow or decreased in the number of customers, while those in the upper Jungle have experimented fast grown of population and therefore have large waiting lists.

However it should pointed out that in most cases, neither the owners nor the administrators or operators are fully aware on the capacity of their systems and the number of connections possible to cope with; in some cases they do not want to connect new users because they are afraid of overloading the systems; also, they hardly understand about saving energy or other ways of rational use of energy to cope with larger demands.

Fig 6.24 Installed capacity and peak demand (kW)



An example of the lack of awareness about the capacity of their system and its conservation is Mayorarca, where the peak demand is only 15 kW and their installed capacity is 40kW, however they do not know about their power demand because of the lack of instruments, therefore the leaders are reluctant to provide electricity for high demands of energy. In Mayorarca the leaders denied the connection to a welder arguing that "the system has insufficient power", despite to the fact that the villagers need welding services.

Figure 6.24 shows the present power installed and the peak demand for all systems surveyed. In three hydro systems (Maria, Shitariyacu and Longuita), the installed capacity is almost saturated, while in Maria the waiting list after 10 years of installation is made of 15 families (who could be accommodated if the leaders would like to); in Shitariyacu and Longuita it is simple impossible to connect new users because of the insufficient capacity and the large numbers in the waiting lists.

Table 6.14 Power, system age and number of users

Village	Power (kW)	Scheme age	Users at starting	Users now	Waiting list
Maria (H)	20	10	120	149	15
Shitariyacu(H)	120	7	450	450	700
Mayorarca(H)	40	9	50	60	10
Chaviña(H)	90	26	120	346	15
Santa Catalina(H)	90	8	50	99	10
Longuita(H)	40	8	180	210	40
Las Juntas(H)	25	5	55	55	3
San Martin(D)	50	5	60	120	60
San Roque (D)	60	8	80	250	300
Limabamba(D)	50	8	90	60	0
Totora(D)	50	7	80	60	0
Tambo Quemado(D)	40	5	89	88	0
La Coipa(D)	90	20	130	250	120
Mazocruz(D)	120	17	130	380	50

It is found that hydro schemes are more frequently undersized, while diesel sets oversized; among the reasons for that are: the design of hydro schemes is made according to the availability of resources[28]; while for diesel sets there are generally no design phase, those systems are generally given to villages or communities according to their availability in stock of the central government[29]. Examples of these are La Coipa and Mazocruz, see figure 6.24

6.2.11 Source of energy

The source of energy clearly influences in the use of energy. It was found that there are important differences on tariffs, participation, use of energy appliances and others.

Hydro schemes have more reliable energy during the year, and all (except for Mayorarca) have 24 hours of electricity a day.

For diesel sets, the reliability of the fuel supply plays an important role in the electricity supply; those more isolated from the large commercial centres have more restrictions to get fuel.

Managerial factors

6.2.12 Ownership

This study covers Government, Municipality, Community and Private ownership and management; Cooperative owned and managed was not considered for the reasons explained in chapter 5.

Ownership plays an important role in decisions on the type of management, tariff structures and participation or not of the users. When the systems are government property, the tariffs, and all administration issues are under the national regulations for electricity businesses, for all the other sorts of property national regulations do not apply, hence the villages with electricity generation systems have their own "rules", generally decided with a great influence of the owners. However the

[28] In many cases they design is based in the resources available rather than in the size of the demand, they use the minimum flow of the river as rated flow.
[29] The government generally have diesel sets in stoke, sometimes because they have purchased several units but not all installed, other times because some cooperation donates systems without previous studies of the needs.

decisions about management are generally done at the beginning of the operation of the systems and in most cases will last for the entire life of the system.

The main installers of small isolated energy systems in Peru have been Central Government (through the Ministry of Energy and Mines and other Ministry of Agriculture), Local Government (Municipalities), and at less extent by NGOs and Churches, and only very occasionally communities and cooperatives. Most systems have been built through project (one project one installation), except for few cases such as the PRONAMACHS programme, which included the installation of several hydro schemes.

Ownership is generally attributed to the implementers; except for very few cases that the implementers hand over the property to the community or municipality.

Most small isolated systems installed by the government have been through political intermediation of individuals, who are in power or have political affiliation with the party in power; once installed the property goes to ADINELSA.

Systems installed by Municipalities have generally been done under the Major's leadership, using municipality, central government and international cooperation funds. Municipalities generally keep the ownership and management of the systems once are installed.

Systems are installed by NGOs and Churches generally the ownership end up in the hands of the communities.

6.2.13 Management

In rural areas, the systems managed by the government are generally the largest ones. There is not a precise lowest power size limit for government owned and managed systems, but from the official information it is found that these are hardly bellow 50kW; Tambo Quemado included in this study is one of the few exceptions. Table 6.15 shows the installers, ownership and management for the survey sample.

6.2.13.1 Government management

The two government-managed systems (Chaviña and Tambo Quemado) included in this sample show a good technical performance. Chaviña has an average of only 10

down time days per year, the second shortest down town time for the hydro schemes studied after Las Juntas. Tambo Quemado has 13 down time days per year (becoming the diesel set with the smallest down time). The equipment for both cases are found in good order and with regular maintenance, which is done by the utility in charge of running the system.

As for energy provision, Chaviña provides 24 hours service and sufficient energy for the users. Regarding energy consumption per family, this village holds the fourth position within the 7 hydro schemes (see Fig. 6.22); this suggests that the metering encourages people to save energy, in fact, few of the domestic users said that they switch lights off when they do not need lighting and/or buy less wattage light bulbs to consume less energy.

Table 6.15 Installer, Owner and Manager

System	Installer	Ownership	Management
Maria (H)	Church + people	Community	Community
Shitariyacu(H)	Government	Municipal	Municipal
Mayorarca(H)	NGO + people	Community	Community
Chaviña(H)	Government	Government	ADINELSA (through Utility)
Santa Catalina(H)	Mun + people	Municipal	Municipal
Longuita(H)	Mun + people	Municipal	Municipal
Las Juntas(H)	NGO + people	Community	Community
San Martin(D)	Private	Private	Private
San Roque(D)	Government	Community	Community
Limabamba(D)	Municipal	Municipal	Municipal
Totora(D)	Municipal	Municipal	Municipal
Tambo Quemado(D)	Government	Government	ADINELSA (through Utility)
La Coipa(D)	Municipal	Municipal	Municipal
Mazocruz(D)	Municipal	Municipal	Municipal

Government owned systems (through ADINELSA) are operated by regional utilities (who are subcontracted by ADINELSA); the amount paid to perform that service is not of public domain, but it is understood that small systems like Chaviña and Tambo

Quemado are heavily subsidised by the government. However in practice utilities hire local people (villagers) to perform the basic operation and administration activities; in Chaviña the utility employs 1 operator and1 as administrator to run the system, both locals. In Tambo Quemado the utility employs 1 local person to perform both operation and administration of the system, but the activities of this person are limited to switch on and off the diesel set every day, to deliver the bills to the users and collect payment on a monthly basis.

6.2.13.2 Municipality management.

Seven surveyed systems are managed by Municipalities (3 hydro schemes and 4 diesel sets), all show a poor management. It is found that most problems arise from the lack of local capacity to perform maintenance activities; all show a high number of down time days per year. Municipalities hardly get information neither to preserve it, therefore they have difficulties to get spare parts or access to experts, consultants, sellers of manufacturers[30].

Regarding electricity services, hydro schemes managed by municipalities provide 24 hours a day service; while diesel sets provide only 3 hours per day, except for the local festivities when they provide from 8 to 12 hours a day, and happens 3 to 4 times per year. Municipalities also show large number of down time days per year. See figure 6.20 and table 6.15.

The number of people employed to operate the systems in most cases is 2 except for the case of Shitariyacu where there are 4 employees, 2 operators and 2 administrators. But all municipalities have other employees within the local government, who have a supervisory role to the running of the system; all of them paid from the council resources rather than from the electricity sell (because the income from the system is not enough).

Most Municipalities do not keep separate accounts for the income from electricity, they expend receive and expend it as part of the "budget", therefore when they have to pay the repairs of a sadden failure of the system, it may take several days until

[30] In few large towns, it is possible to find all spare parts to buy; the main problem appears to be the lack of money or difficulties to take decisions to buy the spare parts.

they find the money to do it[31], also they have internal discussions to approve which sometimes contribute to prolong the time without electricity.

6.2.13.3 Community management

Technically, community managed systems show several weaknesses, among the hydro schemes, out of three them under community management, two (Mayorarca and Maria) show the highest down time per year due to the lack of experts and/or spare parts, the reasons are mainly associated with little information they get, their difficulties to keep information records and their difficulties to make quick decisions; however Las Juntas shows the lowest down time exactly the opposite and it shows the best performance of all cases studied, they also show good record keeping and good information about suppliers of spare parts and manufacturers. For diesel sets, the only system of the sample under community management – San Roque – shows the largest number of down town days among the diesel sets, this is due to lack of spare parts and experts, the reasons for such a poor performance are the same as those for hydro schemes, see figure 6.20.

Other reasons that contribute to increase the down time days and poor technical performance in systems under community management is the complicated administrative procedures[32], the lack of money and information about where to get technical assistance.

Regarding administrative issues, community-managed systems generally do not have accounting systems, bank accounts and proper rules to run the systems.

Las Juntas is the only community owned (privately managed) system which shows a different situation, it shows an excellent performance in all the fields, good management of the systems, proper tariff scheme, people trained to operate and maintain the scheme, bank account, independence of political interference, and others. The main reason for such a good management performance is clearly the use of the concept of private management, where the owner –the community- hires

[31] This situation generally happens when the systems are broken, the Municipality has to cope with the purchase of the spares and the qualified labour needed to repair the system.
[32] The decisions in communities require generally more than one meeting and communities generally have more problems of lack of money than any other institution managing electricity systems.

to a very small local company to operate the system and pay for such work; they have also set rules and conditions which rule the responsibilities of the stakeholders.

6.2.13.4 Private management

San Martin is the only surveyed system under private ownership and management. Although Las Juntas has introduced the concept of private management (keeping ownership in hands of the community), for the purpose of the analysis, San Martin is the only system privately owned and managed.

San Martin shows different performance characteristics to all the other systems:

It has the largest number of down time days per year of all the systems of the sample –206 days (56% time out of operation)-; the reasons reported by the manager (owner) to users can be seen in Fig 6.20. The largest proportion of the down time days (156 days) is agreed between the entrepreneur and the users (since the electricity supply is for 4 days weekly), and it is agreed on the grounds the high operation costs[33]; however additional to those days the owner will not provide electricity another 40 days arguing the lack of money, in practice it is a "good excuse" of the owner to save fuel and consequently spend less money in the running costs and make his system profitable. Furthermore it was found that some users realise such a fact, but they accept it because it is the only option available.

The operator, manager and owner of the diesel set, takes all decisions about the electricity service: number of hours of energy provision per day, tariffs, cutting the service to his customers or even to stop the service for as long as he wants. The users have no other option but accept the facts.

Other issues about management

a) Operation and administration facilities. -As shown in table 6.16, only 3 out of the 14 systems (2 hydro schemes and 1 diesel set) have offices dedicated to the operation and administration of the systems; other 3 of them (1 hydro scheme and 2 diesel sets) share offices with other facilities or with some businesses; the remaining 8 systems just use the powerhouse as the office, although it is not necessarily recognised as such by users.

[33] This arrangement of 4 days electricity supply per week is decided by the owner and is basically in the basis of payment, because the owner argues that money users pay is only enough for four days service.

In those three systems that have their own office (Chaviña, Las Juntas and San Roque), it was found that, independent offices for administration contribute positively to the management of the schemes (keeping information, instruments and tools in a proper place and having a place to meet clients among other facts).

Table 6.16 Operation and administration facilities

	Office			Tools		
System	Own	Shares	Don't have	Enough	Not enough	Doesn't have
Maria (H)			X			X
Shitariyacu (H)		X			X	
Mayorarca (H)			X			X
Chaviña (H)	X				X	
Santa Catalina (H)			X			X
Longuita			X			X
Las Juntas (H)	X				X	
San Martin (D)		X				X
San Roque (D)	X				X	
Limabamba (D)			X			X
Totora (D)			X			X
Tambo Quemado (D)		X			X	
La Coipa (D)			X			X
Mazocruz (D)			X			X

b) Tools. - Only 5 out of the 14 systems were found to have some tools, but in all these 5 cases the tools were insufficient to perform all maintenance activities (see table 6.16), the most common tools found were screwdrivers, sets of small spanners, hammer, globes, measurement tapes, tools for civil works and simple electrical instruments like voltmeters and Amp meters. The other 9 systems surveyed, were found to have very basic tools, the most common, few spanners, screwdrivers, hammer and globes. They do not have electrical instruments of any kind (they are qualified as don't have).

None of the 14 systems have all the necessary sets of tools and instruments necessary to perform proper maintenance. Among the reasons for having insufficient tools were: the lack of information about sellers and the lack of money, but also the lack of training to owners, operators and administrators.

c) Financial performance of the systems. - The only indicator of the financial performance is the net income of the villages, see fig 6.25. The net income is the total income from bill collection less expenses (pay of operators and/or administrators, spare parts, fuel, technical assistance services and other expenses incurred in the operation of the systems).

As shown in figure 6.25 the financial performance is clearly better for hydro schemes than it is for diesel sets, 5 out of the 7 hydro schemes of the survey sample have positive net income; one shows considerable monthly losses -Santa Catalina –, and one have relatively small monthly losses –Longuita –. For diesel sets the financial performance shows is the other way around; 5 out of the 7 diesel surveyed have considerable monthly losses (Tambo Quemado; Coipa, Mazocruz, Totora and Limabamba), see Fig 6.25 and only two have positive net income.

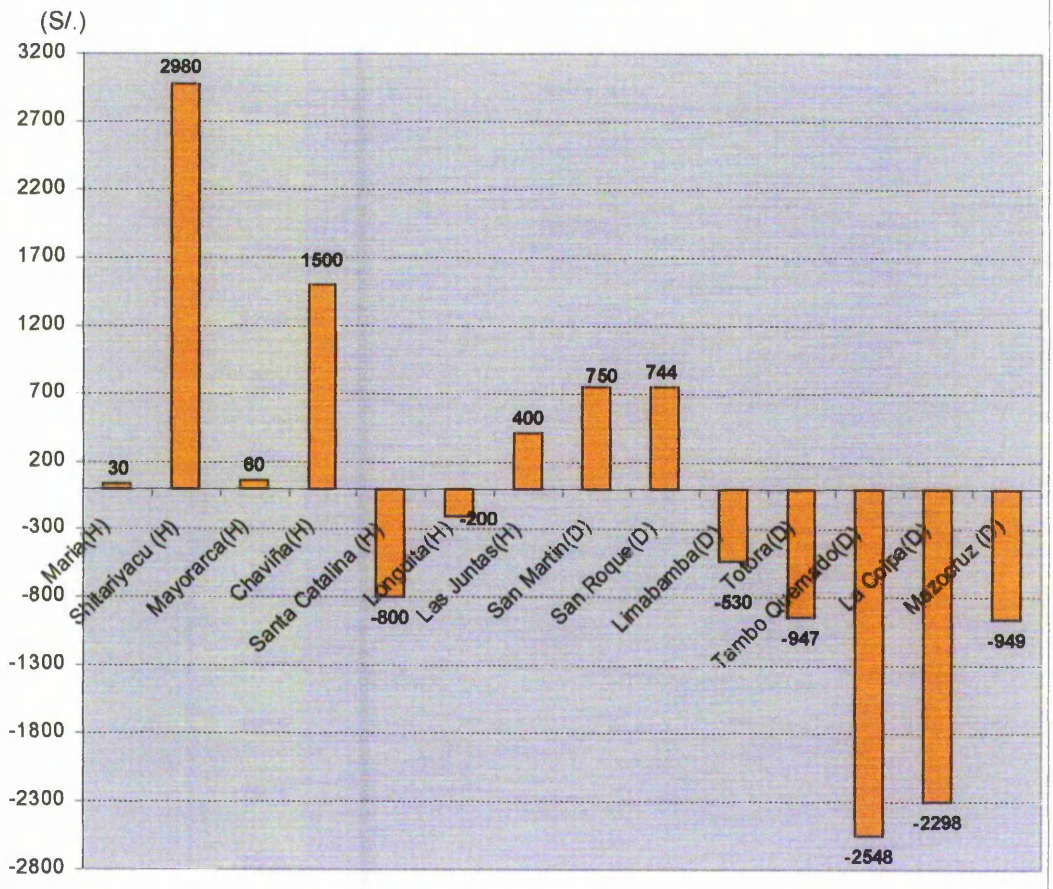
All systems under community management (both hydro schemes and diesel sets) show a positive net income. San Roque, despite to the fact that expends an important part of its income on fuel, it positive monthly income; also it is the third highest net income of all the surveyed systems under community management, with a monthly net income of S/. 744.00 (US$ 228); among the reasons for such a "good performance" are: 1) It has a relatively large number of customers, the largest among community management (250 users; 2) it has the highest tariff among those under community management, 3) it has a relatively low delay to pay (8.3%) and, 4) it saves a very high amount on money due to the high number of down time days during the year (saves form purchasing fuel).

For hydro schemes, Las Juntas, despite to the small number of users (55 families), it shows a particular healthy financial performance with a net monthly income of about 400 soles (US$123).

As for the other communities with hydro schemes (Maria and Mayorarca), according to the interviewed operators and administrators, they are not much aware about the risks of damage and the life span of the systems; therefore they are only concerned

about getting enough income from electricity services to cover the monthly expenditure rather than any other possible long term investment (for example savings for spare parts). Some leaders know about possible needs of large amounts of money in case an important failure but they ignore[34].

Fig 5.25 Monthly average net income from electrcity services for the different villages (Soles)



Those systems under the management of the Municipalities, all show poor financial performance. Among the reasons for it are: 1) the low tariff for hydro schemes (except for Shitariyacu); 2) the high cost of fuel for the diesel sets, 3) high delay to pay of users, 4) the existence of resources to subsidize the schemes[35], 5) the

[34]Mayorarca, Maria and San Roque have had requirement of large amounts of money to repair their schemes in the past, when that have happen, they just wait for various months until they find some agency or government institution to pay for its repairs. The last in Mayorarca has happen in 2001 with the damage of the alternator, due to the lack of regulator.
[35] The Municipalities receive important amounts of money in a monthly basis from the central government, which is given taking into account the degree of poverty and the number of people; the poorer the village is the more money per person the municipality receives.

political interests of the local authorities (the Majors), who will always use any possible excuse to make political offers, such as free services.

Shitariyacu shows a good financial performance, the most important reasons for that are, 1) no expenditure in fuel (when comparing with diesel sets), it has the highest tariff among the hydro schemes and one of the highest of all the sample, it has the largest number of users among all the systems, therefore it has the largest income from electricity services and the expenditure on operation and management of the scheme are not so high.

The government managed schemes, Chaviña (hydro scheme) and Tambo Quemado (diesel set), show different pattern, the first one shows an important monthly net income while the second shows the opposite, however it is difficult to judge to these systems, because whatever it could happen, they would always be looked after by the government, and consequently they are not urged to look for income from tariffs.

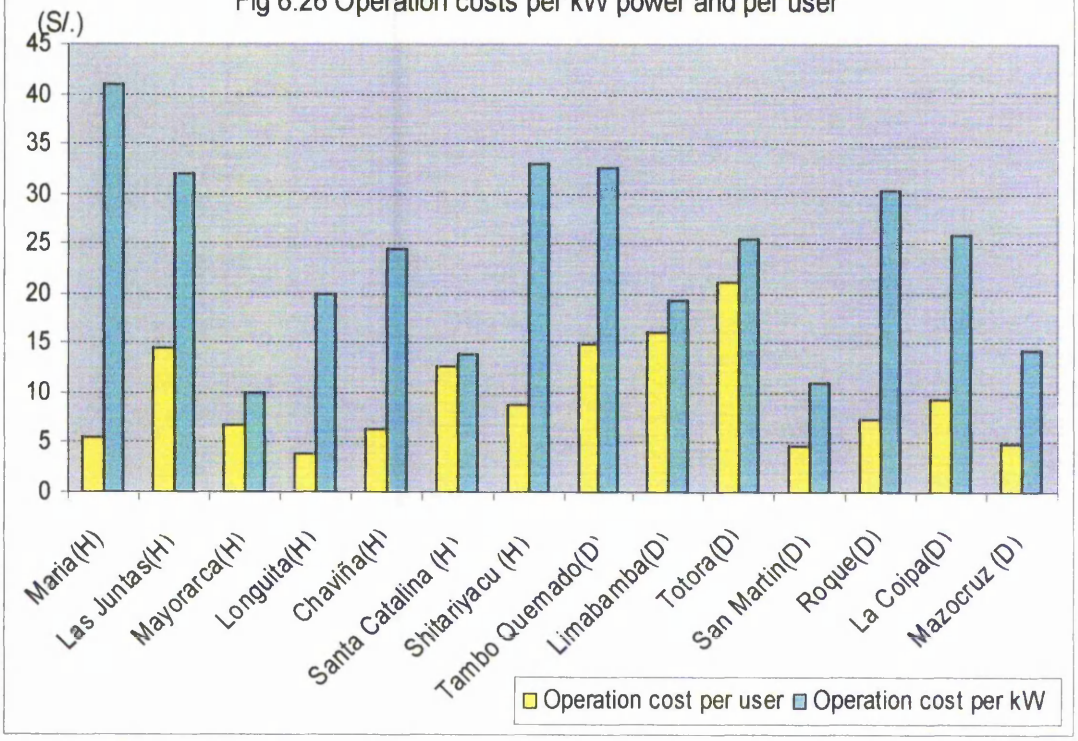
Nevertheless the results show that government managed systems are charging lower tariffs than those systems managed and/or owned by Communities and Municipalities, that happens despite to the fact that they use regulated tariffs (see table 6.4).

d) Operation cost of the systems per unit power and per user for the different sizes of the systems, without including fuel. - Figure 6.26 shows the operation costs per unit kW installed as well as operation costs per user; the cost of fuel has been excluded in this figure in order to compare both technologies used on the same basis. All hydro schemes are grouped in the left side of the graph ordered by size, from the smallest to the largest; the diesel sets are grouped in the right side of the figure, ordered in the same way as for the hydro schemes.

It was found that there were no clear trends relating to installed capacity with operation costs per kW (unit cost) of the schemes neither for hydro schemes nor for diesel sets. For example the operation cost per unit kW for Las Juntas (with 25kW kW installed power) is close to the operation cost per unit kW for Shitariyacu (with 120kW installed power); and similar situation happens with the operation costs per user. These results imply that there is not a clear effect of the economics of scale within this range of installed capacity.

The average operation cost for hydro schemes is 8.32 Soles per user and for diesel sets it is 11.16 Soles. The average operation cost per unit kW installed for hydro schemes is 24.85 Soles and for diesel sets it is 22.68 Soles[36]. The reason for such a difference is not clearly explained, however maintenance costs of civil works may contribute to this difference, but it is the fact that hydro schemes are better off in terms of net income it may encourage the management expend a bit more in salaries and services.

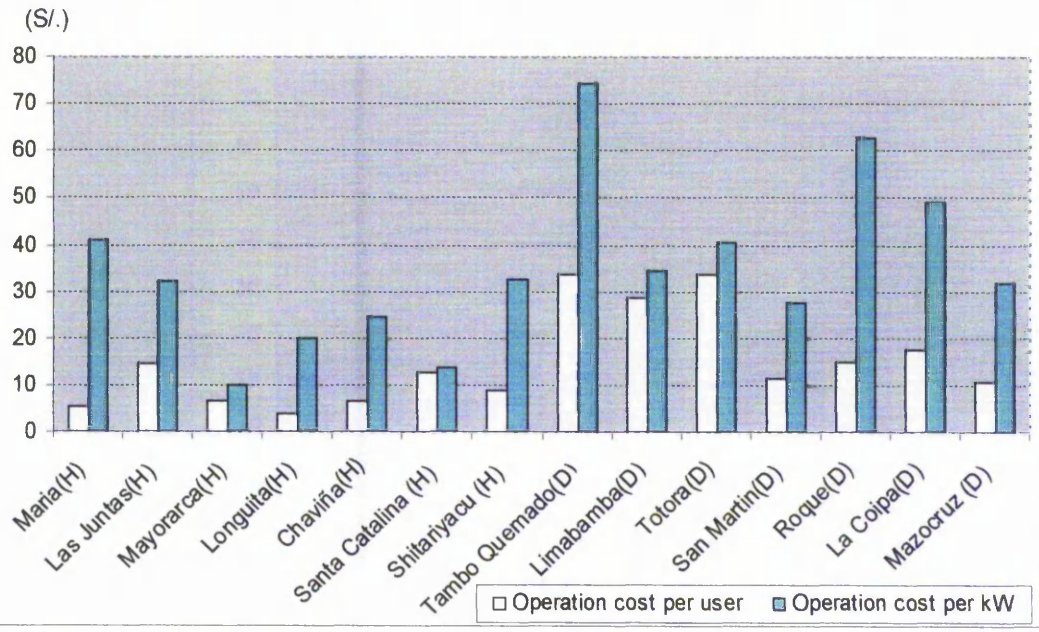
Fig 6.26 Operation costs per kW power and per user



e) Operation cost of the systems per unit power and per user for the different sizes of the systems, without including fuel . - As seen in figure 6.27, when the fuel is counted, the operation costs for diesel sets change dramatically comparing with the previous case (without considering fuel); the average cost per installed kW is 45.71 Soles and the average cost per user is 21.61 Soles. The difference is mainly in the hours of operations; the more hours service is provided the higher the operation cost per user and per kW installed is.

[36] The exchange rate at this time was 1US$=3.25 Soles

Fig. 6.27 Operation costs per user and per kW, includes costs diesel fues (Soles)



6.3 Factors of wider context

The main focus of the present study was the critical factors at local context; however the limited information gathered regarding the issues of the wider context from interviews to users, leaders and authorities, and from the available information in the energy sector (the Ministry of Energy and Mines) or other sectors. It is possible to draw some preliminary conclusions.

6.3.1 Degree of development of the village

The study shows that there are small differences regarding the degree of development among villages surveyed, all of them very isolated, with poor communications and little connection with the central and regional governments, with exceptional assistance programmes like FONCODES[37] and with no political power.

The main economic activities of all villages are subsistence agriculture and/or subsistence animal husbandry, which is complemented with income from remittances of family members selling temporary labour in other regions of the country in the urban areas or abroad.

[37] This programme funds small community projects submitted by the community, those communities with high isolation can hardly take advantage of it because they have hardly have technical assistance for the preparation of their project, and also because sometimes they are not aware about the programme and the kind of assistance.

Table 6.17 Services provided in the villages	
Village	Servicies
Shitariyacu (H)	Piped water[38], satellite telephone, elementary and high school, health centre, police station, 70% of families have sewage and 30% with latrines, electricity.
Mayorarca (H)	Piped water, satellite telephone, high school, health centre, no Sewage, electricity, no police station.
Chaviña (H)	Piped water, elementary and high school, health centre, police station, drinking water, sewage, and electricity from a small hydro scheme
Las Juntas (H)	Piped community water services, health centre, satellite telephone, electricity.
Maria (H)	Piped water, satellite telephone, health centre, police station, 30% of families with sewage and 70% with latrines
Santa Catalina (H)	They have access to drinking water, health centre, elementary and high schools and electricity service provided by a small hydro scheme. Piped water, satellite telephone, 40% have latrines, health centre, elementary school.
Longuita (H)	No water services, no telephone, 20% have latrines,
Totora (D	Elementary schools, health centre,
Limabamba (D)	Piped water, satellite telephone, elementary and high school, health centre, police station and electricity
San Roque (D)	They have elementary school, health centre, electricity, no other services
Tambo Quemado(D)	Elementary school, heath, electricity, no sewage, no latrines.
Mazocruz (D)	Piped water, satellite telephone, electricity, health centre, elementary and high schools, only 40% of families have latrines
San Martin (D)	No drinking water, elementary education school, have no health centre, no sewage no latrines.
La Coipa (D)	Piped water, satellite telephone, elementary and high school, health, electricity services, police station, 90% of families have sewage

Despite to the fact that the village sample covers a wide range of the development Index (see section 6.1.2), small differences were found on the most relevant indicators, for example the average monthly cash income vary from approximately US$ 30 to US$ 77 for all the range of villages surveyed; the range of services provided vary from village to village[39]; all of them have elementary education, health centres for basic medical attention and some of them have high school education, also majority of them have satellite telephone services, see table 6.17.

Figure 6.25 shows that there is not a clear performance pattern of the electricity services in connection with the poverty index (which is the main indicator of the degree of development) and the financial success or failure of the system, According to such indicator, Las Juntas is the poorest village among those with hydro schemes but it has the healthiest financial and technical performance of all the micro hydro schemes; while for villages with diesel sets, those two with lowest poverty index have a positive net income the others just perform poorly.

Therefore from the data collected it is safe to say that the degree of development of the village is not a Critical Factor for the actual performance of stand alone electricity schemes in rural areas.

6.3.2 Market connection

The findings of the study show that the connection of the village with markets may have some impact on the benefits of the electricity services for the users; people in villages with better connection to markets take advantage of the electricity services to sell their products in better conditions, they have more opportunities for social and cultural exchanges with large towns and cities; but there is no evidence of influence of market connection over the financial performance of the systems. For example Las Juntas has the best market connection of all the villages studied that is because it lies in the shore of a large road that connects the most important towns of the Coast region with those Upper Jungle and the Andes in the north of the country. Therefore the electricity services in Las Juntas has been important for the local inhabitants to implement quite few small business such as, fruits and vegetable shops, coffees, small restaurants, tire repairs, welding workshop and others, the main clients being the road travellers. San Martin in the opposite situation is very isolated; in this village electricity has clearly not contributed to any sort of income generation activity, neither it contributes to improve any social service like health

centre, education centre and others, yet it has a successful financial system. Like for those two examples shown above, it is found that there is no evidence of market connection of the villages and the success or failure of the electricity systems.

Therefore market connection is clearly not a Critical Factor for the performance of the schemes and their sustainability. However electricity could contribute to the development of the community once it is implemented, especially when the service is 24 hours a day and of good quality, such is the case of most of the villages with hydro schemes, where there are not only small income generation but also benefits from other services requiring electricity for lighting.

6.3.3 National capacity

Since the issue of technical capacity was assessed in section 6.2.10 within the Critical Factors of local context, this section only refers to national capacity to manufacture equipment and spare parts.

The study shows that there are no local capacity (in the villages) to do even small repairs and maintenance of equipment and the capacity is limited for electrical wires (except for the case of Las Juntas); but in most cases there is local capacity to cope with minor civil works repairs and maintenance. Therefore the existence of technical experts and manufacturers (or at least suppliers) of equipment and spare parts nationally or regionally is vital for the successful operation and maintenance of stand-alone systems.

In most of the cases studied there have been failures of equipment in the past, such as burning of alternators, braking parts of turbines, valves, electronic controls, and others[40]. Although such failures are not frequent, when they occur, the solution generally requires large quantities of money, but it also requires the availability of spare parts in the market and the right information within the administration team members. According to the information gathered, to purchase spare parts, the operators and/or owners generally have to travel to the capital city or few large towns, they have to put the purchase orders for manufacturing and wait several months until the parts are manufactured, they have to deal patiently with additional time required to arrange transportation for the parts and to install them. The degree of difficulties and costs increase as the distance to the provider increases, and it becomes even more difficult if not impossible to get spare parts or technical

assistance from outside the country. Fortunately, at present in Peru there is national capacity on the manufacturing and supply of parts for both technologies studied.

Therefore the national technical capacity for manufacturing equipment and spare parts definitively plays a role in the success of small energy systems; consequently it is considered a critical factor for the success of any isolated stand alone electricity systems. The lack of spare parts and specialised assistance could even be the reason to stop the systems forever after an essential part brakes or is damaged.

6.3.4 Legal framework

It was found that the legal framework has little or no connection with the operation of the small isolated systems in Peru, except for those owned by the government. The government has no responsibility neither interest on the systems owned by Municipalities, Communities, Privates and Cooperatives, therefore these service providers run their service at their own criteria and also their own risk.

Small isolated electricity systems are not subjected to government supervision about performance, standards, tariffs, safety and other technical or legal issues; therefore each owner of a system sets his own tariff scheme, has a different power connection to customers, and has his own rules about quality, bill collection and others; but at the same time owners are vulnerable, because they have no tools to enforce their rules.

Therefore the present legal framework has no influence in the performance of the small stand alone energy systems in Peru. And consequently it does not look to be a critical factor for the performance of the systems.

However looking at the risks that electricity service providers face, it is felt that support, guidelines and rules from government could be helpful for a better performance of isolated electricity services, especially for the financial performance and sustainability and could encourage the investment of small local private entrepreneurs.

6.3.5 Bureaucracy

The fact that the government has no connection with the small stand alone electricity suppliers, it makes Bureaucracy to be innocuous to performance of these systems,

therefore is not a Critical Factor for isolated stand alone electricity schemes in Peru. However it is felt that if government rules and regulations have to be issued implemented, it would be good to have an efficient bureaucracy, otherwise it could somehow affect the performance of the systems; for example if government have to deal with national tariffs, a poor performance of the bureaucracy to update tariffs could affect the financial performance of the systems.

6.3.6 Proper tax frame

It was found that the government has little or no connection with small electricity providers in rural areas (except for their own systems), there are not clear rules on taxes and there are no controls or guidelines for the running of these systems; and the absolute majority of the systems are run informally (in not all the non-government systems) and without noticing the National Tax System. It was also found that running the systems informally have clear advantages such as the setting of tariffs to the convenience of the owner.

Therefore small isolated systems run informally and consequently the tax system has no influence in the performance of the isolated stand electricity systems in Peru, hence Proper tax frame is clearly not a critical factor for success or failure of these systems.

6.4 Summary of findings.

Average family income and poverty index.

In most villages surveyed there is certain degree of correlation between average family cash income and the poverty index of the village; for example in Mazocruz - the village with the highest poverty index of the survey sample- the average monthly family cash income is the lowest; similar results were found in other villages. Those with moderate poverty rates like Santa Catalina and Longuita are in the mid range of family cash income.

In Las Juntas, the average family cash income clearly does not correlate with the official poverty index and similar situations were found in other villages. In fact, Las Juntas has the second highest poverty index of the survey sample (according to official information); whereas the survey revealed that it has one of the highest average family cash income rates within the sample. This may be because of the great improvement of the road that passes through the village[41], connecting it with

markets and also providing opportunities for people to increase their income through small businesses like cafes, restaurants and small shops to sell food and local products to passers-by. The hydro scheme might have played an important role in providing these services. In conclusion, neither poverty indexes nor cash income can be used as an accurate guide to the economic status of a village, but together they provide a useful indication.

The opposite to Las Juntas occurs in San Martin where the official poverty index is moderate, but the data collected in this research study reveals that the average family cash income is low; it is believed that one of the reasons for this situation, among others, is its isolation from "large markets" and its complete disconnection during the wet season due to the lack of good roads.

Basic electricity requirements

The study reveals that people in rural areas have an unavoidable basic need for energy for home lighting, torches and communication (radios). When they have no access to electricity, they light their homes with kerosene lamps and wax candles and use small batteries for radios and torches; these needs have to be met no matter how poor they are.

The study also reveals that such basic energy needs vary according to the cash income of the villagers, but there is a bottom line quantity of energy demand which is reflected in figures 6.6a and 6.6b. This bottom line is met regardless of cash income; therefore the poorest families use a higher percentage of their income on purchasing energy resources to meet their basic requirements.

Benefits from electricity

Besides the disadvantages of diesel sets pointed out previously, people in villages with diesel sets spend more on complementary energy sources because of the limited hours of electricity supply.

It was found that the first and most common benefit from electricity is clearly lighting and communications (radio and small TVs), however the benefits that people appreciate the most are better conditions for children to study, more security and paying less for lighting, although the benefits are expressed with more optimism and in a higher proportion by those with hydro schemes.

Despite the poverty of the villagers, there is a desire to use more appliances. There are more appliances in villages with hydro than in those with diesel sets. It was also found that there are few very modern appliances such as DVDs and computers, which only the better off families in the village can afford.

Regarding people's opinion concerning the changes, more people living in villages with hydro think that electricity has brought positive changes than people living in villages with diesel sets.

Cost of energy

The study reveals that the cost of energy depends much upon the technology used to provide the electricity service. The average cost per unit of energy (US$/kWh) is much higher for diesel sets than for hydro schemes; in fact in the survey sample it was found that the average cost per kWh in hydro schemes is only 0.18 Soles (US$ 0.055), while for diesel sets it is 1.61 Soles (US$ 0.49). In other words, people living in villages with diesel sets pay about 9 times more for electricity services than people with hydro schemes.

Tariffs and bill collection

Tariffs are set randomly and with no relation to the poverty index, as might have been expected; each village has its own tariff scheme, except for government owned schemes (managed by regional utilities), which use the regulated tariff for rural areas.

Payment arrears are not necessarily due to users' lack of money, but are more related to the quality of management. For example in Las Juntas and San Martin (both with a private administration), the collection of rates is good despite the fact that in each case they have the highest cost for hydro and diesel respectively.

Apart from the government owned systems, small stand alone electricity services have neither support from government nor rules or guidelines regarding standards or other matters that could influence the performance of the systems.

National regulations on tariffs and the quality of electricity services do not apply to stand alone systems in practice, because the government has neither the capacity to reach them nor the interest to do so.

Users of diesel sets express willingness to pay higher amounts than they are paying now for better electricity services; however, the meaning of better services for them is mainly more hours of service and sometimes more participation in decision-making.

In those systems where users pay more for electricity, they generally have a better idea about the financial needs of the system, because the management teams or the owners have to explain the costs to them. In fact in the villages with diesel sets, many interviewees justified the higher tariffs as necessary for buying fuel.

It is important to notice that flat rates work conveniently for diesel sets; this is because it is possible to set a "high tariff" regardless of the few hours of service and the limited consumption of the large majority of users (ending up with a high energy cost per unit). However, this practice helps the financial performance of the systems.

Bill collection is a difficult task; most of the systems have shown long delays in collecting overdue bills; in fact the average for hydro schemes is 16.8% and for diesel sets 20.29%. There appear to be several reasons for this, most of them related to the performance of the management teams and the proper use of rules; for example, the capacity to apply penalties, the relation between the management team and the community. The type of management also has some influence on the effectiveness of the management team; for example systems under Municipal management have more difficulties in applying their rules[42] than the others because Mayors do not want to become unpopular with their people.

Connection cost

The connection costs were low in all cases studied; therefore it is safe to say that they have not been a barrier for users to gain access to electricity in any of the surveyed villages.

As for the case of tariffs, in isolated stand alone schemes there are no rules or guidelines regarding connection costs, as these have been chosen randomly. The decisions about the amounts to pay are made by leaders and local authorities.

It was found that in villages with hydro schemes the connection costs were higher than in villages with diesel sets (average 74.3 Soles -US$22.86– for hydro schemes and 25.3 Soles –US$ 7.78- for diesel sets). There is no clear reason and/or explanation for such differences.

Community participation

The study reveals that in hydro schemes there is generally better community participation in the installation than in diesel sets; in micro hydro schemes the users participate with labour and in decision making, whereas in diesel sets the participation is limited to decision making.

Furthermore, in villages with hydro schemes there is generally good participation in maintenance activities, with the exception of Chaviña (government owned), but the participation in diesel sets is virtually non existent; the main reason is that hydro schemes require non-qualified skills which can be provided by the users (generally for civil works), while diesel sets require skills that are not found in rural communities.

The study shows that in villages with diesel sets, users are more willing to participate than in villages with hydro. The explanation is that in villages with hydro schemes a significant number of users feel satisfied with their participation, which is not the case in villages with diesel sets and therefore they would like to be more involved.

The study indicates that community participation is an important factor for the performance of the systems. Participation in the installation and in operation and maintenance decisions is a good practice for keeping good relations between the management team and users and may influence the financial performance in some aspects, such as the prompt payment of bills.

Political interference

It was found that political interference in isolated stand alone electricity generation systems is a common fact. Politicians generally appear with promises of better services and free electricity. Diesel sets appear to be more exposed to political interference because of their main disadvantages in terms of the cost of fuel, hours of service, high downtime days per year and others, therefore politicians can easily take advantage of these to criticize the electricity service providers (generally the local authorities)[43] and offer "alternatives".

Political interference has a significant influence on important issues like punctual payment, which directly affects the financial performance of the systems or at least makes it more difficult for the management team to reverse the influence of the politicians.

Ownership

In small rural systems, ownership does not usually mean financial benefits for the owner. For Municipalities, government and communities it is an issue of service to the community. However, it is also clear that as far as Mayors (municipal ownership) and the government are concerned, ownership means controlling the service and therefore opportunities for political benefits and control. For private entrepreneurs, such as the case of San Martin, ownership means some financial benefits (although generally small), prestige and power in the community.

Ownership is an issue generally defined at the beginning of the process, sometimes before the installation (when local authorities or governments install the systems), and during or at the end of the installation when an external donation agency[44] installs it. Once ownership is defined it is very difficult to change it, if not impossible.

Operation and maintenance of the systems (technical performance)

The study reveals that the lack of preventive maintenance programmes is common in all systems, except for those managed by concessionaires. A similar situation occurs with the quality of the maintenance; community managed systems appear to have the poorest management, followed by those owned by municipalities. Among the community-owned, the exception is Las Juntas, where the maintenance and operation of the system is good, since it is managed by a small local private enterprise.

The study reveals that the number of downtime days per year is high for all systems, except in Las Juntas; the worst are the diesel sets. For hydro schemes the most important reasons are the lack of water resources due to poor design, and the lack of spare parts and experts; for diesel sets the main reasons are the unreliable supply of fuel[45] and its high cost. However, in the case of the privately managed diesel set, a reasonable financial performance of the system is the most important reason.

Local Capacity

Training for the operators and administrators of small isolated electricity generation systems is generally scarce and poor, more so in the case of administrators; this fact contributes to the poor management results in unreliable systems.

It was also found that the owners rarely look upon management or administration as a key factor for the good performance of the systems, therefore they generally hire operators, except for a few cases in which owners have thought about the need for administrators.

Villages with hydro schemes appear to be more "in control of the system", which is not the case for diesel sets, mainly because users participate more during the installation of the systems and in maintenance decisions.

In most of the cases operators and administrators have not been properly trained to promote energy saving and rational use of energy in order to cope with a fast growing demand when it occurs. The exception is Las Juntas where the administrators are conscious about that issue.

Technical assistance

In most cases there is a lack of local capacity to do repairs, new connections or the extension of distribution lines. Management teams rely on external services through consultancies (except for those owned by the government).

Technical assistance can only be found in large towns and predominantly in Lima (the capital of the country); therefore the degree of isolation of the villages is directly related to the degree of difficulty in obtaining technical assistance. Also, the more geographically isolated the villages are, the less means of communication are available, a situation that makes it even more difficult to obtain assistance. The capacity of the management team is very important to overcome such difficulties.

Load factor

The load factor in hydro schemes is generally higher than that in diesel sets, mainly because hydro schemes provide electricity 24 hours, except for Mayorarca (12 hours), whereas diesel sets provide very few hours. The main reason is the source

of energy and the cost of obtaining it; whereas hydro energy is free, diesel is expensive.

The demand diagrams show that in diesel sets there is a relatively uniform consumption during the few hours of service provided. This is because energy is used mainly for lighting and TV, which are mostly switched on during the few hours of operation of these systems. For hydro schemes the diagrams show high peak demands during the first evening hours (when lighting and TV are on), but also a small demand during the rest of the day.

In villages with hydro schemes the average consumption of energy per family is about 5 times that of the families in villages with diesel sets (i.e. 58.3kWh and 11.5kWh per month respectively).

For hydro schemes the lowest energy consumption is recorded by community managed schemes (Mayorarca, Maria and Las Juntas), for different reasons: In Mayorarca, because they only run the scheme 12 hours a day; in Maria because of the limited energy availability in the system- 20kW for 159 users. In Las Juntas there is a well-understood concept of energy saving and they have a comprehensive tariff structure to encourage this.

The maximum average power demanded per family during peak hours ranges from 0.16 to 0.25 kW for hydro schemes and from 0.08 to 0.19kW for diesel sets. There are no other clear reasons for this difference apart from a few more appliances, a few more lights bulbs and an inefficient use of energy. The lowest peak demands occur due to the limited capacity of the system, as is the case of Mazocruz (0.08kW).

Appropriate sizing and planning of the systems

The study reveals that the sizing of the systems is generally poor and no uniform criteria have been used for sizing the systems. It was found that hydro schemes are frequently undersized while diesel sets are oversized.

The growth of the number of users depends very much on the location; villages in the Upper Jungle have grown faster than those in the Andes, but this issue was evidently not taken into consideration when sizing the schemes. Consequently, some systems in the Upper Jungle have large waiting lists of people who cannot be

connected to the service, such as Shitariyacu and San Roque, whereas some schemes in the Andes have fewer users now than at the beginning, mostly because the population of the village has decreased.

Source of energy

The source of energy has a clear influence on the number of hours of the service, the amount of energy consumed and its benefits. As shown in table 6.8, villages with hydro schemes usually have more appliances than those with diesel sets and they also have a greater application of productive uses. Therefore, villages with hydro schemes have more opportunities for productive uses and income generation than villages with diesel sets.

It was found that villages with hydro have longer hours of services, higher electricity consumption per family and a much lower cost.

There is clearly more community participation in the process of installation, decision-making and running the system.

Villages with hydro have much less expenditure on complementary sources of energy (wax candles, kerosene, dray batteries and others).

A higher proportion of consumers recognise the benefits of having electricity. Also, hydro energy systems are less sensitive to political interference.

Management

The study reveals that management is the most important factor of all, because it will generally determine the performance of the scheme.

It was also found that the management of the systems is generally tied to the type of ownership; therefore the types of management can be arranged as follows:

1. Government ownership and management. – The great majority of systems installed by government are under this category; in which case after installation the Central government hands over the property of the system to ADINELSA (government organisation), which in turn hires the regional utility to run the system. According to the results of the study, this sort of

management generally has a good or fair technical performance but a poor financial performance; see figure 6.25, the diesel set of Tambo Quemado and the hydro scheme of Chaviña; in both cases the net income only covers the costs of local operators but not the administration costs and overheads of ADINELSA or the utility.

2. Municipal ownership and management. - According to the results of this study, Municipalities are poor managers of electricity services, they have serious difficulties in setting tariffs, applying rules (especially penalties), and generally they are more susceptible to political interference than other types of management and their technical, financial and social performance is generally poor.

3. Private ownership and management. - San Martin falls under this category. The results reveal that it has a healthy financial performance, but the management appears to be relatively poor in social, economic and technical terms.

4. Community ownership and management. – The results reveal that communities are good at social performance; there is generally a good participation of the community in decisions as well as in maintenance activities. However the financial performance shows a mix of results; some have a reasonable or acceptable financial performance, others struggle to meet the monthly expenses of running the hydro schemes. One of the reasons is that Communities have internal structures which in most cases lead to difficulties in the management of the system, among them:
    i) Community members versus electricity users; in most communities only a small proportion of its members gain access to electricity (those who live in the hub of the community forming a village), the majority do not (those spread throughout the community-owned land). This situation leads to different priorities among members, hence the difficulties in prioritising the services of systems when problems arise.
    ii) Communities tend to carry out most activities by contributing their efforts rather than money, therefore activities that require money,

such as the purchase of spare parts, are generally delayed and this in turn results in downtime days.

5. Community owned private management - the case of Las Juntas. - According to the results of this study, this system shows the best performance in all aspects. This is because such a combination provides the opportunity to tackle all (or most) issues; private management provides good financial, technical and economic performance, while public ownership provides the social performance. In Las Juntas, the owner (community) hires a small local company to provide the service of "operating the electricity services"; this secures the presence of somebody to look after the scheme continuously. The local enterprise is cheap enough so that the income from tariffs is sufficient to pay the enterprise. It is worth mentioning that members of the enterprise consider it more important to have a job than to think about growing and earning a large profit.

The type of management used in Las Juntas appears to be the reason for the success of the hydro scheme in that village and looks promising as a management option for small-decentralised systems. Nevertheless, it is worth bearing in mind that the success of this community is due to the fact that they seriously considered other critical factors, local capacity-building in particular.

Operating costs of small stand alone systems

Operating costs do not follow a pattern related to the size of the schemes as might be expected; the operating costs of Las Juntas with 25kW are similar to those of Shitariyacu with 120 kW. Santa Catalina with 99 users has similar operating costs per user to Las Juntas with 55 users. These issues are clearly related to the lack of proper management models and tariffs. They have also had a significant input of ideas and training from a supportive NGO, in this case Practical Action.

Despite the few hours of operation of diesel sets, their operating cost per unit kW and user is double that of hydro schemes, only because the cost of fuel has such a great influence on the operating costs.

The cost of fuel is by far the most important reason for the very few hours of operation of diesel sets.

CHAPTER VII

CONCLUSIONS AND RANKING OF THE FACTORS, AND RECOMMENDATIONS

7.1 Conclusion on the critical factors

The results of the study reveal that of the 13 possible critical factors in the local context considered in chapter four, only 3 are really critical; the other 10 are important, but not critical. Therefore, as seen in the table below, the factors have been categorised in two groups: "Critical Factors" and "Important Factors".

An example of an important factor is the poverty status of users, which may affect the financial health of a system in some way, but is not critical for the success of the system, because in rural villages the basic energy required for lighting for at least a few hours every evening will always be met, despite the level of poverty. Consequently, the "Capacity to Pay" becomes relative, because what actually happens is that the poorest groups of people consume less energy to fit their budget (or their capacity to pay). Although it can also be an initial barrier for gaining access to energy, once users gain access, it no longer influences the performance of the system. Such is the case in all surveyed systems, where connection costs have been low in all cases.

Under these considerations, the factors categorised as "important factors" can be overcome if the "critical factors" are working properly. Table 7.1 shows the critical factors, listed in order from the most to the least critical; the important factors also appear in table 7.1, although not in order because there are not enough elements to do so; in fact, it is worth bearing in mind is that they are all important, therefore for any stand alone energy system it is necessary to pay attention to all of them in order to ensure a sound performance of the system in financial, technical and social terms.

7.1.1 Critical factors of a local context

The study reveals that management is the most critical factor of all, because most of the other factors can be overcome if this one is dealt with properly. If the scheme has a good model in place and a capable team, the majority or all of the critical and important factors can be overcome. It will be possible to set up a proper tariffs scheme, a good bill collection system and good technical services; San Martin and Las Juntas are examples that demonstrate this.

Local capacity is another critical factor; only properly trained local people are capable of operating, managing and administrating the system appropriately and only local human resources are cheap enough to keep running costs low. Like in the previous factor, Las Juntas is a good example of the local capacity to run the system, where a team of three properly trained local people run the system efficiently; they operate the system, set tariffs, collect bills and cope appropriately with a range of issues related to electricity and businesses. Nevertheless, in rural areas it is difficult if not impossible to find trained local people, therefore the local capacity to run stand alone systems must be created whilst the system is being implemented.

The third critical factor is technical assistance; because electricity generating systems are a new technology for rural people, therefore whenever a serious fault in the system occurs, the villagers need specialised assistance from outside the community. In fact, all the systems studied have relied on external specialised assistance services through consultancies (except those owned by the government)[1]. When they do not find technical assistance available or these are extremely expensive, the system may be stopped for several months or forever. In the cases covered by this study, community managed systems found it difficult to obtain these services; some municipalities also reported difficulties; privately run schemes (including Las Juntas) reported not much difficulty; which again corroborates the fact that the management of the system is always a critical factor.

Although in chapter three it was categorised as a possible critical factor in the local context, the fact is that technical assistance is more an issue or factor of a national context, therefore it is now considered as a complementary factor to national capacity; Technical assistance/national capacity are therefore considered as one, see table 7.1.

[1] In some cases, even government systems use the services of consultants from the capital.

Table 7.1 Critical factors and important factors for the performance of small stand alone systems in rural areas	
Critical Factors	Important Factors
a) Local Context 1. Management 2. Local capacity (training) b) National (or wider) Context 3. Technical Assistance/national capacity	a) Local Context • Effective bill collection • Household benefits from electricity • Load factor • Capacity to pay • Cost of energy • Community participation • Low connection cost • Source of energy • Ownership • Political interference b) National Context (wider context) • Degree of development of the village • Market connection • National capacity • Legal framework • Bureaucracy • Proper tax frame

7.1.2 Critical factors of National (or wider) context

Of the six factors of a wider context considered in chapter four, the only one that is critical to some extent is the "national capacity" to manufacture spare parts and equipment. In this country, the availability of spare parts at an affordable price is critical to shorten the downtime periods caused by failures or damages of parts or components of the systems; however it is complementary to "technical assistance". Therefore for this study, both technical assistance and national capacity are presented as a single factor (see table 7.1).

7.1.3 Important factors of a local context

Effective bill collection is a very important factor for the financial performance of the systems, but it does not have much influence on other factors. It will affect the financial performance of the systems, however good or bad bill collection will only depend upon good or bad management of the system and the capacity of the administrators. As seen in section 6.2.4 Santa Catalina (hydro scheme) and Mazocruz (diesel set) have good bill collection but a poor financial performance.

Access to more benefits from electricity is an important factor. People appreciate electricity more if they perceive more benefits from it, but electricity does not necessarily contribute to a good financial and/or technical performance of the scheme. For example in San Martin, where the benefits are very limited, the financial situation of the system is fine and the system has kept running for several years on a private basis, whereas in Santa Catalina and Longuita, where there are clearly more benefits from electricity than in San Martin, the financial performance of the hydro schemes is poor. Therefore the benefits from electricity are important for people and for the development of the village, but they are not critical for the success of the systems.

The Load factor is important, in fact hydro systems have a much higher load factor than diesel sets, because they provide more opportunities for productive uses and for generating extra income[2], however the influence of this factor in the financial or technical performance of the systems is very limited; for example, although the diesel set in San Martin has the lowest load factor of all the schemes, it has a reasonable financial performance; on the other hand Maria, which has a good load factor among the surveyed systems, has a poor financial performance.

Capacity to pay is an important factor for the people (the lower the proportion of their income used to pay their electricity bill, the better it is for the family), however it does not necessarily contribute to the good performance of the system, nor to the benefits of electricity, therefore it is not a critical factor. In Mazocruz, the poorest community of the sample, payment delays are small compared to the other systems. Therefore,

[2] Micro hydro schemes have a higher load factor because they operate 24 hours and provide energy to a larger number of appliances and small businesses. In all cases, businesses are family units rather than community ones, therefore the extra income from businesses improves the financial performance of the system if there is a good bill collection and a good tariff.

as long as the cost of energy is not excessive and the management of the system is good, users will pay their electricity bill. However, extremely poor people may find it difficult to pay if their flat rate is high, but systems with an appropriate tariff and measured consumption can always adjust their consumption to their budget (meeting their minimum vital requirements).

The cost of energy is important but not critical. In fact, the diesel sets in the sample have a very high cost of energy per unit, but people can still pay for it if they need electricity; furthermore, if they have a metered or graded tariff, they can save by limiting their use of electricity[3]. Again, the clearest example is Las Juntas, where about 60% of the users only pay about US$3.00 a month, which in many cases is less than the average spent for lighting sources when they have no access to electricity.

Community participation is an important factor and it is a good practice that can contribute to the good performance of the systems, reducing maintenance costs, for example. The participation of community members heightens their awareness of issues related to electricity and the generation system, however it is not critical, either for the financial performance or for the technical performance.

Low connection cost is an important factor because it can ensure that poor people are connected to electricity; this is especially true for the poorest sectors of the villagers soon after the installation of the system is completed, but once they are connected it does not affect the performance of the system.

The source of energy is an important factor, particularly as regards benefits for users. As shown in most of the figures in chapter 6.0, families living in villages with diesel sets are at a disadvantage compared to those in villages with hydro schemes as far as benefits are concerned: they pay more per energy unit, have fewer hours of service, have more downtime days during the year, have fewer appliances because of the kind of service and, finally, they can barely cope with the operating costs of the systems due to the high cost of fuel. In fact, the survey shows that users' opinions are more favourable

[3] Very poor people in rural areas are happy with better lighting; in many cases, one or two bulbs for 2 to 4 hours provide the light they need for their evening activities.

towards the service with hydro systems than the service with diesel sets. In the long run this may affect the performance of the systems, but it is not a critical factor.

Ownership of the systems is an important factor, because it is associated to the management of the system as the owner usually decides on the type of management or at least plays a crucial role in the decision. For example, Mayors are unlikely to agree to hand over the management of the system to somebody else, even though they are aware of the difficulties of managing this type of service. The interesting fact is that ownership is very important and can have a great influence only during the implementation phase and when the management of the system is established; afterwards, ownership is not as important as management, therefore ownership is not a critical factor.

Political Non-interference is an important factor for the success of stand alone systems; the interviewed operators and administrators revealed that politicians could easily influence people when they talk about rights, about not paying for the service, low tariffs, non-application of penalties and other issues that directly affect the financial performance of the systems. The political factor may be present throughout the life of the scheme. Both national and local politicians can easily influence users to opt for positions affecting the performance of the systems, but it is not a critical factor, especially if there is a good management and if the users are conscious of the different issues related to electricity (the need for a tariff, paying on time, and others).

7.1.4 Important factors of a wider context

Apart from the national capacity explained in section (7.1.2), which clearly shows to be Critical, the other factors of a wider context may play a role in the success or failure of stand-alone schemes; however the limited evidence obtained through this study shows that they are not critical.

Better degree of development of the village, good market connection, appropriate legal framework, diligent Bureaucracy and proper tax frame could be positive for income generating activities, businesses and access to markets, hence mort availability of cash income and hopefully no difficulties to pay electricity bills and more interest of the people to care their system, which all together could may contribute to the financial performance and sustainability of the system. A diligent

bureaucracy would be helpful to villagers and especially to the management of the schemes hence it could also contribute to enhance the performance of the system. However none of these mentioned factors appear to be critical to the success of the systems, as shown in Las Juntas and others.

7.2 The small enterprise management model[4]

This management model has been designed and implemented by Practical Action, after a post-implementation study of performance in off-grid generating schemes installed in Peru during an ESMAP/Practical Action project between 1996 and 1998. The model attempts to embrace all the local village-level issues that affect sustainability; It was initially piloted in the district of Conchán, in the province of Chota, department of Cajamarca (see figure 7.1), and it has since been implemented in other areas by Practical Action and is now being adapted and employed in other contexts.



Figure 7.1.-80kW micro hydropower plant 80kW, Conchan, Peru

[4] The section 6.2 has been taken from the book Electricity Services in Remote Rural Communities "The Small Enterprise Model" published by the same author in 2006.

7.2.1 Objectives of the model

The principal objective of the model is the *efficient management* of small-scale stand-alone electricity schemes, where electricity scheme is taken to mean all the physical elements related to the generation and distribution of electricity: energy resources, civil infrastructure, electro-mechanical equipment and the electricity transmission (when needed), distribution networks and household connections. Management is taken to mean all the activities involved in sustainably operating, maintaining and administrating small-scale electrical schemes.

The model introduces the concept of entrepreneurial management, which is generally new in remote rural areas where historically management models for electricity services have been run by central governments, municipalities, communities or cooperatives and in very few cases privately-managed by the service owner.

The model seeks to promote financial management free from the interference of political interests, be they from within the community or outside, with the appropriate number of people for operating, maintaining and managing the service, which has positive consequences for the financial performance of the scheme as it is viewed as a business or service.

It also aims to establish a culture of paying for the electricity services, attempting to do so in the fairest way possible for the different user types (payment must be in accordance to consumption). It is difficult to generalize about tariffs and what these should cover in poor and isolated communities, however, the income of the scheme must cover at least its operation and maintenance costs.

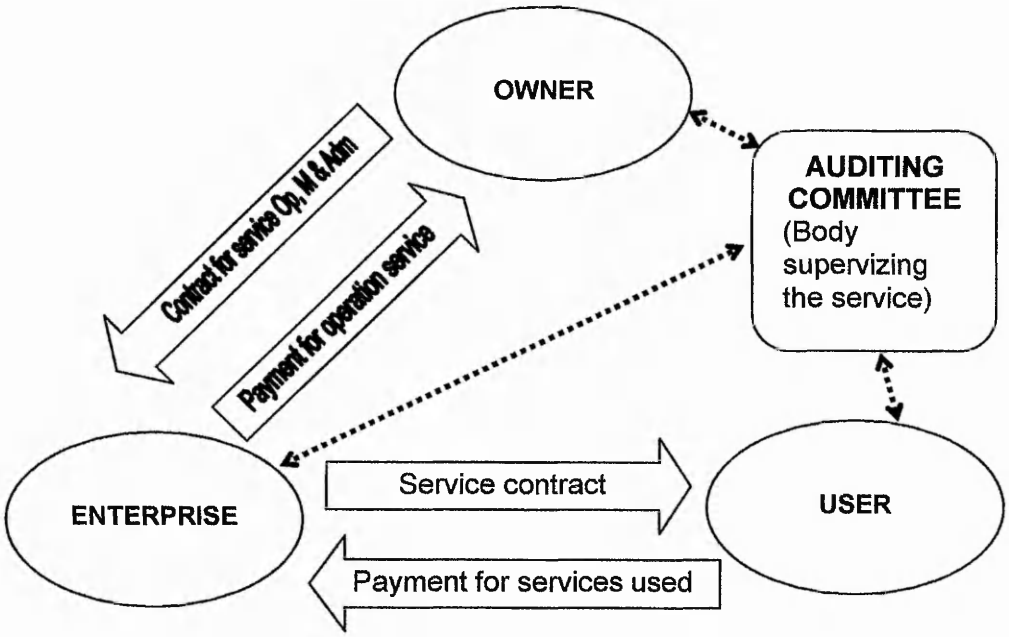
The model promotes and supports the rational use of energy and its use for income generation through the provision of local services and the transformation of products, thereby seeking to promote community development. The participation of the population is promoted as much as possible in the planning of the management system and in decision-making about the operation, maintenance and management of the scheme. In this way, people assume their responsibility for the scheme and recognize the rights and obligations of the different actors.

The model builds on existing local human capacity to develop skills in managing small-scale schemes efficiently. It takes into account internal relations, values and principles and creates or empowers local capacity to ensure the sustainability of the scheme. The core idea is that the enterprise must always belong to the local area.

7.2.2 Actors within the model

There are four main actors involved in the operation of stand-alone electricity schemes: the owner, the micro-enterprise operating the service, the users (households that receive the service) and the users' auditing committee. Each of these has a clear and well-defined role in the model, as illustrated in Figure 7.1. They have assigned responsibilities and established rights in relation to the role they play. For example, the owner must respect the contracts signed with the enterprise, the enterprise must fulfil its responsibilities for operation, maintenance and management, and in exchange, it receives financial remuneration for its efforts.

Figure 7.2 - Diagram of the small enterprise management model



A set of mechanisms has been developed to ensure responsibilities are fulfilled. The rules are established in specific documents and agreed to by all parties. All the actors are aware of the contents of each document. These are developed within the current legal framework. Legal tools and means are employed to enforce the agreements, for example contracts are registered with notaries.

The implementation of the model requires a long consultation process with the community on the viability and sustainability of the scheme. Extensive training is provided on the different issues inherent in maintenance, operation and administration, service costs, lifetime of the scheme and other related issues. Agreements arise out of intense dialogue about the role of the actors, the operating enterprise and the instruments for applying the model. Once agreements have been reached, these are formalized and the actors receive their formal set of responsibilities by writing, which gives them the force of law. Essentially, the community gains a sense of responsibility, commitment, duties and rights, without losing the communal sense of ownership and cooperation among themselves.

The model has been piloted since 1999 in the micro-hydroelectric scheme of Conchán. To date five more schemes have been organized in the same way. The achievements show that this concept has been a success and that it is applicable without limits of scale, to pico-, micro- and mini-electricity generation schemes used to supply energy to small communities. These can be hydraulic or diesel, but the tariff structures applied will differ in accordance with the cost.

7.2.3 Relationships between the actors

The owner

To apply the model correctly, it does not matter who the owner is but it is important that ownership is clearly defined. In practice, it could be the community, a state agency, the church, the municipality or another agent, what matters is that there be an owner capable of enforcing their property rights under all circumstances and also aware of the responsibilities they must comply with.

The model clearly addresses the issue to ownership and also clarifies the responsibilities of owners and how they can achieve the smooth running of the scheme.

The model defines the proprietor as the named owner of the infrastructure in relation to the other actors in the model and to the different institutions and/or individuals who interact in any way with the scheme and actors. The owner is responsible for the efficient management of the scheme, overseeing the provision of an electricity

service of the highest possible quality, taking into consideration the capacity and limitations of the scheme. The owner also signs contracts with the enterprise running the electricity services, overseeing adherence to the contracts and the services, and takes part or is represented in the auditing committee.

The small enterprise

Under this scenario, a local (private) micro-enterprise takes charge of the management of the scheme. This enterprise is selected through an open and public tendering process, giving equal opportunities to all the local inhabitants who believe themselves capable of assuming the management of the electricity service and are keen to do so.

Selecting the local private micro-enterprise is complicated and requires a great deal of work, since in rural communities normally such enterprises do not exist. In most cases there is not even local capacity to manage a micro-enterprise. Therefore an ad hoc approach is employed by the model. This was designed for this process and tested in all the cases piloted to date. First the terms of reference are prepared, then all the people interested in operating the scheme are invited to compete under equal conditions, that is, applications are invited from all who believe they are capable of operating the service, with educational talks and simple information leaflets provided. Before the installation, it is important to assess local capacity to highlight needs and the level of training necessary before the recruitment process.

For the recruitment process itself, the minimum levels of achievement for candidates are identified, the selection criteria are agreed with local authorities and leaders and the selection procedure begins. An evaluation committee is formed, which defines the evaluation criteria and selects the enterprise. Once selected, the winning enterprise completes the necessary procedures to register itself as a legal entity and then take over the management of the electricity services. Once the enterprise is chosen, it receives all the necessary support to make complete its registration with the corresponding government agency.

One advantage of this model is that it brings down costs for running electricity services and supports the efficient and sustainable management of the scheme; it also clearly contributes to the creation or strengthening of local capacity and

promotes the concept of enterprise (in some cases these may be the first enterprises formed in the area).

The main responsibility of the small enterprise is to manage the service efficiently. This includes energy supply, billing, bill collection, connection to new customers, disconnections and reconnections when required, and all the activities related to the operation and maintenance of civil works, equipment and electrical wiring of the scheme. The responsibilities of the operating small enterprise are detailed in the contracts.

The small enterprise trains the users (clients) on the rules, tariffs and the practical ways to make reasonable and efficient use of electrical energy. At the same time it trains the local population about the sustainability of the scheme. It signs contracts with each user, using a standard form developed for this purpose in which it undertakes to meet good service standards. It also takes contributes one member to the auditing committee.

The users

The users are the people (the customers) that use the electricity service provided by the scheme and pay for it. To obtain the right to the service, they need to request it and accept a supply connection via electric cables. This service can be for domestic purposes, small businesses, institutional requirements or other needs. Each of the users is considered to be a client and receives the rules for energy use and commits to adhering to them in a contract with the operating enterprise.

The auditing committee

The fundamental role of the auditing committee is to supervise service delivery. It is made up of representatives from the owner, the small enterprise and the users. The users will elect a representative in an open assembly then nominate her/him to be part of the auditing committee. This committee controls and inspects as necessary to ensure responsibilities and obligations are met by each of the three other actors in the management model. It will solve claims and conflicts within parties when they happen. It must be impartial and its supervisory responsibility must be completely devoid of political interests.

The auditing committee performs its supervisory function either under its own initiative or in response to complaints from users about poor service or other issues. It generally does not discipline actors, but the representative of the community will clearly explain the actions of the committee to regular assemblies of the community. Any complaint is aired in the committee and agreements must be communicated to the interested party.

7.2.4 Operation of the model

The operation of the electricity service and the relationships between the different actors are clearly defined in the code of conduct on operation and functions. The contracts establish the rules and the operating mechanisms to run the service effectively. As such, the contract defines the principal functions, responsibilities and rights in the relationships between actors.

The owner of the scheme hires the micro-enterprise to manage and operate the scheme as a whole, that is, to carry out the necessary tasks to ensure the day-to-day functioning of the scheme according to the agreements. The relationship between the owner and the micro-enterprise is governed through a contract developed and agreed by both parties, signed and publicly registered. This contract documents the responsibilities, rights and duties of each party, and is valid for at least five years. In exchange for the enterprise's efforts, the proprietor pays it a monthly sum. The rules on collecting payment from users and the use of this money are established as part of the tariff structure (Sanchez, 2006). The amount to be paid is defined and agreed upon and fixed in the contracts, in order that both parties adhere to it. The contract also fixes the rules on disputes and considers how these can be resolved. It also takes into account relevant local law codes where necessary.

The total paid for the service must under no circumstances exceed the sum collected from billing. Generally the payment to the micro-enterprise is calculated according to the effort required to manage the scheme. It is recommended that the structure of the payment be composed of two parts of a fixed amount (a base payment), plus a variable amount, which depends on performance in bill collection. This arrangement is an effective incentive for the enterprise not to tolerate late payments from users, to promote the electricity service to new users, and even to save energy, because in

this way they can reach new customers and get more income.

The direct relationship between the enterprise and the user is simple – the user requests the service, accepts the tariff and signs a service contract with the enterprise (because the tariff has been agreed before in community meetings). The contract covers the liabilities and penalties of the enterprise while user are also bound by the contract and service terms. The electricity service contracts have a single format and are applied equally to all users, irrespective of their condition. They do not privilege any users. The relationship between the enterprise and users is also governed by a code of conduct, which is developed before or immediately after the scheme or management model is launched for the approval of the community and authorities.

The enterprise provides the service and all the relevant information to users on the scheme conditions and operations. It sends monthly bills and collects payments. It also provides assistance to install new connections, extensions of the services and other services required at household level.

As outlined in the previous section, the user committee or auditing committee primarily acts as a trustee overseeing the quality of the service. As such, it does not have any written documents with the users, but it must respond to requests from any of the actors.

In contrast, there are direct contracts governing the relationship between the owner of the scheme and its users. These appear in the code of conduct and both actors thus made aware of their responsibilities and those of the other actors. They show each other mutual respect and hold discussions when necessary. The proprietor does not have any powers to intercede on behalf of any user in the case of negligence or abuse by the enterprise. The owner is completely neutral in disputes between any of the actors.

7.3 RECOMMENDATIONS

7.3.1 Local context

These recommendations are related to the social, technical, managerial and political issues required for successful stand alone rural electrification systems. However, their position below does not correspond to any order of importance for their success; some of them are related to Critical Factors, others to Key Factors.

For the implementation of a successful stand alone rural electrification system, management should be considered as the central and most critical issue; clearly define the ownership and type of management, define the relations between stakeholders and establish the necessary rules and instruments of interaction between them.

Building the capacity of the community and especially of the team to run the system should be a clear and well-programmed task, which should be taken into consideration from the planning stage. This should include technical and management capabilities to accomplish the management and operation tasks when running the schemes.

Before starting the implementation of stand alone systems it is recommended to examine the existing technical capabilities in the region and in the country, implement the necessary programme or projects to strengthen the existing national and/or regional capacity or build it if it is non-existent. This will include the transfer of technology and know how.

Providing information to the management team on where and how to find technical assistance, manufacturers, consultants, installers and sellers and the cost of such services, should be part of the capacity building.

Make people sufficiently aware of the capacity and limitations of their system, productive and rational use of energy, demand growth and life span of their system.

The choice of the source of energy should be based on the best financial and technical performance of the existing resources. In this respect, it is important to point out that the choice must be made by users, who should be well informed about the unit cost of energy, the number of hours of electricity supply, the kind of end uses

they can have and the benefits and limitations related to the performance of the system.

Information to help them make the choice should include examples of typical uses and costs. For example, typical domestic cost per family, typical cost for a small carpentry workshop or shops, restaurants, cafes and others, showing calculations and possible billings according to consumption. The information for the choice should also include the possible cost of replacement of the system's components, either because of possible failures or due to the life of parts and components.

The management team as well as the population should be aware of the possibility of political interferences. People should be taught about examples of this kind of interference and how this can damage the sustainability of the system. The visits of politicians may be unavoidable and listening to them too, but if people know their system and its advantages and disadvantages they will be able to distinguish between true and false promises of politicians.

Every stand-alone electricity generation system should have a tariff scheme, which should be aimed at covering all the necessary operating and maintenance costs and possible replacements.

The participation of the people in the design, implementation, operation and management of the scheme is important; therefore it is recommended to use all possible instruments and approaches to ensure their participation in all stages. This gives them a sense of ownership of the system, which may be beneficial for the overall performance of the scheme.

7.3.2 National Context

It is very important that the government design and implement an appropriate rural electrification strategy, which includes all the population sectors and all energy options. Special attention should be given to isolated villages and communities, because they confront the most difficult barriers for gaining access to electricity.

A national rural electrification programme should have clear priorities within its strategy. The example of Thailand is worth looking at, as this strategy prioritised the poorest villages; at the same time, however, the strategy also gave priority to those

villages that could contribute co-funding for the implementation, which helped to raise some extra funds for the programme and also to meet some demands for obtaining and paying for electricity, which have already been prepared. The Chilean rural electrification strategy is also an interesting example of an efficient investment of resources; the government calls for bids for the implementation of the systems, considering the cheapest proposal.

A rural electrification programme should have clear policies regarding subsidies and standards as well as guidelines for tariffs. Rural people will rarely gain access to electricity by their own means or by the intervention of typical private companies from outside.

The government should not only look for large national or foreign private investment but it should primarily look at the potential of small local investment, which will make the system more financially efficient.

To attract private entrepreneurs in rural electrification the government should eliminate taxes[5] for small and isolated systems. This will encourage small new local investors to venture into the electricity services business and will be an incentive for existing investors to officially establish their business and perhaps invest in new ones.

Further studies on the possible mainstreaming of successful management models should be conducted, specifically that of Las Juntas - Community ownership + Local private management.

To accelerate the process of providing electricity to rural people, it is recommended that the focus should be on the provision of energy rather than on integrated systems or programmes, because this distracts attention, resources and a lot of effort.

Energy could be a good driving force for the development of poor communities in rural areas; therefore after the implementation of energy schemes, the government and development agencies should consider the promotion of efficient and productive

[5] At the moment all small companies must comply with all tax regulations, regardless of their financial situation, therefore it is easier for them to remain informal. Those who would like to be formal realise that establishing a formal company involves a lot of hassle.

energy uses, businesses and the improvement of social services like health, education, communications and others.

The Government should consider educating politicians at both local and national levels, because without a clear understanding of energy issues they can negatively influence a range of issues, such as non- private intervention and others; sometimes they disseminate ideas that threaten the sustainability of businesses, such as "free electricity", "electricity is a right" or other slogans that frighten away private investors or promoters.

The government should evaluate the national capacity to manufacture equipment and provide technical assistance, filling the gaps for a future sustainable energy programme.

The government should support and promote financial schemes for the implementation of rural energy schemes with public and private participation, since these have proved to be successful; such is the case of the Revolving fund for micro hydro implemented by Practical Action in Peru[6] (Tarnaviewki, 2006)[7].

A rural electrification programme should seriously consider heightening users' awareness of the different issues involved in energy, creating a minimum knowledge about the subject – "Energy Literacy" of the people – since a well-informed demand will be of much benefit to the sustainability of the systems.

7.3.3 Future studies

More research work on the critical factors is recommended, especially in different contexts, in order to strengthen or contradict the findings of this study, because different contexts may involve different critical factors. Also research on alternatives and strategies to overcome the critical factors for each case are necessary.

Specific studies on community-owned and private management model (Las Juntas model) and its replication are recommended, especially because other organisations have started to use this model for small energy schemes and for small water

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[7] The revolving fund for the implementation of micro hydro schemes in Peru is a financial scheme which is in implementation since 1993

services. Examples of use of this model are: The "PERZA" project in Nicaragua (Project for Electrification of Rural and Isolated Zones); in this project the implementing agencies (Government and the World Bank) are using the small enterprise-management model for hydro schemes. And in Peru, where the World Bank Office for the Andean Region of is piloting this model for the management of small isolated water supply services.

More research about the role of the wider context factors is worth considering (see table 7.1); this is because this research study had focused mainly on local context factors. A better understanding of the wider context factors would contribute to the design of the right policies and strategies to accelerate the rural electrification process.

More research on approaches for knowledge dissemination on energy issues in the rural context is important in order to have certain "Energy literacy" of present and future electricity users, and to promote effective community participation in the implementation and running of the energy systems[8]. This is necessary because better informed people can engage more effectively in both implementation and running of energy systems, can participate in policy debate as well as in the decision making and choice of technology options and other important issues regarding energy services.

[8] Well-informed communities react more favourably to the different issues related to the operation and management of the electricity schemes (this is the case of Las Juntas).

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APPENDIX A: SAMPLE FRAME AND SURVEY POPULATION

A.1 Sample Frame (diesel sets and hydropower schemes bellow 500kW) installed nationally

A.1.1 Diesel sets

No	(kW)	Company	System	Village	province	Department
1	5	ELECTRO ORIENTE SA	Nueva Lima	Bajo Bravo	Bellavista	San Martin
2	10	Municipallity of Phinaya	Phinaya	Pitumarca	Canchis	Cusco
3	17	ELECTRO SUR SA	Moquegua (SIA) - 4	Ichiña	General Sanchez Cerro	Moquegua
4	17	ELECTRO SUR SA	Moquegua (SIA) - 5	La Capilla	General Sanchez Cerro	Moquegua
5	17	ELECTRO SUR SA	Moquegua (SIA) -3	Chuchumbaya	Mariscal Nieto	Moquegua
6	20	ELECTRO ORIENTE SA	San Martin de Alao	San Martin	El Dorado	San Martin
7	20	ELECTRO SUR MEDIO SAA	Santiago de Chocorvos	Santiago de Chocorvos	Huaytara	Huancavelica
8	29	ELECTRO SUR SA	Moquegua (SIA) - 9	Quinistaquillas	General Sanchez Cerro	Moquegua
9	30	ELECTRO SUR SA	Moquegua (SIA)-6	Matalaque	General Sanchez Cerro	Moquegua
10	33	ELECTRO ORIENTE SA	Pacayzapa	Alonso Alvarado	Lamas	San Martin
11	35	ELECTRO ORIENTE SA	Cabo Pantoja	Torres Causano	Maynas	Loreto
12	35	ELECTRO ORIENTE SA	El Alamo	Putumayo	Maynas	Loreto
13	35	ELECTRO ORIENTE SA	El Porvenir	Fernando Lores	Maynas	Loreto
14	35	ELECTRO ORIENTE SA	Petropolis	Yavari	Ramon Castilla	Loreto
15	35	ELECTRO NOR OESTE SA	La Tina	Ayabaca	Ayabaca	Piura
16	35	ELECTRO NOR OESTE SA	Chirinos	Suyo	Ayabaca	Piura
17	35	ELECTRO NOR OESTE SA	Sicches	Sicchez	Ayabaca	Piura
18	35	ELECTRO NOR OESTE SA	Jilili	Jilili	Ayabaca	Piura
19	35	ELECTRO ORIENTE SA	Sapuena	Sapuena	Requena	Loreto
20	40	ELECTRO ORIENTE SA	Santa Rosa	Santa Rosa	El Dorado	San Martin
21	40	ELECTRO ORIENTE SA	Piscuyacu	Piscoyacu	Huallaga	San Martin
22	50	ELECTRO ORIENTE SA	La Huarpia	Jepelacio	Moyobamaba	San Martin
23	50	ELECTRO ORIENTE SA	Cuñunbuque	Tabalosos	Lamas	San Martin
24	50	ELECTRO ORIENTE SA	Cumbaza	San Antonio	San Martin	San Martin
25	50	ELECTRO ORIENTE SA	Cusco	Alto Bravo	Bellavista	San Martin
26	50	HIDRANDINA SA	Cajacay	Cajacay	Bolognesi	Ancash
27	50	ELECTRO SUR MEDIO SAA	Cordova	Cordova	Huaytara	Huancavelica
28	50	ELECTRO SUR SA	Moquegua (SIA) -1	Calacoa	Mariscal Nieto	Moquegua
29	60	ELECTRO ORIENTE SA	Roque	Alonso Alvarado	Lamas	San Martin
30	60	ELECTRO ORIENTE SA	Sacanche	Sacanche	Huallaga	San Martin

31	60	ELECTRO ORIENTE SA	Pachiza	Pachiza	Mariscal Caceres	San Martin
32	67	ELECTRO SUR MEDIO SAA	Ticrapo	Huytara	Castrovirreyna	Huancavelica
33	80	ELECTRO ORIENTE SA	Pongo de Caynarachi	Caynarachi	Lamas	San Martin
34	80	ELECTRO ORIENTE SA	Caspizapa	Caspizapa	Picota	San Martin
35	80	S.E.A.L	Lomas	Lomas	Caraveli	Arequipa
36	80	ELECTRO SUR ESTE SA	Mazo-Cruz	Santa Rosa	El Collao	Puno
37	90	ELECTRO ORIENTE SA	Jepelacio	Jepelacio	Moyobamaba	San Martin
38	90	ELECTRO ORIENTE SA	San Juan de Pacayzapa	Alonso Alvarado	Lamas	San Martin
39	90	ELECTRO ORIENTE SA	Agua Blanca	Agua Blanca	El Dorado	San Martin
40	90	ELECTRO ORIENTE SA	Shamboyacu	Shamboyacy	Picota	San Martin
41	95	ELECTRO NOR OESTE SA	Montero	Montero	Ayabaca	Piura
42	96	ELECTRO ORIENTE SA	Shapaja	Shapaja	San Martin	San Martin
43	96	ELECTRO ORIENTE SA	Tingo de Ponaza	Tingo de Ponanza	Picota	San Martin
44	100	ELECTRO ORIENTE SA	Santa Clotilde	Napo	Maynas	Loreto
45	100	ELECTRO NOR OESTE SA	Paimas	Paimas	Ayabaca	Piura
46	100	ELECTRO ORIENTE SA	Bagazan	Sapuena	Requena	Loreto
47	100	ELECTRO ORIENTE SA	Tamanco Viejo	Emilio San Martin	Requena	Loreto
48	100	ELECTRO NORTE SA	Pomacochas	Florida	Bogara	Amazonas
49	100	ELECTRO ORIENTE SA	San Roque de Maquia	Maquia	Requena	Loreto
50	100	ELECTRO ORIENTE SA	Tierra Blanca	Sarayacu	Ucayali	Loreto
51	100	ELECTRO ORIENTE SA	Zapatero	Zapatero	Lamas	San Martin
52	100	ELECTRO ORIENTE SA	Tingo de Saposoa	Rioja	Rioja	San Martin
53	100	ELECTRO ORIENTE SA	Utcurarca	Alberto Leveao	San Martin	San Martin
54	100	ELECTRO ORIENTE SA	Pasarraya	Alto Saposoa	Hullaga	San Martin
55	100	ELECTRO ORIENTE SA	Buenos Aires	Buenos Aires	Picota	San Martin
56	100	ELECTRO ORIENTE SA	El Eslabon	Eslabon	Huallaga	San Martin
57	100	ELECTRO ORIENTE SA	San Pablo	Bellavista	Bellavista	San Martin
58	100	ELECTRO ORIENTE SA	Inahuaya	Inahuaya	Ucayali	Loreto
59	100	ELECTRO ORIENTE SA	Pajarillo	Pajarillo	Mariscal Caceres	San Martin
60	100	HIDRANDINA SA	Cachicadan	Cachicaran	Santiago de Chuco	La Libertad
61	100	HIDRANDINA SA	Llamellin	Llamellin	Antonio Raymondi	Ancash
62	100	HIDRANDINA SA	Buena Vista	Buena Vista	Casma	Ancash
63	100	ELECTRO CENTRO SA	Izcuchaca	Izcuchaca	Huancavelica	Huancavelica
64	100	ELECTRO SUR MEDIO SAA	Huachos	Huachos	Castrovirreyna	Huancavelica

65	100	ELECTRO SUR MEDIO SAA	Castrovirreyna	Castrovirreyna	Castrovirreyna	Huancavelica
66	100	ELECTRO CENTRO SA	Huancapi	Huancapi	Victor Fajardo	Ayacucho
67	100	ELECTRO PUNO SAA	San Juan de Oro	San Juan de Oro	Sandia	Puno
68	100	ELECTRO SUR MEDIO SAA	Chipao	Chipao	Lucanas	Ayacucho
69	100	ELECTRO SUR MEDIO SAA	Lucanas	Lucanas	Lucanas	Ayacucho
70	100	ELECTRO SUR MEDIO SAA	Tambo Quemado	Leoncio Prado	Lucanas	Ayacucho
71	100	S.E.A.L	Huanca	Huanca	Caylloma	Arequipa
72	100	S.E.A.L	San Camilo	La Joya	Arequipa	Arequipa
73	100	ELECTRO SUR SA	Moquegua (SIA) -8	Puquina	General Sanchez Cerro	Moquegua
74	100	ELECTRO PUNO SAA	Masocruz	Masocruz	El Collao	Puno
75	120	ELECTRO ORIENTE SA	Pampa Hermoza	Zapatero	Lamas	San Martin
120	120	ELECTRO ORIENTE SA	Shatoja	Santa Rosa	El Dorado	San Martin
77	130	S.E.A.L	Yauca	Yauca	Caraveli	Arequipa
78	140	ELECTRO SUR MEDIO SAA	Tantara	Cabana	Lucanas	Ayacucho
79	150	ELECTRO NOR OESTE SA	Suyo	Suyo	Ayabaca	Piura
80	150	ELECTRO ORIENTE SA	Colonia Angamos	Yaquerana	Requena	Loreto
81	150	ELECTRO ORIENTE SA	Flor de Punga	Capello	Requena	Loreto
82	150	ELECTRO NOR OESTE SA	Parachique	Sechura	Piura	Piura
83	150	ELECTRO ORIENTE SA	San Antonio de Cumbaza	San Antonio de Cumbaza	San Martin	San Martin
84	150	HIDRANDINA SA	Pallasca	Pallasca	Pallasca	Ancash
85	150	ELECTRO SUR ESTE SA	Chincheros	Chincheros	Urubamba	Cusco
86	160	ELECTRO ORIENTE SA	Huicungo	Huicungo	Mariscal Caceres	San Martin
87	160	S.E.A.L	Cotahuasi	Catahuasi	La Union	Arequipa
88	170	Proyecto Especial Chavimochic	Viru	Viru	Trujillo	La Libertad
89	180	ELECTRO ORIENTE SA	Campanilla	Campanilla	Mariscal Caceres	San Martin
90	182	ELECTRO SUR SA	Moquegua (SIA) - 10	Ubinas	General Sanchez Cerro	Moquegua
91	192	Munic. Distrital Campo Verde	Campo Verde	Campo Verde	Coronel Portillo	Ucayali
92	192	ELECTRO SUR ESTE SA	Huancane	Huancane	Huancane	Puno
93	200	ELECTRO NOR OESTE SA	Bigote	Bigote	Huancabamba	Piura
94	200	ELECTRO NORTE SA	Pucara	Pucara	Jaen	Cajamarca
95	200	ELECTRO NORTE SA	Leymebamaba	Leymebamaba	Chachapoyas	Amazonas
96	200	ELECTRO ORIENTE SA	Yuracyacu	Rioja	Rioja	San Martin
97	200	ELECTRO ORIENTE SA	Orellana	Vargas Guerra	Ucayali	Loreto
98	200	HIDRANDINA SA	Tayabamba	Tayabamba	Pataz	La Libertad

99	200	HIDRANDINA SA	Pomabamba	Pomabamba	Pomabamaba	Ancash
100	200	HIDRANDINA SA	Piscobamba	Piscobamba	Mariscal Luzuriaga	Ancash
101	200	ELECTRO CENTRO SA	Paucara	Paucara	Acobamba	Huancavelica
102	200	ELECTRO CENTRO SA	Acobamba	Acobamaba	Acvobamba	Huancavelica
103	200	ELECTRO SUR ESTE SA	Chuyapi	Quillabamba	La Convencion	Cusco
104	200	ELECTRO SUR ESTE SA	Antabamaba	Antabamba	Antabamba	Apurima
105	200	ELECTRO SUR MEDIO SAA	Pausa	Pausa	Paucar del Sara Sara	Ayacucho
106	200	S.E.A.L	Pampacolca	Pampacolca	Castilla	Arequipa
107	200	S.E.A.L	Caraveli	Caraveli	Caraveli	Arequipa
108	210	ELECTRO ORIENTE SA	Nueva Cajamarca	Nueva Cajamarca	Rioja	San Martin
109	210	The Maple Gas Corp. del Peru	Maquia	Contamana	Ucayali	Loreto
110	220	ELECTRO NORTE SA	Salas	Salas	Lambayeque	Lambayeque
111	220	ELECTRO ORIENTE SA	San Jose de Sisa	San Jose de Sisa	El Dorado	San Martin
112	220	ELECTRO SUR SA	Moquegua (SIA) -2	Carumas	Mariscal Nieto	Moquegua
113	224	ELECTRO SUR MEDIO SAA	Huaytara	Huaytara	Huaytara	Huancavelica
114	230	ELECTRO NORTE SA	Tacabamba	Tacabamba	Chota	Cajamarca
115	230	Minic. Dist. De Chazuta	Chazuta	Chazuta	San Martin	San Martin
116	230	ELECTRO ORIENTE SA	San Ilarion	San Hilarion	Picota	San Martin
117	235	ELECTRO ORIENTE SA	Jenaro Herrera	Sapuena	Requena	Loreto
118	240	ELECTRO PANGOA	Pangoa	Pangoa	Satipo	Junin
119	240	ELECTRO ORIENTE SA	Tabalosos	Tabalosos	Lamas	San Martin
120	250	HIDRANDINA SA	Pto. Malabrigo	Pto. Malabrigo	Razuri	La Libertad
121	250	The Maple Gas Corp. del Peru	Equipo 3 Perforacion	Onoria	Puerto Inca	Huanuco
122	255	Munic. De Alto Tapiche	Alto Tapiche	Alto Tapiche	Requena	Loreto
123	260	HIDRANDINA SA	Cascas	Cascas	Otuzco	La Libertad
124	270	ELECTRO PUNO SAA	Huancane	Huancane	Huancane	Puno
125	298	ELECTRO SUR MEDIO SAA	Andamarca	Lucanas	Lucanas	Ayacucho
126	300	ELECTRO ORIENTE SA	Naranjos	Pardo Miguel	Rioja	San Martin
127	300	ELECTRO ORIENTE SA	Pevas	Pevas	Ramon Castilla	Loreto
128	300	HIDRANDINA SA	San Marcos	Pedro Galvez	San Marcos	Cajamarca
129	300	ELECTRO SUR MEDIO SAA	Changuillo	Changuillo	Nazca	Ica
130	310	HIDRANDINA SA	Tortugas	Casma	Casma	Ancash
131	320	ELECTRO NOR OESTE SA	Santo Domingo	Santo Domingo	Morropon	Piura
132	320	ELECTRO NOR OESTE SA	Malacasi	Morropon	Morropon	Piura

133	320	ELECTRO NORTE SA	Lamud	Lamud	Luya	Amazonas
134	320	ELECTRO SUR ESTE SA	Quillabamba	Cusco	Cusco	Cusco
135	320	S.E.A.L	Ocoña	Acoña	Camana	Arequipa
136	325	The Maple Gas Corp del Peru	Refineria	Cayari	Coronell Portillo	Ucayali
137	340	EDELNOR SAA	Huamaya	Huaura	Chancay	Lima
138	340	S.E.A.L	Chuquibamba	Chiquibamba	Condesuyos	Arequipa
139	345	The Maple Gas Corp. C306del Peru	Agua Caliente	Onoria	Puerto Inca	Huanuco
140	350	ELECTRO NOR OESTE SA	Canchaque	Canchaque	Huancabamba	Piura
141	350	ELECTRO SUR ESTE SA	Iñapari	Iñapari	Tahuamanu	Madre de Dios
142	354	ELECTRO ORIENTE SA	Cuñunbuque	Cuñunbuque	Lamas	San Martin
143	390	ELECTRO ORIENTE SA	Indiana	Indiana	Maynas	Loreto
144	400	HIDRANDINA SA	Santiago de Chuco	Santiago de Chuco	Santiago de Chuco	La Libertad
145	400	S.E.A.L	Bella Union	Bella Union	Caraveli	Arequipa
146	410	ELECTRO ORIENTE SA	Tamshiyacu	Fernando Lores	Maynas	Loreto
147	410	ELECTRO ORIENTE SA	Lagunas	Lagunas	Alto Amazonas	Loreto
148	416	ELECTRO ORIENTE SA	Sauce	Sauce	San Martin	San Martin
149	420	S.E.A.L	Chala	Chala	Caraveli	Arequipa
150	420	ELECTRO SUR SA	Moquegua (SIA)-7	Omate	General Sanchez Cerro	Moquegua
151	430	S.E.A.L	Atico	Atico	Caraveli	Arequipa
152	438	ELECTRO NOR OESTE SA	Ayabaca	Ayabaca	Ayabaca	Piura
153	450	ELETRO NORTE SA	Bellavista	Bellavista	Jaen	Cajamarca
154	460	S.E.A.L	Acari	Acari	Caraveli	Arequipa
155	480	ELECTRO PUNO SAA	Putina	Putina	San Antonio de Putina	Puno
156	500	ELECTRO ORIENTE SA	Rioja	Rioja	Rioja	San Martin
157	500	ELECTRO NORTE SA	Cutervo	Cutervo	Cutervo	Cajamarca
158	500	ELECTRO CENTRO SA	Cangallo	Cangallo	Cangallo	Ayacucho

Table A 1.1.1 Disel sets up to 100kW

Rage of power (kW)	Number of disel sets
0<X<=20	7
20<X<=40	14
40<X<=60	10
60<X<=80	5
80<X<=100	38

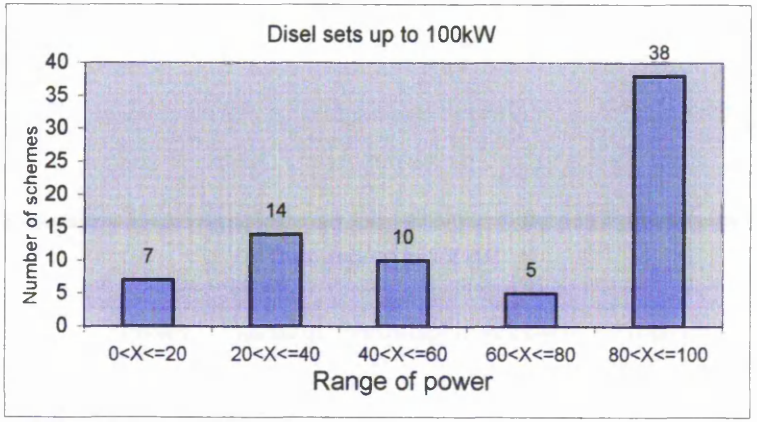
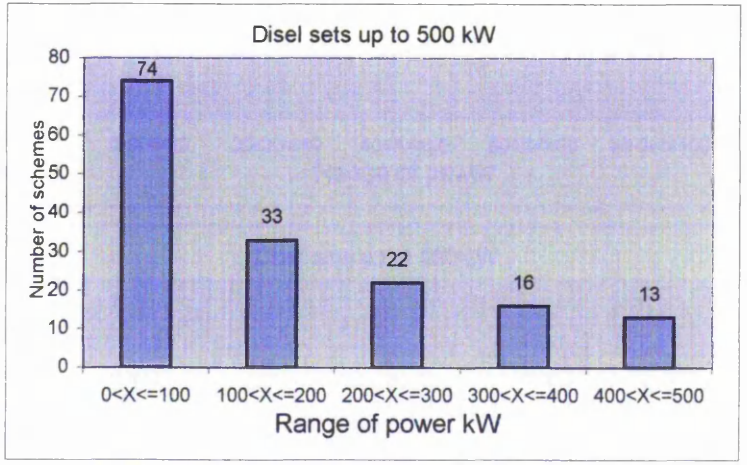


Table A 1.1.2 Disel sets up 500kW	
Range of power (kW)	Number of schems
0<X<=100	74
100<X<=200	33
200<X<=300	22
300<X<=400	16
400<X<=500	13



A.1.2 Hydropower Schemes

No	(kW)	Company	System	Village	Province	Department
1	4	Community	Santa Rosa de Congona	Colasay	Jaen	Cajamarca
2	4	Private	Trinidad	Trinidad	Contumaza	Cajamarca
3	7	Cooperativa	Polulo	San Pablo	San Pablo	Cajamarca
4	10	Cajamarca	Comabayo	Encañada	Cajamarca	Cajamarca
5	10	ELECTRO SUR MEDIO SAA	Santiago de Chocorvos	Santiago de Chocorvos	Huaytara	Huancavelica
6	11	Community	Huacataz	Baños de Inca	Cajamarca	Cajamarca
7	11	Sante	Yumahual	Magdalena	Magdalena	Cajamrca
8	15	Municipality	San Jose de Lourdes	San Jose de Lourdes	San Ignacio	Cajamarca
9	15	Cooperativa	El Tinte	San Pablo	San Pablo	Cajamarca
10	15	Community	Tambomayo	Encañada	Cajamarca	Cajamarca
11	15	Private	Tingo	Tingo	Bagua	Amazonas
12	20	ELECTRO SUR MEDIO SAA	Tantara	Tantara	Castrovirreyna	Huancavelica
13	20	ELECTRO SUR MEDIO SAA	Castrovirreyna	Castrovirreyna	Castrovirreyna	Huancavelica
14	20	ELECTRO SUR MEDIO SAA	Ticrapo	Triccapo	Castrovirreyna	Huancavelica
15	20	Municipality	Maria	Maria	Luya	Amazonas
16	20	Comunidad	San Jeronimo	Pedro Ruiz	Bongara	Amazonas
17	20	Municipality	Molinopampa	Molinopampa	Chachapoyas	Amazonas
18	20	Municipality	Churuja	Churuja	Bongara	Amazonas
19	20	Municipality	Soloco	Soloco	Chachapoyas	Amazonas
20	20	Comunidad	Gollon	Balzas	Chachapoyas	Amazonas
21	25	Municipality	Las Juntas	Pomahuaca	Jaen	Cajamarca
22	25	Municipality	Chalan	Chalan	Celendin	Cajamarca
23	25	Municipality	Riobamba	Quebrada	Calca	Cusco
24	25	Privada	Toraya	Toraya	Chalhuanca	Apurimac
25	25	Privada	Manatial Eterno	Tingo Maria	Tinago Maria	Huanuco
26	30	ELECTRO NOR OESTE SA	Oxahuay	Montero	Ayabaca	Piura

27	35	Cooperativa	Porcon	San Pablo	San Pablo	Cajamarca
28	40	Municipality	Huarango	Huarango	San Ignacio	Cajamarca
29	40	ELECTRO NOR OESTE SA	Montero	Montero	Ayabaca	Piura
30	40	Municipality	Tamborapa	Tabaconas	San Ignacio	Cajamarca
31	40	Municipality	Cortegana	Cortegana	Celendin	Cajamarca
32	40	CIA. Minera San Nicolas SA	Mini CC. HH. El Tingo	Hualgayoc	Hualgayoc	Cajamarca
33	40	Municipality	Combayo	Encañada	Cajamarca	Cajamarca
34	40	Municipality	Alis	Alis	Yauyos	Lima
35	40	ELECTRO SUR ESTE SA	Chincheros	Chincheros	Chincheros	Apurimac
36	40	Municipality	Mayorarca	Pampas Chico	Recuay	Ancach
37	40	ELECTRO SUR MEDIO SAA	Querco	Querco	Huaytara	Huancavelica
38	40	ELECTRO SUR MEDIO SAA	Chipao	Chipao	Lucanas	Ayacucho
39	50	Municipality	Querocotillo	Querocotillo	Chota	Cajamarca
40	50	HIDRANDINA SA	Bambamarca	Bambamarca	Hualgayoc	Cajamarca
41	50	Municipality	Kañaris	Kañaris	Ferreñafe	Lambayeque
42	50	Municipality	Inkawasi	Inkawasi	Ferreñafe	Lambayeque
43	50	ELECTRO CENTRO SA	Izcuchaca	Izcuchaca	Huancavelica	Huancavelica
44	50	Municipality	Providencia	Providencia	Luya	Amazonas
45	50	Municipality	Yambrasba	Yambrasba	Bongara	Amazonas
46	50	Municipality	Chuquibamba	Chuquibamba	Chachapoyas	Amazonas
47	60	ELECTRO NOR OESTE SA	Zapalache	El Carmen	Huancabamba	Piura
48	60	ELECTRO NORTE SA	Leymebamba	Leymebamba	Chachapoyas	Amazonas
49	60	Municipality	Viraco - Machaguay	Chalamarca	Chota	Cajamarca
50	60	HIDRANDINA SA	Huayobamaba	Pedro Galvez	San Marcos	Cajamarca
51	60	Privada	Monte Salvado	Quebrada	Calca	Cusco
52	60	ELECTRO SUR ESTE SA	Antabamba	Antabamba	Antabamba	Apurimac
53	60	S.E.A.L	Huanca	Arequipa	Arequipa	Arequipa
54	70	ELECTRO NORTE SA	Pomahuanca	Pomacahua	Jaen	Cajamarca
55	70	HIDRANDINA SA	Lanchiloma	Namora	Cajamarca	Cajamarca
56	70	Municipality	Macate	Macate	El Santa	Ancash
57	70	Com. Campesina de Cotahuasi	Cotahuasi	Cotahuasi	Yauyos	Lima
58	80	Municipality	Conchan	Conchan	Chota	Cajamarca
59	80	ELECTRO NORTE SA	Achamaque	Luya	Luya	Amazonas
60	80	HIDRANDINA SA	Huyunguita	Cajabamba	Cajabamba	Cajamarca

61	90	ELECTRO SUR MEDIO SAA	Andamarca	Carmen Salcedo	Lucanas	Ayacucho
62	90	ELECTRO SUR MEDIO SAA	Chaviña	Chaviña	Lucanas	Ayacucho
63	93	ELECTRO NOR OESTE SA	Canchaque	Canchaque	Huancabamba	Piura
64	100	ELECTRO NOR OESTE SA	El comun	Frias	Ayabaca	Piura
65	100	ELECTRO NORTE SA	Tacabamba	Tacabamba	Chota	Cajamarca
66	100	HIDRANDINA SA	San Marcos	Paucamarca	San Marcos	Cajamarca
67	100	Municipality	La Peca	La Peca	Bagua	Amazonas
68	100	ELECTRO CENTRO SA	Acomayo	Chichao	Huanuco	Huanuco
69	100	S.E.A.L	Pampacolca	Pampacolca	Castilla	Arequipa
70	100	Municipality	Esperanza	Yambrasba	Bongara	Amazonas
71	100	Municipality	Cuispes	Cuispes	Bongara	Amazonas
72	100	Municipality	Cocabamba	Cocabamba	Luya	Amazonas
73	100	Municipality	Chetilla	Chetilla	Cajamarca	Cajamarca
74	102	ELECTRO NOR OESTE SA	Santo Domingo	Santo Domingo	Morropon	Piura
75	120	Municipality	Colasay	Colasay	Jaen	Cajamarca
76	120	Municipality	Chugur	Chugur	Hualgayoc	Cajamarca
77	120	ELECTRO SUR ESTE SA	Chalhuanca	Chalhuanca	Aymaraes	Apurimac
78	130	ELECTRO ORIENTE SA	San Jose de Sisa	San Jose de Sisa	El Dorado	San Martin
79	135	Municipality	Sondor	Sondor	Ayabaca	Piura
80	146	ELECTRO NOR OESTE SA	Huncabamba	Huancabamaba	Huancabamba	Piura
81	150	ELECTRO NOR OESTE SA	Chalaco	Chalaco	Morropon	Piura
82	150	EDELNOR SAA	Ravira-Pacaraos	Pacaraos	Huaral	Lima
83	150	Municipality	Gracias a Dios	Luya	Luya	Amazonas
84	170	S.E.A.L	Santa Rita de Siguas	Santa Rita de Siguas	Arequipa	Arequipa
85	180	ELECTRO ORIENTE SA	Huimbayoc	Huimbayoc	San Martin	San Martin
86	180	ELECTRO ORIENTE SA	Shanao	Shanao	Lamas	San Martin
87	180	S.E.A.L	Viraco - Machaguay	Viraco	Castilla	Arequipa
88	190	EDELNOR SAA	Yaso	Santa Rosa de Quives	Canta	Lima
89	190	S.E.A.L	Caraveli	Caraveli	Caraveli	Arequipa
90	200	ELECTRO NOR OESTE SA	Sicate	Ayabaca	Ayabaca	Piura
91	200	HIDRANDINA SA	Cachicadan	Cachicadan	Santiago de Chuco	La Libertad
92	200	ELECTRO SUR MEDIO SAA	Pausa	Pausa	Paucar del Sara Sara	Ayacucho
93	200	S.E.A.L	chuquibamba	Chuquibamba	Condesuyos	Arequipa
94	200	Municipality	Tialango	Jumbilla	Bongara	Amazonas

95	200	Municipality	Jazan	Jazan	Bongara	Amazonas
96	220	ELECTRO SUR MEDIO SAA	Laramate	Laramate	Lucanas	Ayacucho
97	230	HIDRANDINA SA	Piscobamba	Piscobamba	Mariscal Luzuriaga	Ancash
98	240	HIDRANDINA SA	Corlas	Cascas	Otuzco	La Libertad
99	240	ELECTRO SUR ESTE SA	Paucartambo	Paucartambo	Paucartambo	Cusco
100	240	ELECTRO SUR MEDIO SAA	Aucara Cabana	Aucara	Lucanas	Ayacucho
101	250	Municipality	Huarandoza	Huarandoza	San Ignacio	Cajamarca
102	250	Municipality	Santo Tomas	Santo Tomas	Cutervo	Cajamarca
103	280	ELECTRO ORIENTE SA	Tabalosos	Tabalosos	Lamas	San Martin
104	280	HIDRANDINA SA	Ocros	Ocros	Ocros	Ancash
105	280	EDELNOR SAA	Acos	San Miguel de Acos	Huaral	Lima
106	280	ELECTRO SUR MEDIO SAA	Cora Cora	Cora Cora	Parinacochas	Ayacucho
107	280	CIA Minera de Caylloma SA	Hi-1	Caylloma	Caylloma	Arequipa
108	300	Emp. Communitaria de Pangoa	Pangoa	Pangoa	Satipo	Junin
109	320	ELECTRO SUR MEDIO SAA	Incuyo	Puyusca	Parinacochas	Ayacucho
110	330	HIDRANDINA SA	Paucamarca	Chocan	San Marcos	Cajamarca
111	350	RAGUSEA AGROINDUSTRIAL SA	Pampania	Santa Ana de Tusi	Daniel A. Carrion	Pasco
112	360	HIDRANDINA SA	Huaychaca	Cachicadan	Santiago de Chuco	La Libertad
113	380	ELECTRO SUR ESTE SA	Huancarae	Huancarae	Andahuaylas	Apurimac
114	400	ELECTRONORTE	Pucara	Jaen	Jaen	Cajamarca
115	400	HIDRANDINA SA	Chiquian	Chiquian	Bolognesi	Ancash
116	400	ELECTRO SUR ESTE SA	Quillabamba	Cusco	Cusco	Cusco
117	400	ELETRO PUNO SAA	Macusani	Macusani	Carabaya	Puno
118	400	ELECTRO SUR ESTE SA	Vicabamba	Vilcabamba	Grau	Apurimac
119	440	CIA. Minera Sayapullo SA	Pacaymonte	Sayapuyo	Otuzco	La Libertad
120	460	Minera Lizandro Proaño SA	Tamboraque I	San Mateo	Huarochiri	Lima
121	490	Emp. Adm. De Chungar SA	Yanahuin	Pacaraos	Huaral	Lima

*SEAL (EMPRESA ELECTRICA DEL SUR OESTE SA)

Table A.1.2.1 Hydropower schemes up to 100kW

0<x<=20	20
20<x<= 40	18
40<x<=60	15
60<x<=80	7
80<x<=100	13

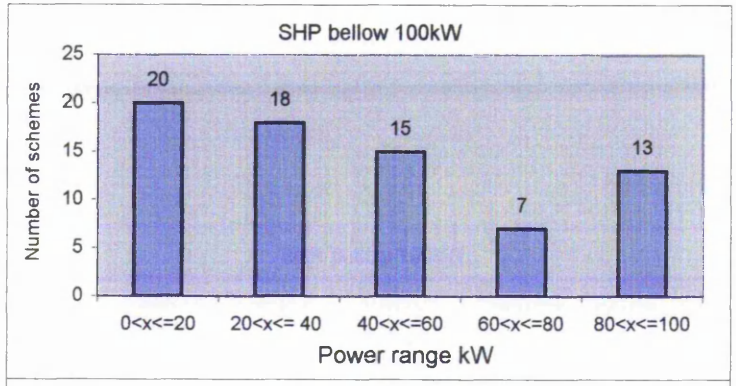
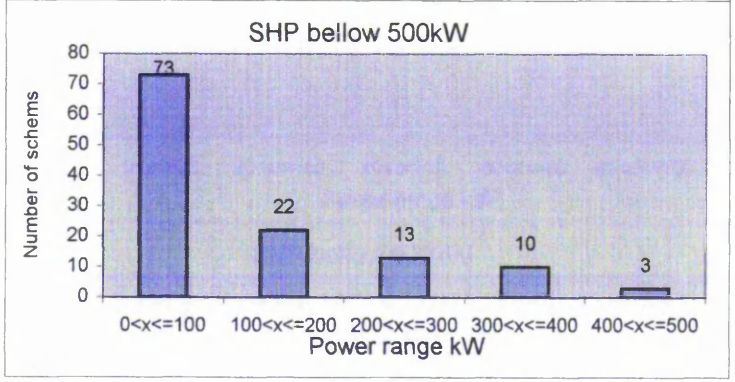


Table A.1.2.2 Hydropower schemes up to 500kW

0<x<=100	73
100<x<=200	22
200<x<=300	13
300<x<=400	10
400<x<=500	3



A.2 Survey Population and Poverty Index

A.2.1 Diesel sets

No	P(kW)	Company	Diesel Set	Village	Province	Department	P.Index
1	20	ELECTRO SUR MEDIO SAA	Santiago de Chocorvos	Santiago de Chocorvos	Huaytara	Huancavelica	0.09651
2	29	ELECTRO SUR SA	Moquegua (SIA) - 9	Quinistaquillas	General Sanchez Ce	Moquegua	0.02277
3	30	ELECTRO SUR SA	Moquegua (SIA)-6	Matalaque	General Sanchez Ce	Moquegua	0.01720
4	33	ELECTRO ORIENTE SA	Pacayzapa	Alonso Alvarado	Lamas	San Martin	0.05572
5	35	ELECTRO NOR OESTE SA	La Tina	Ayabaca	Ayabaca	Piura	0.04180
6	35	ELECTRO NOR OESTE SA	Chirinos	Suyo	Ayabaca	Piura	0.05678
7	35	ELECTRO NOR OESTE SA	Sicches	Sicchez	Ayabaca	Piura	0.04879
8	35	ELECTRO NOR OESTE SA	Jilili	Jilili	Ayabaca	Piura	0.06009
9	40	ELECTRO ORIENTE SA	Piscuyacu	Piscoyacu	Huallaga	San Martin	0.03072
10	50	ELECTRO ORIENTE SA	La Huarpia	Jepelacio	Moyobamaba	San Martin	0.04942
11	50	ELECTRO ORIENTE SA	Cuñunbuque	Tabalosos	Lamas	San Martin	0.05969
12	50	HIDRANDINA SA	Cajacay	Cajacay	Bolognesi	Ancash	0.06225
13	50	ELECTRO SUR MEDIO SAA	Cordova	Cordova	Huaytara	Huancavelica	0.10732
14	50	ELECTRO SUR SA	Moquegua (SIA) -1	Calacoa	Mariscal Nieto	Moquegua	0.04027
15	60	ELECTRO ORIENTE SA	Roque	Alonso Alvarado	Lamas	San Martin	0.05572
16	67	ELECTRO SUR MEDIO SAA	Ticrapo	ticrapo	Castrovirreyna	Huancavelica	0.09577
17	80	ELECTRO ORIENTE SA	Pongo de Caynarachi	Caynarachi	Lamas	San Martin	0.04764
18	80	S.E.A.L	Lomas	Lomas	Caraveli	Arequipa	0.01890
19	80	ELECTRO SUR ESTE SA	Mazo-Cruz	Santa Rosa	El Collao	Puno	0.08837
20	90	ELECTRO ORIENTE SA	Jepelacio	Jepelacio	Moyobamaba	San Martin	0.04942
21	90	ELECTRO ORIENTE SA	San Juan de Pacayzapa	Alonso Alvarado	Lamas	San Martin	0.05572
22	95	ELECTRO NOR OESTE SA	Montero	Montero	Ayabaca	Piura	0.05791
23	100	ELECTRO NOR OESTE SA	Paimas	Paimas	Ayabaca	Piura	0.05872
24	100	ELECTRO NORTE SA	Pomacochas	Florida	Bongara	Amazonas	0.05318
25	100	ELECTRO ORIENTE SA	Zapatero	Zapatero	Lamas	San Martin	0.04778
26	100	ELECTRO ORIENTE SA	Tingo de Saposoa	Rioja	Rioja	San Martin	0.02761
27	100	ELECTRO ORIENTE SA	Utcurarca	Alberto Leveau	San Martin	San Martin	0.02056
28	100	HIDRANDINA SA	Cachicadan	Cachicaran	Santiago de Chuco	La Libertad	0.07808
29	100	HIDRANDINA SA	Llamellin	Llamellin	Antonio Raymondi	Ancash	0.06434
30	100	ELECTRO CENTRO SA	Izcuchaca	Izcuchaca	Huancavelica	Huancavelica	0.07241

31	100	ELECTRO SUR MEDIO SAA	Huachos	Huachocolpa	Castrovirreyna	Huancavelica	0.06369
32	100	ELECTRO SUR MEDIO SAA	Castrovirreyna	Castrovirreyna	Castrovirreyna	Huancavelica	0.09767
33	100	ELECTRO CENTRO SA	Huancapi	Huancapi	Victor Fajardo	Ayacucho	0.04864
34	100	ELECTRO PUNO SAA	San Juan de Oro	San Juan de Oro	Sandia	Puno	0.10107
35	100	ELECTRO SUR MEDIO SAA	Chipao	Chipao	Lucanas	Ayacucho	0.07737
36	100	ELECTRO SUR MEDIO SAA	Lucanas	Lucanas	Lucanas	Ayacucho	0.08938
37	100	ELECTRO SUR MEDIO SAA	Tambo Quemado	Leoncio Prado	Lucanas	Ayacucho	0.06577
38	100	S.E.A.L	Huanca	Huanca	Caylloma	Arequipa	0.02639
39	100	S.E.A.L	San Camilo	La Joya	Arequipa	Arequipa	0.02299
40	100	ELECTRO SUR SA	Moquegua (SIA) -8	Puquina	General Sanchez Ce	Moquegua	0.03534
41	100	ELECTRO PUNO SAA	Masocruz	Masocruz	El Collao	Puno	0.10404
42	120	ELECTRO ORIENTE SA	Pampa Hermoza	Zapatero	Lamas	San Martin	0.04779
43	130	S.E.A.L	Yauca	Yauca	Caraveli	Arequipa	0.02348
44	140	ELECTRO SUR MEDIO SAA	Tantara	Cabana	Lucanas	Ayacucho	0.04275
45	150	ELECTRO NOR OESTE SA	Suyo	Suyo	Ayabaca	Piura	0.05678
46	150	HIDRANDINA SA	Pallasca	Pallasca	Pallasca	Ancash	0.05733
47	150	ELECTRO SUR ESTE SA	Chincheros	Chincheros	Urubamba	Cusco	0.02865
48	160	S.E.A.L	Cotahuasi	Cotahuasi	La Union	Arequipa	0.02482
49	182	ELECTRO SUR SA	Moquegua (SIA) - 10	Ubinas	General Sanchez Ce	Moquegua	0.02500
50	192	ELECTRO SUR ESTE SA	Huancane	Huancane	Huancane	Puno	0.08350
51	200	ELECTRO NOR OESTE SA	Bigote	Bigote	Huancabamba	Piura	0.03805
52	200	ELECTRO ORIENTE SA	Yuracyacu	Rioja	Rioja	San Martin	0.03478
53	200	HIDRANDINA SA	Tayabamba	Tayabamba	Pataz	La Libertad	0.08436
54	200	HIDRANDINA SA	Pomabamba	Pomabamba	Pomabamaba	Ancash	0.06509
55	200	HIDRANDINA SA	Piscobamba	Piscobamba	Mariscal Luzuriaga	Ancash	0.06074
56	200	ELECTRO CENTRO SA	Paucara	Paucara	Acobamba	Huancavelica	0.12712
57	200	ELECTRO CENTRO SA	Acobamba	Acobamaba	Acvobamba	Huancavelica	0.10577
58	200	ELECTRO SUR ESTE SA	Antabamaba	Antabamba	Antabamba	Apurimac	0.06175
59	200	ELECTRO SUR MEDIO SAA	Pausa	Pausa	Paucar del Sara Sar	Ayacucho	0.05687
60	200	S.E.A.L	Pampacolca	Pampacolca	Castilla	Arequipa	0.03295
61	200	S.E.A.L	Caraveli	Caraveli	Caraveli	Arequipa	0.02563

A.2.2 Hydro schemes

	P(kW)	Company	Plant	Department	province	District	P. Index
1	20	ELECTRO SUR MEDIO SAA	Tantara	Huancavelica	Castrovirreyna	Tantara	0.07819
2	20	ELECTRO SUR MEDIO SAA	Castrovirreyna	Huancavelica	Castrovirreyna	Castrovirreyna	0.09767
3	20	ELECTRO SUR MEDIO SAA	Ticrapo	Huancavelica	Castrovirreyna	Ticrapo	0.09577
4	20	Municipality	Maria	Amazonas	Luya	Maria	0.05517
5	20	Comunidad	San Jeronimo	Amazonas	Bongara	Pedro Ruiz	0.05620
6	20	Municipality	Molinopampa	Amazonas	Chachapoyas	Molinopampa	0.04455
7	20	Municipality	Churuja	Amazonas	Bongara	Churuja	0.04577
8	20	Municipality	Soloco	Amazonas	Chachapoyas	Soloco	0.04715
9	20	Comunidad	Gollon	Amazonas	Chachapoyas	Balzas	0.06249
10	25	Municipality	Las Juntas	Cajamarca	Jaen	Pomahuaca	0.08661
11	25	Municipality	Chalan	Cajamarca	Celendin	Chalan	0.06823
12	25	Municipality	Riobamba	Cusco	Calca	Quebrada	0.05000
13	30	ELECTRO NOR OESTE SA	Oxahuay	Piura	Ayabaca	Montero	0.05791
14	40	ELECTRO NOR OESTE SA	Montero	Piura	Ayabaca	Montero	0.05791
15	40	Municipality	Tamborapa	Cajamarca	San Ignacio	Tabaconas	0.06098
16	40	Municipality	Cortegana	Cajamarca	Celendin	Cortegana	0.06796
17	40	ELECTRO SUR ESTE SA	Chincheros	Apurimac	Chincheros	Chincheros	0.08709
18	40	Municipality	Mayorarca	Ancach	Recuay	Pampas Chico	0.06215
19	40	ELECTRO SUR MEDIO SAA	Querco	Huancavelica	Huaytara	Querco	0.08161
20	40	ELECTRO SUR MEDIO SAA	Chipao	Ayacucho	Lucanas	Chipao	0.07736
21	50	Municipality	Querocotillo	Cajamarca	Chota	Querocotillo	0.06153
22	50	HIDRANDINA SA	Bambamarca	Cajamarca	Hualgayoc	Bambamarca	0.06106
23	50	Municipality	Kañaris	Lambayeque	Ferreñafe	Kañaris	0.06896
24	50	Municipality	Inkawasi	Lambayeque	Ferreñafe	Inkawasi	0.05992
25	50	ELECTRO CENTRO SA	Izcuchaca	Huancavelica	Huancavelica	Izcuchaca	0.07241
26	50	Municipality	Providencia	Amazonas	Luya	Providencia	0.08236
27	50	Municipality	Yambrasba	Amazonas	Bongara	Yambrasbamba	0.09768
28	50	Municipality	Chuquibamba	Amazonas	Chachapoyas	Chuquibamba	0.05779
29	60	ELECTRO NOR OESTE SA	Zapalache	Piura	Huancabamba	El Carmen	0.04531
30	60	ELECTRO NORTE SA	Leymebamba	Amazonas	Chachapoyas	Leymebamba	0.04596
31	60	Municipality	Viraco - Machaguay	Cajamarca	Chota	Chalamarca	0.07589
32	60	HIDRANDINA SA	Huayobamaba	Cajamarca	San Marcos	Pedro Galvez	0.03927

33	60	ELECTRO SUR ESTE SA	Antabamba	Apurimac	Antabamba	Antabamba	0.06175
34	70	Seal- Sociedad electrica del Sur C	Huanca	Arequipa	Arequipa	Arequipa	0.00137
35	70	ELECTRO NORTE SA	Pomahuanca	Cajamarca	Jaen	Pomacahua	0.08661
36	70	HIDRANDINA SA	Lanchiloma	Cajamarca	Cajamarca	Namora	0.06004
37	70	Municipality	Macate	Ancash	El Santa	Macate	0.06919
38	70	Comunidad Campesina de Cotah	Cotahuasi	Lima	Yauyos	Catahuasi	0.01922
39	80	Municipality	Conchan	Cajamarca	Chota	Conchan	0.06360
40	80	ELECTRO NORTE SA	Achamaque	Amazonas	Luya	Luya	0.04423
41	80	HIDRANDINA SA	Huyunguita	Cajamarca	Cajabamba	Cajabamba	0.04344
42	90	ELECTRO SUR MEDIO SAA	Andamarca	Ayacucho	Lucanas	Carmen Salcedo	0.04362
43	90	ELECTRO SUR MEDIO SAA	Chaviña	Ayacucho	Lucanas	Chaviña	0.07275
44	93	ELECTRO NOR OESTE SA	Canchaque	Piura	Huancabamba	Canchaque	0.04168
45	100	ELECTRO NOR OESTE SA	El comun	Piura	Ayabaca	Frias	0.06242
46	100	HIDRANDINA SA	San Marcos	Cajamarca	San Marcos	Paucamarca	0.06687
47	100	Municipality	La Peca	Amazonas	Bagua	La Peca	0.04225
48	100	ELECTRO CENTRO SA	Acomayo	Huanuco	Huanuco	Chinchao	0.10334
49	100	Seal- Sociedad electrica del Sur C	Pampacolca	Arequipa	Castilla	Pampacolca	0.03295
50	100	Municipality	Esperanza	Amazonas	Bongara	Yambrasba	0.09768
51	100	Municipality	Cuispes	Amazonas	Bongara	Cuispes	0.05624
52	100	Municipality	Cocabamba	Amazonas	Luya	Cocabamba	0.07715
53	100	Municipality	Chetilla	Cajamarca	Cajamarca	Chetilla	0.06190
54	102	ELECTRO NOR OESTE SA	Santo Domingo	Piura	Morropon	Santo Domingo	0.03998
55	120	Municipality	Colasay	Cajamarca	Jaen	Colasay	0.07931
56	120	Municipality	Chugur	Cajamarca	Hualgayoc	Chugur	0.05942
57	120	ELECTRO SUR ESTE SA	Chalhuanca	Apurimac	Aymaraes	Chalhuanca	0.04540
58	130	ELECTRO ORIENTE SA	San Jose de Sisa	San Martin	El Dorado	San Jose de Sisa	0.06516
59	135	Municipality	Sondor	Piura	Huancabamba	Sondor	0.05001
60	146	ELECTRO NOR OESTE SA	Huncabamba	Piura	Huancabamba	Huancabamaba	0.03805
61	150	ELECTRO NOR OESTE SA	Chalaco	Piura	Morropon	Chalaco	0.03434
62	150	EDELNOR SAA	Ravira-Pacaraos	Lima	Huaral	Pacaraos	0.01570
63	150	Municipality	Gracias a Dios	Amazonas	Luya	Luya	0.04423
64	170	Seal- Sociedad electrica del Sur C	Santa Rita de Siguas	Arequipa	Arequipa	Santa Rita de Sig	0.02399
65	180	ELECTRO ORIENTE SA	Huimbayoc	San Martin	San Martin	Huimbayoc	0.05123
66	180	ELECTRO ORIENTE SA	Shanao	San Martin	Lamas	Shanao	0.03622

67	180	Seal- Sociedad electrica del Sur C	Viraco - Machaguay	Arequipa	Castilla	Viraco	0.02440
68	190	EDELNOR SAA	Yaso	Lima	Canta	Santa Rosa de C	0.01932
69	190	Seal- Sociedad electrica del Sur C	Caraveli	Arequipa	Caraveli	Caraveli	0.02563
70	200	ELECTRO NOR OESTE SA	Sicate	Piura	Ayabaca	Ayabaca	0.04180
71	200	HIDRANDINA SA	Cachicadan	La Libertad	Santiago de Chuco	Cachicadan	0.07808
72	200	ELECTRO SUR MEDIO SAA	Pausa	Ayacucho	Paucar del Sara Sar	Pausa	0.05687
73	200	Seal- Sociedad electrica del Sur C	chuquibamba	Arequipa	Condesuyos	Chuquibamba	0.01984
74	200	Municipality	Tialango	Amazonas	Bongara	Jumbilla	0.01792
75	200	Municipality	Jazan	Amazonas	Bongara	Jazan	0.04336

A.3 Actual Survey Sample, where field data collection took place

A.3.1Diesel sets

P. index		Village	Onership	District	Department	Province
0.0438	120	San Martin	Private	Yanatile	Cusco	Yanatile
0.0597	250	San Roque	Community	Alonso Alvarado	San Martin	Lamas
0.0598	60	Limabamba	Municipality	Limabamba	Amazonas	Mendoza
0.0711	60	Totora	Municipality	Totora	Amazonas	Mendoza
0.0728	88	Tambo Quemado	Government	Tambo Quemado	Ayacucho	Lucanas
0.0782	250	La Coipa	Municipality	La Coipa	Jaen	Cajamarca
0.0963	350	Mazocruz	Municipality	Mazocruz	El Collao	Puno

A.3.2 Hydropower schemes

P. index	Power (kW)	Village	Ownership	District	Department	Province
0.0552	20	Maria	Community	Maria	Amazonas	Luya
0.0596	120	Shitariyacu	Municipality	Pachiza	San Martin	Mariscal Caceres
0.0622	40	Mayorarca	Community	Chico	Recuay	Ancash
0.0728	90	Chaviña	Government	Chavina	Ayacucho	Lucanas
0.0756	90	Santa Catalina	Municipality	Luya	Amazonas	Luya
0.0785	40	Longuita	Municipality	Longuita	Amazonas	Lyya
0.0866	25	Las Juntas	Community	Pomahuaca	Cajamarca	Jane

A.3 Initial Survey Sample (changed in the field changed due to the reasons explained in chapter V)

A.3.1 Diesel sets

P. Index	P(kW)	Management	Plant	District	Department	province
0.10404	100	Municipality	Masocruz	Masocruz	Puno	El Collao
0.07737	100	Regional utility	Chipao	Chipao	Ayacucho	Lucanas
0.06969	50	Regional utility	Cuñunbuque	Tabalosos	San Martin	Lamas
0.05318	100	Regional Utility	Pomacochas	Florida	Amazonas	Bongara
0.04027	50	Regional Utility	Moquegua (SIA) -1	Calacoa	Moquegua	Mariscal Nieto
0.02500	182	Regional utility	Moquegua (SIA) - 10	Ubinas	Moquegua	Grl. Sanchez Cerro

A.3.2 Hydropower schemes

P. Index	P(kW)	Management	Plant	District	Department	Province
0.08661	25	Community	Las Juntas	Pomahuaca	Cajamarca	Jaen
0.07275	90	Regional Uitility	Chaviña	Chaviña	Ayacucho	Lucanas
0.06215	40	Community	Mayorarca	Pampas Chico	Ancach	Recuay
0.05791	30	Regional Utility	Oxahuay	Montero	Piura	Ayabaca
0.04715	20	Municipality	Soloco	Soloco	Amazonas	Chachapoyas
0.04344	80	Regional Utility	Huyunguita	Cajabamba	Cajamarca	Cajabamba
0.01792	200	Municipality	Tialango	Jumbilla	Amazonas	Bongara

APPENDIX B
MAIN CHARATERISTICS OF THE SITES VISITED

1) Maria

Located in the Department: Amazonas (North East Andes), Province of Luya, District (county) of Maria. The village is the capital of the District, which has larger population living in the country side. Its altitude over the sea level is 3225 metres.

Its closest town is Chachapoyas – at about 50km of distance and about 2.5 hours trip by track of bus, with every day transport.

Maria has a cold weather due to its altitude, however despite to its altitude the average temperature during the year keeps relatively higher comparing with other village of the same altitude in the in the Andes, this is due to the influence of warm winds from the upper Jungle.

The main economic activities are of agriculture and animal husbandry. Among the most important agricultural products are: potatoes, maize, and a variety of beans, regarding animals they grow cows and sheep in a domestic scale (2 to 5 cows and from 5 to 15 sheep per family) in this region.

The most important market for Maria is Chachapoyas, a twon with about 10000 people, where they sell and buy products. They take their small overplus production to the market and buy products from other regions like salt, sugar, cooking oil and others.

As for services, there are elementary and high school, health centre, drinking water and police station, electricity is provided from a small hydro scheme of 20kW.

2) Shitariyacu

Located in the Department: San Martin, Province of Marical Caceres, District (Council) of Pachiza. Its altitude over the sea level is 342.0 metres. It is located about 180 km from the city of Tarapoto Department of San Martin in the lower fringes of the Upper Jungle of that region, in the right margin of the so called "Carretera Marginal de la Selva", the most important road in the north of the country which links the coast region with the upper Jungle and the Jungle. A trip from Tarapoto to Shitariyacu lasts for

about 9 hours by track, or any other vehicle. A second important town of the region is Juanjuy, which can be reached from Shitariyacu after 2 hours trip by road.

The weather in Shitariyacu is warm and humid during the whole year round.

The main economic activities are agriculture and animal husbandry. The products cultivated are Cocoa, coffee, maize, banana, papaya, pineapple and other fruits of the regions, like citrus products. The animals grown in this area are mainly cattle but in very few quantities.

Shitariyacu has its own small market to sells products. However the most important and closest external market is Juanjuy.

Shitariyacu has elementary and high school education services, piped water and electricity services with a small hydro scheme, police station, and a small health centre.

3) Mayorarca

Located in the Department of Ancash Province of Recuay, District of Pampas Chico. Mayorarca is a small village at an altitude of 3400 metres over the sea level in the Central part of the North Andes of Peru, in the so called "Cordillera Negra".

Its weather is cold, its maximum average temperature during the sunny days is 19.5°C, the average night temperatures from October to April is 5°C, while from its average for the period May to September is 3°C. The rainy Season is from October to March, with the peak rainy period during February and March, although Mayorarca is a village with low rainfall due to the influence of the Peruvian Coast which is mostly dray.

The population in this region speak Spanish as Official Language, but Quechua is widely spoken as mother tongue.

As regards communications to other towns and Markets, Mayorarca is located at about 300m from an important road that connects it with the towns of the Coast (Barranca, Huarmey, and Trujillo) and with the Capital of the Region – Huaraz-, which is the largest and most important town of the Central North Andes of Peru.

The main economic activities are agriculture and domestic animals. The main products cultivated are potatoes, maize, and some high Andean products like Quinua and Quiwicha. They grow regularly sheep and very few cows per family.

Their most important Market is Huaraz in the Andes and Barranca in the Coast, although they also have an internal market where they sell and buy products.

As for services, they have provision of water, piped but not potable, schools for elementary education and high education, health centre, health centre, and telephone for the use its members, which is operated via satellite

4) Chaviña

Located in the Department Ayacucho (South Central Andes), Province of Lucanas District (county) of Chaviña, at and altitude of 3310 metres over the sea level.
The weather is cold during the whole year round, with temperatures close to frizzing in the winter nights and as high as 20°C during the day in summer. It is a dray area with scarce rainfalls during the months of February and March and in much less proportion during October and November.

The closest town is Puquio, at about 120 km, and it takes about 4 hours of trip by bus or track to reach it; the most important market for this village is Nazca in the Coast, which can be reached by bus in 12 hours trip by bus.

The main economic activities are agriculture and animal husbandry. They cultivate cereals like barely, oat and wheat; potatoes and "high altitude Andean crops" like Quinua and Quiwicha. Each family grows few domestic animals, like sheep, llamas, alpacas and guinea pigs.

The population of this region speak two languages, Quechua as a mother Language and Spanish (national language).

They have a local market, which is active every Sunday for the buy and sell of local products, but also small products that come from external sellers like clothes, shoes, and domestic utensils from Nazca.

As for services, Chaviña has elementary and high school, health centre, police station, drinking water, sewage, and electricity from a small hydro scheme.

5) Santa Catalina

Located in the Department: Amazonas (North East Andes), Province of Luya, District (county) of Luya. Its altitude over the sea level is 1700. This village has a relatively warm whether with pleasant temperatures during the whole year around, ranging from 8°C in the nights to 28°C during sunny days in the summer. It has frequent rainfalls, especially during the summer (February and March and during the spring (in October and November).

The closet town to Santa Catalina is Chachapoyas and consequently it most important and almost only market.

The main economic activities of the population are agriculture and animal husbandry. The main agricultural products are: potatoes, maize, peas, and at less extent cassava; the most common animals grown by the peasants of this village are cows and other domestic animals like chicken and guinea pigs.

They have access to drinking water, health centre, elementary and high schools and electricity service provided by a small hydro scheme.

6) Longuita

Department of Amazonas, Province of Luya, District (County) of Longuita. At 2100 Metres over the sea level. This village has a typical medium high inter-Andean weather, with frequent rain during February to March (in the summer and October to November (in the spring)

This village is located in the north Andes, about 40 km away from Chachapoyas, 2 hours trip by buy bus

The main economic activities are agriculture, and animal husbandry. The most common products are potatoes, beans, maize. They also grow few domestic animals, cows and sheep.

There is elementary, drinking water, health centre and electricity services provided by a hydro scheme.

7) Las Juntas:

Located in the Department of Cajamarca, Province of Jaen, District: Pomahuaca. At an altitude of 1100 Metres over the sea level. This Village is located in the right margin of the most important road "Caretera Marginal de la Selva", which links all the important cities of the northern Coast (Chiclayo, Piura others) with those of the Northern Upper Jungle (Jaen, Tarapoto, Rioja, Moyobamba and others). The whether of Las Juntas is warm during the whole year round its average temperature during the day is 26°C, while during the night is 15°C.

Its economy is based on Agriculture, their main product is rice, and in much less proportion maize and vegetables. There is little activity on animal husbandry

Las Juntas has good access to markets, being the main ones Chiclayo (in the Coast) and Jaen (in the Upper Jungle); businessmen from Chiclayo, Jane and other markets visit then from now and then to purchase their products and then carry to the markets. As for other communication means, Las Juntas has a satellite telephone this village is well communicated.

This village has a provision of water (not potable), a small heath centre; there is no education centres; children have to go to Pomahuaca (County for both elementary and high school).

8) San Martín

Located in the Department: Cusco, Province of Calca, District(County) Yanatile. At an altitude of 900 metres over the sea level. Its maximum average temperature during the day hours is 28°C, while its average temperature during the night hours is 15°C.

The main town of the region is Cusco, which can be reached after several hours trip, as follows; from Cusco to Calca 3 hours by road, with regular transportation once a day, from Calca to Yanatile 8 hours through a rough road (without pavement), and finally from Yanatile to San Martin about 2 to 3 hours by bus or track. During the rainy season the access from San Martin to Calca could be blocked for several weeks or even

months. The transport from Calca to Yanatile is twice a week (by bus), on Mondays and Thursdays.

The main activities of the population are agriculture and animal husbandry. The agricultural products being, coffee, cassava, Cocoa, peanuts, coca, maize and other regional products and fruits; they grow few animals, which basically used for cash, purposes.

Their man markets are Yanatile and Calca, they have occasionally the visits of people who go to purchase coffee or Coca and cocoa - products of "high value"-.

They have access to piped water (not treated), have elementary education school, and have neither health centre nor other facilities.

9) San Roque:

Located in the Department of San Martin, Province of Lamas, District: Alonso Alvarado. At an altitude of 2100 metres over the sea level. It is in the northern Upper Jungle. Its weather is average during the whole year round with an average temperature of 20°C during the day and 12°C during the night. Its closet town and most important Market is Moyobamba, at a approximately 80 km distance, which can be reached travelling by road for about 4.5 hours

The main economic activities are agriculture and animals. They cultivate Cocoa, coffee, maize, cassava and other of the region; they also grow cows in a very low scale (1 to 5 per family). They also grow few animals, especially cows.

Their internal market day is on Sunday every week, where they sell their own products and purchase those brought from cities, from other parts of the country, for more important purchases their regional markets are Moyobamba and Tarapoto.

They have elementary and high school education, and a Technical Occupational Centre, health centre, water supply (not potable), police station and a Military Regiment due to its proximity to the border with Ecuador.

10) Limabamba

Located in the Department of Amazonas, Province of Rodriguez de Mendoza, and District of Limabamba. At a 2050 Metres over the sea level. The weather is pleasant weather with warm temperatures during the whole year round. This village is located in the northeast Andes at about 50 km from Rodriguez de Mendoza

The main economic activities are agriculture and animal husbandry. The most important agricultural products are: Maize, beans, potatoes, and fruits. They grow few animals per family, especially cows.

The main services in this village are elementary and high school, health centre, water supply (not potable), telephone and police station.

11) Totora

Department of Amazonas, Province of Rodriguez de Mendoza, District (County) of Totora. At a 1560 metres over the sea level. Its weather is a moderate warm during the whole year around, with frequent rain during the summer (in February and March) and spring (October and November). Its weather is warm and humid. It is located in the northeast Upper Jungle.

The closet towns are Rodriguez de Mendoza. The transport to these towns is through rustic roads.

The economy is based in agriculture and animal husbandry. The main agricultural products are: Coffee, cocoa, casaba, banana and fruits. Very little activities on animals are performed.

The services in the village are elementary school, health centre and electricity.

12) Tambo Quemado

Located in the Department of Ayacucho (South Central Andes), Province of Lucanas District (county) of Tambo Quemado. Its altitude over the sea level is 2685 metres. Its weather is pleasant, with temperatures ranging from relatively cold during the nigh and sunny and relatively warm during the day. This region is mostly dry during the whole year round, with very low precipitation.

The closet town is Nazca in the Coast region is about 250km distance, which can be reached in a 6 hours trip by bus.

The main economic activities are agriculture and animal husbandry, the main products are cereals like barely, wheat, oat; and legumes like lentils, peas; potatoes are also an important agricultural product of the zone. In this region there is an important agricultural practice in the Andes called "Andenes" (which consists on levelling the slopes in a sort of ladder) to have small planes areas for cultivation. There is also a very limited activity in animal husbandry (very few sheep and cows per family).

Although they have a local market every Sunday, people generally travel from time to time to Nazca to purchase domestic products.

Tambo Quemado has elementary, heath centre, access to electricity services through diesel set, which provides few ours of services per night and it is a managed by the regional utility.

13) La Coipa

Located in the Department of Cajamarca, Province of Jaen, District of La Coipa, at an altitude of 774 metres over the sea level. Located in the North Upper Jungle of Peru. Close to the border with Ecuador, its closet town is Jaen, which is at about 40 km away from La Coipa. A trip from La Copia to Jaen takes approximately 2 hours in the dray season, but could be up to 4 hours during the rainy season due to the bad conditions of the road. It has a warm and humid weather, with frequent rain in February and March in the summer and in October and November in spring.

Their main economic activities are agriculture and animal husbandry. The main agricultural products are coffee, maize, cocoa, maize and fruits; their main animal production is based on the few cows and domestic animals like chicken and guinea pigs.

Their closet and most important market is Jaen, although, which is possible to reach it in a 2 hours trip by track or bus.

This village has elementary and high school, drinking water, health centre and electricity services, they also have a police station.

14) Mazocruz

Department of Puno, Province of El Collao, District (County) of Mazocruz, at an altitude of 3900 metres over the sea level. It is located in the Andean Plateau of el Collao near the Lake Titicaca, its altitude over the sea level is 3900m, its climate is cold during the whole year around, with maximum average temperatures of 12ºC during the day and temperatures bellow 0ºC during the night. The coldest months are from June to September.

Their main economic activities are self-subsistence agriculture, and small businesses, they trade products from the neighbour country of Bolivia in small quantities and sell in Peru or vice versa. The land is of very poor quality and the whether conditions are difficult for agriculture and animal husbandry. Very few animals are grown in this village, llamas, sheep and guinea pigs, this do contribute very little to their economy.

Their main market is the City of Puno, and the towns of Desaguadero and Juliaca. This village have a 50 kW diesel set which provide electricity to 200 families and have 250 families in waiting list, the system is run by the Municipality and it is currently heavily subsidised by this institution. They have 3 hours per day of electricity.

Besides electricity, Mazocruz has a health centre, elementary and high schools, during water and sewage systems.

APPENDIX C: QUESTIONNAIRE

HOUSEHOLD ENERGY USERS

I) CAPACITY TO PAY

1) Name of the interviewee _____

2) Number of family members _____

3) What is the family main activity?

Farming, _____
Employee of the Gov. Inst _____
Retired _____
Other _____

If the main activity is farming continue with question 4, if not go to question 5

4) Income due to production activities in the family property

Family income

Agriculture

Product	S/ (total) received	Spent for cultivation S/
Potatoes		
Maize		
White		
Celery		
Peas		
Vegetables		
Casaba		
Rice		
Coffee		
Others		
Sub-Total(F)		

Animals

Type of animals	(S/)	Expenses to grow (S/)
Cows		
Sheep		
Goats		
Horses		
Pigs		
Others (global)		
Sub-total (A)		

5) Does any member of your family work out of the village; Yes____, No _____

If yes. How much does he/she sends to the family per year?

How much per year (S/)	Mark with X
Less than 500	
500 to 1000	
1000 to 1500	
1500 to 2000	
Other	

6) What is the year family income (include income from member from outside)?

II) AFFORDABLE TARIFFS

7) How much do you pay for electricity monthly? S/. _____

8) What do you think about the tariff?

It is high _____
It is OK _____
It is low _____
Don't know _____

9) What do you think about the quality of the electricity?

It is very good _____
It is good _____
It is bad _____
Don't know _____

10) Would you pay more for better services? Yes ____, No _____, don't know _____

If the answer is yes; how much would you pay? _____

11) Do you use other sort of energy to replace electricity? Yes ____ No _____,

If yes fill the table

Source	No week	Cost per week (S/.)
Wax candles		
Kerosene		
Dry batteries		
Wet battery		
Small diesel set		

III) BENEFITS FROM ELECTRICITY

12) Use of electricity

a) Bulbs

Power (Watts)	Number units	Use (hours per day)
40		
50		
60		
100		

b) Fluorescents

Power	Number of units	Use (hours per day)
20		
30		
40		

c) Domestic appliances

Domestic equipment	Use (hours per day of use)
Refrigerator	
Radio	
TV	
Other (Name)	
Other (Name)	

13) How have your family benefited from electricity?

- Pays less than before for lighting _____

- Children can study more comfortable _____
- Food can be preserved _____
- Makes easier the domestic work (artefacts) _____
- Better health services _____
- Family income have increased due to night hours work _____
- Better informed about current issues in the country _____
- Security in the village _____

14) Have there been changes in the village due to electricity? Yes ___, No ____

If yes, are these: Positive ____, negative_____, no changes _____

III) COMMUNITY PARTICIPATION

15) Had you taken part in the installation of the scheme? Yes ____, No ____

If yes; how?
Have taken part in the decision _____
Provided Labour _____
Given money _____

16) Do you take part in the maintenance work of the system; yes ___ No ____

17) Do you feel that you have taken part in decision making? Yes ___, No___

18) If yes; would you like to take more active participation, yes ___, No _____

19) If not; do you think it is important like to take part on it? yes ____, No _____

IV) CONNECTION COST

20) How long time have you access to electricity? _____ Years

21) How much have you paid for the connection? S/._____

22) Have you been without connection to electricity for some time due to its cost?
Yes _____, No_____

23) What do you think about the connection cost?
It is Expensive_____
Fair _____
Cheap _____

OPERATORS AND ADMINISTRATORS

VI) MANAGEMENT OF THE SYSTEM

1) Name of the interviewee _____

2) Position in the management team
Responsible for the Administration _____
Responsible for the Operation _____
Member of the Administration team _____
Member of the operation team _____

a) Management

3) Type of organisation in charge of the Management

Municipality _____
Government directly _____
Government contract to the utility _____

4) How many members are there? Operators _____, Administrators _____

5) Who appoints the management team?

Community Assembly _____
Utility _____
Municipality _____
Government _____

b) Facilities For management

6) Administration office

Have own office _____
Share office _____
Have no office _____

7) Equipment for administration

Have the right equipment _____
Short of equipment _____
Not equipment _____

c) Tariffs decision making

8) Who decides about the tariff?

Community _____
Municipality _____
Government tariff _____

9) Criteria to decide tariff

Vote _____
Operating costs _____
National regulation _____
Comparing to other town _____

10) Frequency of updating tariff

Regularly (every x months) _____
Irregular _____
No updating _____

d) Type of tariff

11) Flat

11.1) Unique cost for all families, S/. _____ per month

11.2) Flat according to sectors

Sector	Cost
Domestic	_____
Commercial	_____
Institutional	_____

12) Metered

12.1) Unique cost per kWh, S/. _____ per month

12.2) Metered according to sectors

Sector	Cost (S/./ kWh)
Domestic	_____
Commercial	_____
Institutional	_____

VII) BILL COLLECTION

13) Number of customers

At the start of scheme _____

Now _____

Waiting list _____

14) Do you keep list of customers? Yes_____ No _____

15) Do you keep accounts books? Yes _____ No _____

16) Delay to pay

% delay _____

17) Are there sanctions for those not paying? Yes _____, No _____

Type of sanctions:

Cut electricity _____

Economic sanctions _____

Other (What?) _____

Income and expenses

18) Total income monthly S/ _____

19) How much is paid to administrators (monthly)? S/_____

20) How much is paid to operators (monthly)? S/ _____

21) How much is spent on repairs, spare parts and others (monthly)? S/ _____

22) Other expenses (monthly) S/ _____

VIII) LOCAL CAPACITY TO OPERATE AND ADMINISTRATE THE SYSTEM

23) Level of education of operators and administrators

Education	How many Op.	How many Adm.
Elementary school completed		
Elementary school not completed		
High school completed		
High school no completed		
Technical institute		
Other		

24) Training of the management team

Training	Duration in weeks		Who trained to	
	OP	**Adm**	**Op**	**Adm**
At the beginning of the operation only				
Once a year				
Irregular				
Never				
Other				

25) Do you have a programme for preventive maintenance? Yes _____, No _____

26) Who does the repairs when it is needed?
The team _____
External people _____
Both _____

27) Do you have operation manuals? Yes _____, No _____

28) If yes. Do you use those manuals? Yes _____, No _____

29) Do you have maintenance manuals? Yes _____, No _____

30) If yes. Do you use those manuals, yes _____, No _____

II) Tools and spares

31) Tools for repair at the beginning
Were all tools _____
Some tools _____
No tools _____
32) Tools for repair now
All tools _____
Some tools _____
No tools _____

33) Spare parts now
There are all types of spare parts in the store _____
There are some spare _____
There are no spare _____

III) Turn down time

34) Turn down time

	Reason	Days
Lack of resource	_____	_____
Lack of spares	_____	_____
Lack of experts	_____	_____
Lack of information (where to find experts)	_____	_____
Lack of money to pay experts	_____	_____
Other reason	_____	_____

Total down time _____ Days

35) Parts most frequently failing

Turbine and/or accessories _____
Generator and/or accessories _____
Controller _____
Grid and/or transmission lines _____
Civil works _____
Other (what) _____

IX) ACCESS TO TECHNICAL SUPPORT

36) Need for external support

Have you required external technical support? Yes ____, No ____
Is it easy to get technical support? Yes _____, No _____
The cost of the tech. services is: Expensive _____, Fair _____ cheap _____?

X) LOAD FACTOR (READING FROM THE SYSTEM)

37) Copy reading book, or take reading

Time	Readings of Amps and Volts in each phase (when no kW meter is available), total demand					
	Phase 1		Phase 2		Phase 3	
	V	Amps	V	Amps	V	Amps
6:00						
7:00						
8:00						
9:00						
10: 00						
11:00						
12:00						
13:00						
14:00						
.... 24:00						
1:00						
2:00						
3:00						
4:00						
5:00						
6:00						

XI POLITICAL INTERFERENCE

38) Has ever a politician promised to improve the electricity service of the village? Yes __, No___

39) How he/she have though improving it?

New scheme _____
Connection to the grid _____
Rebuilding the existing scheme _____
Other _____

40) Have ever candidates to mayors offered cheap electricity when campaigning?
Some of them _____, all _____, none _____

41) Do Mayors interfere with the Adm. of the Scheme? Yes ___ No____ If yes how?
Changing members of administration _____
Using the income of the scheme for other purposes than the scheme _____
Interfere in bill collection _____
Interfere in the plans of connection of people to electricity _____
Interfere in the application of sanctions _____
Other _____

BUSINESS PEOPLE

1) Name of the owner of the business _____

2) Type of business _____

I) AFFORDABLE TARIFFS

3) What do you think about the tariff? It is, Expensive _____OK _____, cheap _____,

4) How good is the service? It is , Good ___, OK _____, Poor _____

5) Would you pay more for a better service, Yes ____, No_____, if yes how much? ____

II) CONNECTION COST (how it affects to the business)

6) How long have you got electricity? _____

7) When you were connected, the cost was, Expensive ____, OK ____, Cheap_____

8) Have you delayed connection to electricity because of lack of money? Yes __, No __
if yes Why?
Lack of money _____
Administrators took time _____
Did not want to _____
Other _____

III) BENEFITS FROM ELECTRCITY

9) Year of start of the business_____

10) Staff at the beginning _____, Staff now _____

11) Have you increased income due to electricity? Yes ____, No ____
If yes, Why?
How much was it at the beginning _____, How much is it now _____

12) Would you start business without electricity? Yes ____, No ___, not applicable ____

13) Machines or equipment for business and power (kW)

Machine	Power (kW)
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

14) Market
Local _____
Regional _____
Other parts _____

15) Limitations to grow
Size of market _____
Lack of capital _____
Lack of raw material _____
Lack of trained people _____
Poor electricity service _____
Other (what) _____

LEADERS AND AUTHORITIES

I) POLITICAL INTERFERENCE

1) Name of the interviewee _____

2) Age of the scheme? _____

3) Who paid for the installation _____

Government _____
Church _____
Municipality _____
Other _____

4) Who was the key person to have the present scheme?

The mayor _____
Minister _____
The president _____
Other _____

5) Has ever a politician from central government promised to improve the service? Yes _____, No _____

6) How has He/She thought he would have improved?
Building a new scheme _____
Connection to the grid _____
Rebuilding the existing one _____
Other _____

II) COMMUNITY PARTICIPATION

7) Had community provided support (work) for the installation?, Yes ____, No ____

8) Do community take part in work of operation and maintenance?, Yes ___, No __

9) Do community take part in the decision for tariff?, Yes ____, No ____

10) If Yes How do they take part
They argue _____; they vote ____, other _____

III) LOCAL CAPACITY

11) Who does the repairs of the Scheme?
The operators _____
Technicians from the village _____

Consultants from the region _____
Consultants external to the region _____

12) If the repairs are not done by the operators or village people. What is the reason?
Lack of trained personal _____
No trust on the local people _____
Authorities do not want _____
Operators do not like to do it _____
Other _____

13) Is there any technical institute in the near by? Yes ____, No ____

General Issues (macro level)

1) Degree of development of the village
A review and comparison between villages about their degree of development (mainly the poverty map)
2) Market connection
During the visit there will be some questions about the main markets; this will be complemented with other information about access roads, population of the main markets, etc.
12) National capacity
The national capacity will require information about manufactures and service providers on equipment, spear parts and technical assistance
13) Legal framework
There will a short summary regarding the legal framework, specifically about the rural electrification
14) No bureaucracy
The issues about bureaucracy require some comments
15) Proper tax frame
Similar to number 5

APPENDIX D

A sample questionnaire filled in the field

Usuarios domésticos

I) CAPACIDAD DE PAGO

1) Nombre del entrevistado Jovita Duran Alvarado

2) Numero de miembros de la familia 02

3) Cual es la principal actividad de la familia?

Agricultura, X
Empleado de institución de Gob. ____
Retirado ____
Otro ____

Si la actividad principal es agricultura continúe con las pregunta 4, si no vaya a la 5

4) Ingresos por las actividades de producción en la propiedad de la familia (año pasado)

Agricultura

Producto	S/ (total) recibido	S/. Gastado en la producción
Papa	1,200	400.00
Maíz		
Trigo		
Cebada		
Arveja		
Verduras		
Yuca		
Arroz		
Café		
Otros		
Sub-total (F)		

Animales

Tipo de animal	(S/)	S/. Gastado en la crianza
Vacuno		
Ovino		
Caprino		
Caballos		
Cerdos		
Otros(global)		
Sub-total (A)		

5) Alguno de los miembros de la familia trabaja fuera del pueblo? Si ____, No X

Si la respuesta es si. Cuanto envía para la familia (al año)?

Cuanto envía al año (S/)	Marque con (X)
Menos de 500 a 400	
500 a 1000	
1000 a 1500	
1500 a 2000	
Otro	

6) Ingreso familiar anual incluyendo el aporte del miembro (s) que esta(n) fuera? S/. 1,000

II) Tarifas apropiadas

7) Cuánto paga al mes por electricidad? S/. 7-00

8) Que piensa de la tarifa de electricidad?

Es alta X
Esta bien _____
Es baja _____
No sabe _____

9) Que piensa sobre la calidad de la energía?

Es muy buena_____
Es buena X
Es mala _____
No sabe _____

10) Pagaría más si tuviera mejor servicio? Si X, No ____, No sabe____

Si la respuesta es si, cuanto? S/. De acuerdo al consumo

11) Usa UD. Otro tipo de energía para reemplazar o complementar la electricidad?

Si ____ No X, Si la respuesta es si

Fuente de energía	Costo por semana (S/.)
Velas	
Kerosén	
Pilas	
Baterías	
Pequeño grupo diesel	

III) Beneficios de la electricidad

12) Uso de la electricidad

a) Focos

Potencia (Watts)	Numero de unidades	Horas de uso al día
40		
50	04	3 horas.
60		
100		

b) Fluorescentes

Potencia	Numero de unidades	Horas de uso al día
20		
30		
40		

c) Artefactos domésticos

Artefactos	Horas de uso al día
Refrigeradora	
Radio	2 horas
TV	3horas
Otro (Nombre)	
Otro (Nombre)	

13) Como se beneficia la familia con la electricidad?

- Gasta menos que antes de tener electricidad ___X___
- Los niños estudian mas cómodos _____
- Se conserva alimentos _____
- Facilita las labores domesticas (artefactos) _____
- Mejores servicios de salud ___X___
- Mejor ingreso familiar debido a mas trabajo nocturno _____
- Mejor informados sobre lo que pasa en el país ___X___
- Seguridad en el poblado ___X___

14) Ha observado cambios en el poblado debido a la electricidad?

Positivos_X_, Negativos_____, No hay cambios _____

III) Participación de la comunidad

15) Ha tomado parte en la instalación del sistema? Si _X_, No _____
Si la respuesta es si; como?

- En la decisión para construirlo _____
- Apoyo con trabajo ___X___
- Aportó dinero para la construcción _____

16) Ud. Colabora parte en el trabajo de mantenimiento del sistema; Si _X_, No ____

17) Siente Ud. Que toma parte en las decisiones sobre la electricidad?, si _X_, No___

18) Si la respuesta es si, le gustaría tomar parte más activa. Si _X_, No _____

19) Si la respuesta es no le gustaría tomar parte?, Si ____, No _____

IV) Costo de Conexión

20) Cuanto tiempo que Ud. tiene electricidad? ___7___ Años ___—___ meses

21) Cuanto pagó Ud. Para que le conecten la electricidad a su domicilio? 10.00

22) Estuvo Ud. Sin electricidad algún tiempo por el alto costo? si ____, No _X_

23) Que piensa del costo de conexión? Fue:

Alto _____
Bajo _____
Esta bien ___X___

USUARIOS CON NEGOCIOS

1) Nombre del entrevistado NANCY ollantes Jesus

2) Tipo de negocio Todo de 6A.

I) Tarifas adecuadas

3) Cuánto paga al mes por electricidad? S/. 7.00

4) Que piensa de la tarifa de electricidad?
   - Es alta _____
   - Esta bien _____
   - Es baja X
   - No sabe _____

5) Que piensa sobre la calidad de la energía?
   - Es muy buena _____
   - Es buena _____ → Es regular
   - Es mala _____
   - No sabe I

6) Pagaría más si tuviera mejor servicio? Si X, No ____, No sabe____

   Si la respuesta es si, cuanto? S/. De acuerdo a mi

7) Usa UD. Otro tipo de energía para reemplazar o complementar la electricidad?
   Si ____ No X, Si la respuesta es si

Fuente de energía	Costo por semana (S/.)
Velas	
Kerosén	
Pilas	
Baterías	
Pequeño grupo diesel	

II) Costo de Conexión

8) Cuanto tiempo que Ud. tiene electricidad? 7 Años _____ meses

9) Cuanto pagó Ud. Para que le conecten la electricidad a su domicilio? 20 00

10) Estuvo Ud. Sin electricidad algún tiempo por el alto costo? si ____, No X

11) Que piensa del costo de conexión? Fue:
   - Alto _____
   - Bajo _____
   - Esta bien X

III) Beneficios de la electricidad

12) Año de inicio del negocio 1

13) Número de staff al inicio 2 Número de staff ahora 3

14) Ha incrementado sus ingresos debido a la electricidad? Si X, No _____

Si la respuesta es si, Cuanto fue al inicio. S/2,[illegible] y cuanto es ahora S/.[illegible]

15) Iniciaría su negocio sin electricidad en el pueblo?, Si___, No X, no aplicable __

16) Máquinas o equipos usados en el negocio y potencia (kW)

Máquina	Potencia (kW)
TV	
Rad[illegible]	

17) Mercados a los que dirige sus productos

Local X

Regional _____

Otros _____

18) Limitaciones para crecer con su negocio

Tamaño de mercado _____

Falta de capital _____

Falta de materiales _____

Falta de personal capacitado X

Mal servicio de electricidad _____

Otro (cual?) _____

Hayorarec

Operadores/administradores

VI) Manejo del sistema

1) Nombre del entrevistado SANTOS TIBURCIO SANCHEZ

2) Posición en el equipo de manejo
   - Responsable de la administración ____
   - Responsable de la operación X
   - Miembro del equipo de administración ____
   - Miembro del equipo de operación ____

a) Manejo del sistema

3) Tipo de organización que maneja el sistema
   - Una unidad dentro de la Municipalidad ____
   - Gobierno central ____
   - Agencia de gobierno contrata a la concesionaria de la zona ____
   - * Comite de Electrificacion X

4) Escriba el número de miembros, Operadores 4, Administradores 1 (Tesorero)

5) Quien contrata a los miembros del equipo de manejo?
   - La comunidad mediante asamblea X
   - La concesionaria de la zona ____
   - La Municipalidad ____
   - El gobierno ____

b) Facilidades para el manejo

6) Facilidades para la administración
   - Tiene su propia oficina ____
   - Comparte oficina ____
   - No tiene oficina X

7) Equipos con que cuenta para la administración
   - Tiene el equipamiento correcto ____
   - Tiene solo parte del equipamiento ____
   - No tiene equipamiento X

c) Decisión sobre las tarifas

8) Quien decide sobre la tarifa?
   - La comunidad X
   - La Municipalidad ____
   - Es una tarifa de gobierno ____
   - Otro (quien?) ____

9) Criterio para decidir sobre la tarifa
   - Voto X
   - Costos de operación ____
   - Tarifa regulada ____
   - Comparando con tarifa de otro centro poblado ____
   - Otro ____

10) Frecuencia con se actualiza la tarifa

Regularmente, cada (meses) _____

Repentinamente _____

No se actualiza ___x___

d) Tipo de tarifas

11) Plana

11.1) Costo único para todos los usuarios, S/. 7.00 Por mes

11.2) Plana según sectores

Sector	**Costo (S/)**
Doméstico	_____
Comercial	_____
Institucional	_____
Otro (Cual?)	_____

12) Según consumo

12.1) Único costo por kWh, S/. 0.30 por mes (cuando se pasa de los 23 Kws, se cobra el 0.30 x los Kws consumidos adicionalmente)

12.2) Por sectores

Sector	Costo (S/./ kWh)
Doméstico	_____
Comercial	_____
Institucional	_____
Otro (cual?)	_____

VII) Cobranza de los pagos por electricidad

13) Número de usuarios

Cuando inició el servicio 60

Ahora 60

Hay una lista de espera 12

14) Tiene un padrón de usuarios. Si X No _____

15) Lleva libros de contabilidad? Si X No _____

16) Morosidad

Cuantos usuarios pagan puntualmente _____ (lo cubre el Tesorero)

17) Hay sanciones por la morosidad? Si _____, No X

Tipo de sanción

Corte de luz _____

Corte y pago por reposición _____

Otra (cual?) _____

Ingresos y egresos

18) Cuanto ingresa por tarifas (mensual)? S/._____ (lo cubre el Tesorero)

19) Otros ingresos (mensuales) S/. _____ (50.00 por instalación pero no hay muchos)

20) Cuanto se paga a los administradores (mensual)? S/ (Aporte a donde?)

21) Cuanto se paga a los operadores (mensual)? S/ 155.00

22) Cuanto se gasta en repuestos y materiales (mensual)? S/ _____ (Le sale el técnico)

VIII) Capacidad local para operar y administrar el sistema

i) Educación y entrenamiento

23) Nivel de educación del equipo de manejo

Operadores	Cuantos Operadores?	Cuantos Administradores?
Primaria completa		
Primaria incompleta	1	
Secundaria completa		
Secundaria incompleta		
Instituto técnico		
Otro		

24) Entrenamiento al equipo de manejo

Entrenamiento	Duración (semanas).		Quien entrena a los	
	Op	Adm	Op	Adm
Solo al comienzo de la operación				
Una vez al año				
Algunas veces				
Nunca	X			
Otro				

25) Tienen un programa para mantenimiento preventivo? Si X, No _____

26) Quien hace las reparaciones, cuando son necesarias?
El equipo de operadores _____
Vienen de fuera X
Ambos _____

27) Tienen manuales de operación? Si X, No _____

28) Si la respuesta es si. Los usan? Si X, No _____

29) Tiene manuales de mantenimiento? Si _____, No X

30) Si la respuesta es si. Usan esos manuales, Si _____, No _____

ii) Herramientas y repuestos

31) Existencia de herramientas al comienzo

Hubo todas las herramientas _____
Hubo algunas herramientas X
No hubo herramientas _____

Se han perdido las herramientas

32) Herramientas para reparación ahora
Existen todas la herramientas _____
Existen algunas herramientas _____
No hay herramientas X

33) Repuestos ahora
Hay todo tipo de repuestos en el almacen _____
Hay algunos repuestos _____
No hay repuestos X

iii) Parada del sistema

34) Razones y severidad

	Razón	Días (poner el #)
Falta del recurso (agua, diesel)	X	3-4 días
Falta de repuestos		
Falta de expertos		
Desconocimiento donde hay expertos		
Falta de dinero para contratar expertos		
Otra razón		

Total días de parada 3 días

35) Partes que se dañan con mayor frecuencia
Turbina y/o accesorios _____
Generador y/o accesorios _____
Controlador Tablero de control X
Red y/o líneas de transmisión X
Obras civiles X
Otro (cual) _____

IX) Acceso al soporte técnico

36) Necesidad de apoyo externo
Requiere apoyo de expertos de otro lugar?, Si X, No _____
Es fácil obtener apoyo técnico? Si _____, No X
Es costoso X, regular _____ barato _____

X) Factor de carga del sistema (lecturas de consume, o medidas de consume)

37) Copiar de libro de apuntes o hacer lecturas durante 48 horas seguidas

	Leer los Amp. y Vol. En cada fase (si no hay medidor de KW),					
	Fase 1		Fase 2		Fase 3	
Hora	V	Amps	V	Amps	V	Amps
6:00						
7:00						

No se regis

8:00						
9:00						
10: 00						
11:00						
12:00						
13:00						
14:00						
15:00						
16:00						
17:00						
18:00						
19:00						
20:00						
21:00						
22:00						
23:00						
24:00						
0:00						
1:00						
2:00						
3:00						
4:00						
5:00						
6:00						

XI Interferencia política (de líderes y/o políticos locales)

38) Ha prometido alguna vez un político mejorar el servicio eléctrico? Si ___, No _

39) Como pensaba mejorarlo?
- Construir un Nuevo sistema _____
- Conectando a la RED _____
- Reconstruyendo el actual _____
- Otro (cual?) _____

40) Alguna vez los candidatos a Alcaldes ofrecen electricidad barata o gratis?
Algunos _____, todos _____, ninguno X

41) Interfieren los Alcaldes en la Adm. ?, Si ____ No X ; Como?
- Cambian a los miembros del manejo del sistema _____
- Usan los ingresos para otros propósitos _____
- Interfieren en las cobranzas _____
- Interfieren en los planes de conexión a la gente _____
- Interfieren en las aplicación de sanciones _____
- Otro(Cual?) _____

LIDERES Y AUTORIDADES LOCALES

I) Interferencia política

1) Nombre del eletrevistado Transisco Vega Huaman

2) Cuando fue construido el sistema? 1995

3) Quien pago por la instalación? _____
   - Gobierno _____
   - Iglesia _____
   - Municipalidad _____
   - Otro Gob Luxemburgo

4) Quien fue la persona clave para tener este sistema?
   - Alcalde X
   - Ministro _____
   - El presidente _____
   - Otro _____

5) Alguna vez un político del gobierno central ha ofrecido mejorar los servicios eléctricos? Si _____, No X

6) Como pensaba mejorarlo?
   - Construyendo Nuevo sistema _____
   - Conectando a la red nacional _____
   - Reconstruyendo el sistema _____
   - Otro (cual?) _____

II) Participación de la comunidad

7) Ha apoyado la comunidad con trabajo y/o materiales para la instalación del sistema?, Si X, No _____

8) Participa la comunidad en la operación y mantenimiento?, si X, No _____

9) Participa la comunidad en la toma de decisiones sobre tarifa?, si X, No _____

10) Si la respuesta es si. Como?
   - Discute en asambleas X
   - Vota X
   - Otro _____

III) Capacidad local

11) Quien repara el sistema?
   - Los operadores _____
   - Técnicos de la localidad _____
   - Consultores de la región _____
   - Consultores de fuera de la región X

12) Si la reparación no la hacen los operadores. Cual es la razón?
   - Falta de personal entrenado X
   - No confían en el personal local _____
   - Las autoridades no permiten _____
   - Los operadores se niegan _____
   - Otro _____

13) Hay algún instituto técnico en la zona o en el pueblo? Si _____, No X

APPENDIX E

Publications using information from this Thesis

Paper

Title: The Critical Factors for sustainable stand-alone energy systems in remote rural villages.

Authors: Teodoro Sanchez-Campos[1], Arthur Williams[2], Nigel Smith[3]

Abstract:

The background of this research paper is the lack of electricity services for nearly 2 billion people worldwide, the great majority of them living in rural areas in developing countries. A study has been carried out with the objective to find out the Critical Factors for success of stand-alone energy schemes in isolated rural areas in developing countries. It is hoped that the results of the study will reduce the main barriers that governments and development agencies confront when implementing rural energy programmes. The main hypothesis is that there are social, cultural, financial and technical factors (Critical Factors) that contribute to the existence of such barriers; therefore to tackle rural electrification requires an identification of such factors and appropriate ways to deal with them. The work described in the paper has been carried out as a PhD research at Nottingham Trent University, as part of its research activities in the field of energy.

A wide literature review has been completed regarding the different project and programmes on rural electrification, looking at relevant case studies in order to identify the possible Critical Factors. Questionnaires were designed to collect key data that can be used to prove research hypothesis and the results have been analysed to differentiate between the different factors. The data collection was done in Peru, a Latin American country with one of the lowest rural electrification coefficient in the continent. The sample survey was made of 14 small villages spread throughout the country. Half of the schemes use diesel generators whereas the other half are micro-hydro plants. The results of the research reveal the people's points of view about their energy needs, their preferences. It also reveals the

[1] Practical Action, UK
[2] Nottingham Trent University
[3] Sustainable Control Systems, Nottingham, UK

strengths and weaknesses of the scheme management to cope with the finance, operation and maintenance of the energy schemes.

The paper draws some conclusions about the significance of the various critical factors that have been studied, and outlines lessons that can be learnt for future rural electricity programmes

Book

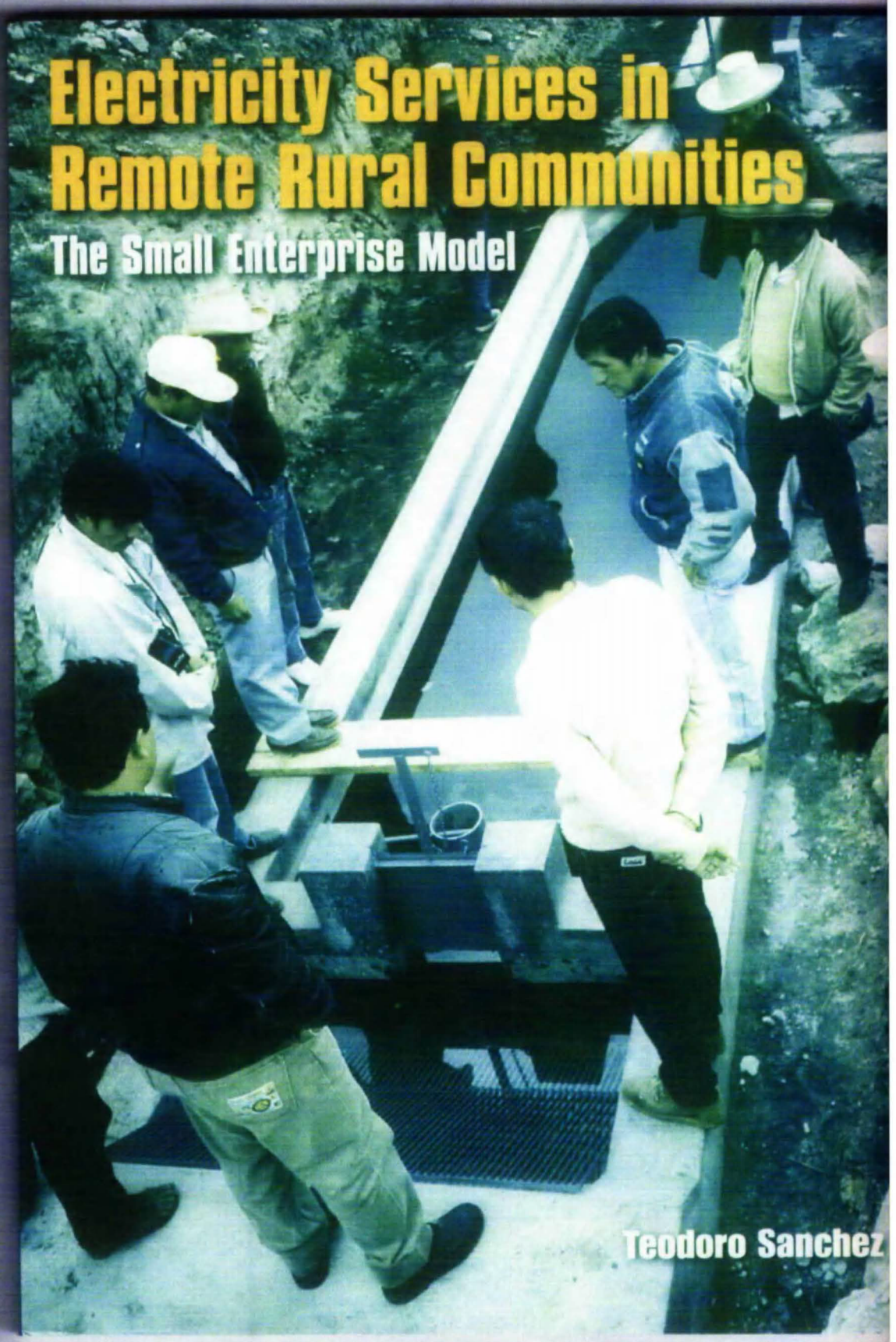
ELECTRICITY SERVICES IN REMOTE RURAL COMMUNITIES
The Small Enterprise Model

Summary: This book describes a private management model for village electrification electricity services in remote communities. The management model had been designed specifically for community owned schemes in remote rural areas, where utilities or private electricity businesses may not arrive in the short future.

The book includes an introduction on the rural electrification situation, a description of the model including: the objective of the model, the business model, stakeholders (actors) taking part in the model arrangement and the tools used for the implementation of the model and the governance of the system within the community.

It also includes a post implementation case study in the village of Conchan, in the North Andes of Peru, where this management model is working successfully for more than 5 years.

The information used for the section on the rural electrification was mainly taken from the third chapter of this PhD Thesis.


Electricity Services in Remote Rural Communities
The Small Enterprise Model
Teodoro Sanchez

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