ENERGY
AND POVERTY

Special Report August 2010

Peru: National Survey of Rural Household Energy Use Special Report 007/10 August 2010

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Exchange Rate

(Effective 2007)
Currency unit = Nuevos Soles (s/.)
1 U.S. dollar = 3.23 Nuevos Soles

Abbreviations and Acronyms

AER	Areas de Empadronamiento Rural
ADINELSA	Electric Infrastructure Administration Enterprise *(Empresa de Administración de Infraestructura Eléctrica, S.A)*
B&W	black and white (TV)
CFL	compact fluorescent lamp (also known as compact fluorescent light bulb)
CIER	Comisión de Integración Eléctrica Regional
CV	coefficient of variation
DEP	Executive Project Directorate
ECLAC	Economic Commission for Latin America and the Caribbean
EDELNOR	Empresa de Distribución Eléctrica de Lima S.A.
ELP	ELECTROPERU-Public Electric Enterprise of Peru
ENAHO	National Household Survey (*Encuesta Nacional de Hogares*)
FONAFE	National Financing Fund for State Enterprise Activity *(Fondo Nacional de Financiamiento de la Actividad Empresarial del Estado)*
FONCODES	National Fund for Compensation and Social Development of Peru
FOSE	Social Tariff for Electricity Consumption *(Fondo de Compensación Social Eléctrica*)
GoP	Government of Peru
HH	household
ICT	information and communication technologies
IDA	International Development Agency
INEI	National Institute of Statistics and Information Technology *(Instituto Nacional de Estadística e Informática)*
kWh	kilowatt-hour
LCE	Law of Electricity Concessions (*Ley de Concessiones Eléctricas*)
LPG	liquified petroleum gas
MEM	Ministry of Energy and Mines *(Ministerio de Energía y Minas)*
MHS	micro hydroelectric systems

NRECA	National Rural Electric Cooperative Association
OSINERG	Supervisory Commission for Energy Investments *(Organismo Supervisor de la Inversión en Energía)*
PPIAF	Public Private Infrastructure Advisory Facility (World Bank)
PV	photovoltaic
WTP	willingness to pay

All monetary amounts are US dollars unless otherwise indicated.

Foreword

In order to gain a better understanding of the existing and potential users of electricity in rural areas of Peru, the National Survey of Rural Household Energy Use was carried out in seven regions of the country, the Coastal North, Central, and South regions, the Andean North, Central, and South regions, and the Amazon region. The Survey provided data on rural household energy use and expenditures, use by rural households of electricity from the grid, and use by rural households of off-grid electricity. The Survey also provided information for an analysis of the economic benefits from electricity use in rural areas in Peru. Finally, the data were analyzed to provide implications for further development of rural electrification policies in Peru. It is important to note that the report represents the situation with respect to rural electrification in Peru in 2005–2006.

The Survey was initiated during the preparation of the World Bank-GEF–assisted Peru Rural Electrification Project. It provided socioeconomic and energy data to inform the design of the Project and also assist in improving policies for rural electrification in Peru. The preliminary data from the Survey were used to prepare the economic and financial analysis for the Peru Rural Electrification Project.

The main conclusion of the survey is that rural households in Peru have a significant desire, willingness, and ability to pay for electricity. Households without electricity from the grid frequently pay more for energy of lesser quality from kerosene lamps or batteries than they would pay for electricity service. However, the need to pay the connection cost is a significant barrier, and 25 percent of households living in areas with electricity service are not connected. Use of car batteries by 18 percent of rural households without electricity is a strong indication of unsatisfied demand for electricity in areas near to the grid.

The Survey report provides data for the planning of rural electrification in the context of Peru, including estimates of the benefits, which are particularly important for the economic analysis of Projects. However, we believe that the survey report will also be useful to other countries as an example of a comprehensive effort to collect and analyze original data on rural household energy use.

Acknowledgments

The Survey was carried out with financing from the Ministry of Energy and Mines for the survey fieldwork and from the World Bank's Energy Sector Management Assistance Program (ESMAP) for the survey design and the preparation of the final report. The work was completed in 2007, it then went through a series of internal and external reviews. It is the intention of the authors that you find this material interesting and insightful. This report has also been published in Spanish by the originating unit within the World Bank. The report can be found as: Perú: Encuesta Nacional de Consumo de Energía a Hogares en el Ambito Rural, 54286-PE.

The authors would like to thank the former and current authorities of the Ministry of Energy and Mines for their help and support, as well as former Vice Minister of Energy Mr. Juan Miguel Cayo Mata.

The Technical Directorate of Demographics and Social Indicators of the National Institute of Statistics and Information Technology (INEI) deserves special mention for designing the sample and the survey, as well as for organizing and supervising the field survey work under difficult conditions, and entering and verifying the data. INEI's team was led by Arturo Arias, and the sample design was done by Juan Valverde Quesada. Patricia Ormeno supervised and coordinated the survey fieldwork on behalf of the Ministry of Energy and Mines. Laura Berman assisted in coordination among the Ministry of Energy and Mines, INEI and the World Bank, and drafting the Introduction to the Report and Annex 1.

Voravate Tuntivate was responsible on the World Bank side for the sample design, development of the questionnaire, providing guidance and supervision of the initiation of the fieldwork, cleaning and analyzing the data, preparing the tables in Annex 2, and drafting a preliminary report.

Peter Meier prepared the complete draft of the first report, as well as the benefits estimates in Chapter 5 of the report, and assisted in review and finalizing the data. Daniel Farchy prepared the second draft of the report and the first draft of the executive summary. Paula Tarnapol Whitacre edited the final draft of the report. Thomas Haven assisted in reviewing and editing the final draft of the main report.

The authors are grateful to the following reviewers for their valuable comments: Dana Rysankova, Kyran O'Sullivan, and Eduardo Zolezzi. Douglas Barnes provided guidance to the task team throughout the preparation of the Survey and the report. The task team leader was Susan V. Bogach. Special thanks to Shepherd, Inc. for copyediting the final report and to Marjorie K. Araya (ESMAP) for coordinating the publication process.

The findings, interpretations and conclusions expressed in this report are entirely those of the authors as individuals.

The report was completed under the guidance of the Energy Unit of the Sustainable Development Department of the Latin America and Caribbean Region of the World Bank.

Executive Summary

Peru is a country of extreme diversity, both in its geography and the socioeconomic conditions of its citizens. This makes it a challenge for the Government of Peru (GoP) to extend access to basic infrastructure services, including electricity, to the dispersed population living in rural areas. Plans and targets have been in place for rural electrification since the early 1970s, but by 2005, only 39 percent of rural households had electricity service. Peru has one of the lowest rural electrification rates in Latin America. An estimated 6 million people in the predominantly poor rural areas of Peru did not have access to electricity in 2005.

The MEM initiated a World Bank and GEF-assisted Rural Electrification Project in August 2006 to assist local distribution companies in reaching rural populations (World Bank 2006). The project aims to supply electricity services to about 160,000 currently unserved rural households, businesses, and public facilities, such as schools and health clinics (serving about 800,000 people), using both conventional grid extension and renewable energy sources.

Detailed data were required in order to prepare the design of the Peru Rural Electrification Project, as well as to improve the rural electrification program and to analyze the economic and financial aspects of rural electrification. Consequently, it was decided to implement the National Survey of Rural Household Energy Use (referred to as the *Survey* in this publication),[1] with the assistance of the World Bank's Energy Sector Management Assistance Program (ESMAP), to obtain information on the demand and use of electricity in rural areas of Peru.

The Survey covered 6,690 households with and without electricity in rural areas of Peru. To represent the target population for rural electrification, rural areas were defined as those populations living in aggregations of 1,000 households or less. (This definition is different from that used by the Institute of Statistics and Information Technology [Instituto Nacional de Estadística e Informática, INEI] in the Census, which defines rural population centers as those with less than 100 dwellings grouped contiguously.) The sample was large enough to provide reliable estimations about the survey population at seven regional levels: Coastal North, Central, and South regions, the Andean North, Central, and South regions, and the Amazon region.[2]

The survey was conducted through the National Institute of Statistics and Information Technology (Instituto Nacional de Estadística e Informática, INEI), together with experts on household energy surveys provided by the World Bank. The information collected includes general socioeconomic information on households, as well as detailed information on their current energy use, energy expenditures, and ability/willingness to pay for electricity services. Until now such data have not been available.

This report presents the main results of the Survey, and shows how Survey information can contribute to the analysis of important policy issues in developing an improved rural electrification framework in Peru.

[1] In Spanish, *Encuesta de Consumo de Energía a Hogares en el Ámbito Rural.*

[2] The expected standard deviation in each region ranged from 0.021 to 0.050 (see Annex 1).

Household Energy Use and Expenditure

The Survey compares energy usage among households in different regions, expenditure quintile classifications, and categories of households with and without access to grid electricity.

Variations in Energy Use

Rural households in Peru, like rural households elsewhere in the world, rely on various sources of energy for lighting, cooking, and appliances. More than 84 percent of rural households rely on fuelwood for cooking, while 24 percent use dung and 11 percent use agriculture residue. Liquified petroleum gas (LPG) is used mainly for cooking by 14 percent of all households. An estimated 74 percent of all households use dry cells for small appliances such as radios and flashlights, and about 60 percent of all households use candles and kerosene for lighting. Electricity is used by 39 percent of all households. A surprisingly high 11 percent of households use car batteries to run electric appliances, indicating a high, unmet demand for electricity services. A tiny fraction, 0.6 percent, have generators, and 0.5 percent have solar home systems.

There is a high degree of regional variation in these figures, particularly between the richer Coastal Regions and the Andean and Amazon Regions that contain significant indigenous populations. The percentage of households in the Andean regions with access to grid electricity ranges from 22 percent in the north to 52 percent in the central region. In the Coastal regions, coverage of grid electricity ranges from 35 percent in the north to about 71 percent in the south. Electricity access is lowest in the Amazon, at 18 percent.

Variations in Energy Expenditures

The total monthly cash expenditure for all types of energy used in the household is estimated to be 25 soles per month, on average. This amounts to about 9.7 percent of total household cash expenditures each month. However, household energy expenditure varies significantly among regions and between financially better-off and poorer households. Energy expenditure represents a heavier burden for households in the three Andean regions than for households in other regions of the country.

Although poor households spend less on energy than nonpoor households, their energy spending accounts for a larger portion of their income. Households in the lowest quintile spend about 17 percent of their total monthly expenditures on energy, while households in all other quintiles spend less than 10 percent. Part of the reason for this discrepancy is that the poor often lack access to relatively cheap grid electricity.

Households with grid electricity are financially better off than households without access (average 430 soles/month versus 317 soles/month). Yet, the Survey also found that households with electricity spend only marginally more on grid electricity and electricity substitutes (16.3 soles per month) than households without electricity spend on substitutes alone (15.4 soles per month). Households without electricity are paying comparable amounts for much-lower-quality services. This indicates that they would be able to pay for electricity if it were available.

Electricity from the Grid

As already noted, the Survey showed that only 39 percent of rural households currently had access to grid electricity. In addition to regional variations, access is strongly correlated with expenditure quintile: 28 percent of households in the poorest quintile have access, compared with 49 percent in the top quintile. Electricity usage among rural households in Peru is relatively low, at an average of 27 kWh per month. This may be due to several factors, including a high tariff, unavailability of inexpensive appliances, and high prevalence of poverty.

As a result of fixed charges, the average effective rate for households that use small amounts of electricity is relatively high. Currently, about 70 percent of households with a grid connection use less than 30 kWh per month. These households' average effective electricity price is 0.76 soles per kWh. However, the average effective price per kWh for households that use more than 30 kWh per month is only 0.46 soles per kWh.

The proportion of total electricity used for lighting is strongly dependent upon expenditure quintile. The bottom quintile uses 39 percent of total electricity consumption for lighting, while the top quintile uses only 21 percent. As income (expenditure) increases, the ability to purchase expensive electric appliances increases, and thus a greater fraction of electricity is used for color TV, sound equipment, and refrigerators.

Radios are by far the most common type of household electric appliance, with 66 percent of electrified households owning one or more, followed by black-and-white televisions (37 percent of households), color televisions (33 percent), and electric irons (25 percent). Appliance ownership variations by region are in line with regional income disparities.

Off-Grid Electricity

People often assume that households without access to the electricity service from the grid do not use electricity. This is not the case. The electricity may cost them more and they may use less of it, but almost all households have some form of off-grid electricity use. This is evidence of a pent-up consumer demand for electricity and an indication that people are willing to pay high prices for small amounts of it.

Car and Dry Cell Batteries

Close to one-fifth of households in rural Peru without electricity use car batteries for televisions and lights. This is an important indication of the very high value of electricity for people in rural areas, as the work and expense involved in charging car batteries is not trivial. Battery costs vary across the expenditure quintiles, with the poor paying higher prices per kilowatt-hour than the more wealthy households. The poorest quintile seems to purchase batteries of significantly lower capacity, while paying similar prices as the richer quintiles do for better batteries.

The use of dry cell batteries for specific uses is very common among both grid and off-grid households in rural areas. Often, such batteries fulfill an energy niche that cannot be entirely met though the use of grid electricity. However, it is also evident that households with grid electricity are less reliant on batteries for their electricity needs than households without access to it. As a consequence, they save having to pay for what is a very expensive form of energy.

Small Generators and Solar Home Systems

Small generators and solar home systems in rural Peru are uncommon. Overall, 0.6 percent of rural households, or an estimated 13,100 households, use small gasoline or diesel generators. The estimated cost of using a generator is much lower than the cost of using a car battery, and it would give far better service levels. It is likely that a significant barrier to the adoption of generators is their high upfront costs.

Solar photovoltaic (PV) systems represent an option for providing electricity to households in remote rural areas, where the costs of grid extension are particularly high. The use of solar systems is quite rare in rural Peru because of a lack of promotion of the use of such systems. Most of the households that would use a solar PV system now use car batteries. Solar systems are estimated to be present in 0.8 percent of all households, or about 16,700 rural households.

Benefits of Rural Electrification

The benefits of electricity consumption can be broken into two categories: direct and indirect. Direct benefits include improvements to lighting and television viewing. Indirect benefits include improved educational outcomes for children in homes with electricity and improved income-generation opportunities. Most of the quantitative work described in the literature relates to estimating the direct benefits. However, there is evidence that some direct benefits, such as improved lighting, give rise to indirect benefits.

There are two principal methods for estimating direct benefits, or the willingness of consumers to pay for services: avoided cost and demand curve estimates. The former tends to underestimate value. This study uses demand curves to estimate the benefits of lighting, television viewing, income-generation, and other services.

Benefits of Electricity Use to Lighting

Although various forms of energy are used by all income groups, it is primarily the poor who depend on high-cost and less-efficient alternatives to grid electricity, such as candles and kerosene, to provide lighting.

Using consumer surplus calculations, the report shows the benefits in switching to different forms of lighting. Benefits from improved lighting range from 17 to 90 soles/month/household, depending on expenditure level and assumptions. The estimates have high variance, but even at the low end of the range, the economic benefits are substantial. Not only do households with electricity enjoy much greater levels of service, but also they obtain a real income gain since their total expenditure on lighting service decreases.

Benefits of Electricity Use to Communications

For radio, most basic calculations suggest that households without electricity would save 4.6 soles per month if they were to use grid electricity. For television viewing, demand curve calculations find a total benefit or willingness to pay of 24.2 soles per month.

Benefits of Electricity Use to Education and Health

The Survey shows that children aged 6 to 18 in households with electricity read or study 65 minutes per night, compared to 51 minutes for those without electricity. Although school enrollments for children aged 6 to 12 with and without grid access are comparable, school enrollment of children aged 13 to 18 in households with electricity is 82 percent, versus 62 percent in households without access.

Although not quantified, the health benefits from reduced burns and respiratory effects from kerosene are major benefits of rural electrification.

Benefits of Electricity Use to Business

About 13 percent of sampled houses reported a home business, with a higher proportion in grid-electrified households (18.3 percent) than households without electricity (7.7 percent). Although the small number of households using electricity from car batteries have a similar proportion of home businesses as those connected to the grid (16.1 percent), it is clear that home businesses are concentrated in households connected to the grid.

Willingness to pay (WTP) for electricity in non-household applications may be estimated from the results of the business survey, which sampled 192 rural enterprises. Sixty-nine (69) percent had access to the grid. Even a simple consideration of energy sources suggests that WTP for electricity for business is much higher than for domestic applications; 26 percent of unelectrified businesses use car batteries and 24 percent use small generators.

Total energy expenditures remain largely unchanged: 154 soles per month for electrified enterprises versus 155 soles per month for unelectrified enterprises. These energy expenditure data do not take into account the dramatic difference in enterprise *incomes*. The average monthly turnover (gross sales) in electrified enterprises is 3,520 soles/month, as opposed to 1,140 soles/month in unelectrified enterprises.

Policy Implications

Chapter 6 uses data from the Survey to consider policy issues relevant to the creation and sustainability of rural electrification programs:

- *Connection rates in electrified villages.* Almost one-quarter of households without electricity are in villages that are electrified. The most common reason given for nonconnection in these villages is the upfront costs of connection, wiring, and equipment. The financial sustainability of projects is strongly influenced by connecting as many households as possible, from which follows that connection costs, perhaps including house wiring, should be part of the overall cost eligible for subsidy.

- *Variations in electricity consumption levels.* An indicative consumption threshold of 22 kWh/household/month is used in this report for whether most rural electrification schemes would be financially viable. Although the average consumption in 374 electrified villages is 35 kWh/household/month, these averages show significant variation across regions. In the Andean South region, the average is only 15 kWh/household/month, and only 23 percent of villages had consumption levels above 22 kWh/household/month. This suggests that there is likely to be a significant problem with financial viability of rural electrification in the Andean South.
- *Growth of electricity consumption.* One of the important assumptions in making financial projections of the viability of rural electrification projects is the rate of growth in consumption. At least based on the experience of those communities prioritized by the current scheme (often the poorest and most lacking in infrastructure access), there is no evidence that annual consumption growth per connected household would be much higher than the commonly assumed 0.5 to 1.0 percent per year. Therefore, the Survey results suggest that these rates continue to be used in projections.
- *Pricing policy.* Those who consume small amounts of electricity pay relatively high prices per kWh, notwithstanding the FOSE mechanism. Households in the lowest quintile capture only 7.7 percent of the total FOSE subsidy received by all rural households, yet this quintile constitutes 20 percent of all households. The highest quintile captures 32.6 percent of the benefit. In short, the targeting performance of the FOSE could be improved. Improvements in the targeting performance could be achieved by further lowering the FOSE cap. If the 50 percent discount were limited to 15 kWh/month and phased out at 25 kWh/month, the share of benefits going to the lowest quintile would be 19 percent, while the richest would receive less than 10 percent.
- *Efficient lighting.* The economic case for linking future rural electrification projects with an efficient lighting program using compact fluorescent lamps (CFLs) is compelling. Rural electrification costs per household are between US$445 and $600, so an additional US$8-$9 for three CFLs per household would have little impact on rural electrification project budgets.

Supplementary Information

The Annexes provide additional information about the Survey design and methodology (Annex 1), more detailed findings (Annex 2), additional details about estimating benefits (Annex 3), and the Survey itself (Annex 4).

1 Introduction

Peru is a country of extreme diversity, both in its geography and the socioeconomic conditions of its citizens. This makes it a challenge for the government of Peru (GoP) to meet its targets to extend access to basic infrastructure services, including electricity, to the dispersed population living in rural areas. Plans and targets have been in place for rural electrification since the early 1970s, but by 2005, only 39 percent of rural households had electricity service. Peru has one of the lowest rural electrification rates in Latin America.

An estimated 6 million people in the predominantly poor rural areas of Peru do not have access to electricity. Together with the scarcity of other infrastructure services, lack of electricity results in high costs for basic energy services, a lower quality of life, poor medical care and education, and limited opportunities for economic development. The extremely high incidence of poverty in rural areas of Peru highlights the importance of investing in provision of basic infrastructure, such as electricity, as part of the national rural development agenda.

The MEM initiated a World Bank- and GEF-assisted Rural Electrification Project in August 2006 to assist local distribution companies in reaching rural populations with well-targeted subsidies, aiming at financing projects that would be financially sustainable after receiving a subsidy of a substantial part of the capital costs (World Bank 2006). The project aims to provide financing for investments in subprojects to supply electricity services to about 160,000 currently unserved rural households, businesses, and public facilities, such as schools and health clinics (serving about 800,000 people), using both conventional grid extension and renewable energy sources.

Detailed data were required in order to prepare the design of the Peru Rural Electrification Project. Data were also needed to improve the rural electrification program and to analyze the economic and financial aspects of rural electrification. The information needed includes general socioeconomic information on households, as well as detailed information on their current energy use, energy expenditures, and ability/willingness to pay for electricity services. Until now, such data have not been available. Consequently, it was decided to implement the National Survey of Rural Household Energy Use (referred to as the Survey in this publication),[3] with the assistance of the Energy Sector Management Assistance Program (ESMAP), to obtain information on the demand and use of electricity in rural areas of Peru.

The Survey was conducted through the National Institute of Statistics and Information Technology (*Instituto Nacional de Estadística e Informática*, INEI) and experts on household energy surveys provided by the World Bank. INEI's Technical Department of Demographics and Social Indicators executed the fieldwork and data processing from April through July 2005 in the 24 departments (*departamentos*) of Peru.

It is essential to point out that the definition of rural population center that is used in the National Survey of Rural Household Energy Use is different from that used by INEI in the census. The definition used by INEI for the purpose of the census is that rural population centers are those with less than 100 dwellings grouped contiguously. The definition used in the National Survey of Rural Household Energy Use

[3] In Spanish, *Encuesta de Consumo de Energía a Hogares en el Ámbito Rural.*

for rural population centers are those with less than 1000 dwellings grouped contiguously, a definition that better represents the target population for rural electrification programs. This difference in definition of rural population centers means that the data from this survey cannot be directly compared with data from the census of other surveys conducted by INEI.

The Survey covered 6,690 households with and without electricity in rural areas of Peru. Rural areas were defined as those populations living in aggregations of 1,000 households or less. The sample was large enough to provide reliable estimations about the survey population at seven regional levels: Coastal North, Central, and South Regions, the Andean North, Central, and South Regions, and the Amazon Region. The expected standard deviation in each region ranged from 0.021 to 0.050 (see Annex 1).

This report presents the main results of the Survey, and shows how Survey information can contribute to the analysis of important policy issues in developing an improved rural electrification framework in Peru.

Geographical and Socioeconomic Diversity in Peru

Each of Peru's seven geographical regions has unique geography and distinct socioeconomic realities. Key to understanding the slow pace of progress in bringing electricity access to rural households in Peru is an appreciation of the impact of this geographic and socioeconomic diversity**.** The country's geography ranges from the high-altitude Andean mountains, through dense, lush Amazonian tropical rainforest, to the dry, flat coastal desert plains. It is estimated that about 65 percent of Peru's rural population live in the Andean regions, while about 20 percent live in the Amazon and 15 percent in the Coastal regions (Table 1.1).

The Coastal North is made up mostly of desert and beaches, although there are also fertile valleys with citrus fruit cultivation. The Ecuadorian border lies to the north. This region has Peru's third-largest population, located mostly in urban areas. Only about one-quarter of its population lives in rural areas, yet 58 percent[4] of those living in rural areas are poor. Income in the region is generated mainly through fishing, agriculture, and mining. Agricultural products include citrus fruit, corn, and potato.

Table 1.1

Population by Region and Area

Region	Total Population	Population Living in Rural Areas	Percentage Living in Rural Areas
Coastal North	3,914,312	951,147	24.3
Coastal Central	1,846,606	315,465	17.1
Coastal South	713,042	173,413	24.3
Andean North	2,270,580	2,057,476	90.6
Andean Central	4,096,006	2,445,860	59.7
Andean South	3,632,728	1,885,401	51.9
Amazon	3,836,036	2,080,865	54.2
Lima Metropolitan	8,228,084	0	0
Total	28,537,394	9,909,628	

Source: INEI, Enaho 2004-I, II, III and IV rounds.

The Coastal Central region, including Lima, contains both the largest percentage of the country's population and greatest share of its economy. Its economy consists of mostly industrial production, as well as services, agriculture; fishing; livestock; lead, zinc, and silver mining; and tourism. The geography is mostly flat with arid conditions, yet there are also fertile valleys. The Andean chain borders to the east.

The Coastal Central region is also mostly urban, with only 17 percent of its population living in rural areas. It has a rural poverty rate of 29 percent, which is low in comparison to the national rural poverty average of 55 percent. Four percent live in extreme poverty, much lower than the national average of 26 percent in rural areas. Rural households in the Coastal Central region spend around 744 soles per month, which is much higher than the average expenditure of 482 soles per month for rural households across all regions.

[4] Poverty figures for this report were calculated using the *Encuesta Nacional de Hogares* (ENAHO) 2004-I, II, III and IV rounds, compiled by the Instituto Nacional de Estadística e Informática (INEI).

The Coastal South region is also flat and desert-like, with some fertile irrigated valleys, the Andes to the east, and the Chilean border to the south. It has both the lowest population of Peru's seven regions and the smallest number of people living in rural areas. Approximately one-quarter of its population lives in rural areas, and it has the lowest rural poverty index of the regions, at 21 percent. The Coastal South also has the country's highest rural household expenditure, about 775 soles per month. The economy depends on fishing; copper mining; agriculture such as corn, potato, and asparagus; production of wine and Pisco; and production of poultry and other livestock.

The landscape of the Andean North is a mixture of high peaks, plateaus, and deep gorges and valleys, which makes the provision of basic infrastructure to these areas very difficult and expensive. This region also has one of the most expansive land areas of the regions. (The entire Andean region covers 30 percent of Peru's total land area.) The Andean North is the world's sixth largest producer of gold, as well as a major producer of livestock, such as cattle and sheep, and associated products, such as milk and cheese. It also produces agricultural goods such as corn, potato, and rice, and has some tourism. However, much of its rural population continues to depend on subsistence farming. It has the highest percent of population living in rural areas, at 90 percent, and the highest index of poverty in rural areas.

The Andean Central region has some of the highest peaks in the world, particularly in the White Andean chain, as well as valleys, gorges, and rivers. As in the Andean North, this difficult geography hinders the provision of public infrastructure such as roads and electricity. Income in this region is generated from lead, zinc, and silver mining and smelting. Potato and other root crops are other major sources of income. Much of the rural population is dedicated to subsistence farming. This Andean region has the largest population of the country (excluding metropolitan Lima), with 60 percent of its inhabitants living in rural areas. Sixty-eight percent of these rural households are poor, and 44 percent live in extreme poverty.

The Andean South is characterized by high altitudes, harsh winters, and strong winds in the areas where much of the population lives, making it difficult to raise any crops other than potatoes. Although there is a thriving tourism industry (mainly from the Cuzco-Machu Picchu area) and a large percentage of its income derives from natural gas production (Camisea), the region also contains Peru's two poorest *departamentos*, Huancavelica and Huanuco. The majority of the rural population generates income through agricultural production, mainly potato, and subsistence farming. A little more than one-half of the total population lives in rural areas. The Andean South has the second highest poverty incidence in the country. Nearly 70 percent of rural households are poor, and about 38 percent are extremely poor.

The Amazon makes up 60 percent of Peru's total land area. It is covered with thick tropical forests in the west and dense tropical vegetation in the center and east. As a result, the region remains largely unexplored and undeveloped. This makes the infrastructure, such as grid-connected electricity, expensive. The Amazon is one of the most populated regions, with 54 percent of its population in rural areas. Although not as poor as the Andean regions, 58 percent of rural households in the Amazon are poor and 26 percent live in extreme poverty. The Amazon region mainly produces citrus fruit and coffee, and also generates income through tourism. It also produces rice and yucca, and there is some petroleum mining.

Household income and expenditures are positively correlated with urbanization and density of population. The coastal regions are the most commercialized, urban, and prosperous. Almost one-third of the country's population lives in Lima, but only 3 percent of its population lives in extreme poverty. Extreme poverty rates among urban populations range from 4 percent in the Central and South areas to 15 percent in the Coastal North. This contrasts sharply with conditions in the North and Central Andes, where a predominantly indigenous population engages in traditional lifestyles. In the Andean regions, between 38 and 47 percent of all households live in extreme poverty, and rural households on average have less than one-quarter of the average annual income per household in Lima (INEI 2005; World Bank 2005) (see Table 1.2). According to data from the World Bank's *Peru Poverty Assessment* (2005), indigenous households

Table 1.2

Poverty Incidence in Rural Areas (% of Households)

Region	Poverty (%)	Extreme Poverty (%)	Monthly Household Expenditure (Soles)[6]
Coastal North	57.8	15.4	583
Coastal Central	29.1	4.2	744
Coastal South	20.9	4.1	755
Andean North	77.8	47.2	271
Andean Central	68.5	44.1	343
Andean South	69.3	37.6	292
Amazon	58.3	26.4	471
Average	55.0	26.0	482

Sources: INEI, 2004, used for poverty figures, and 2005, used for household expenditure figures.

are, on average, poorer, less educated, and less healthy than nonindigenous households.[5]

Access to infrastructure reflects income differences and geographical challenges. In 2003, 62 percent of rural households had access to water and 49 percent to sanitation services. However, only 28 percent of rural households had access to an unpaved road in good condition (13 percent to a paved road), and 9.3 percent of villages had a public phone.

The association of poverty with geographical dispersion is particularly pernicious. The poorest region, the Andean North, has a population density of less than 0.2 inhabitants per square kilometer, compared to well over 4,000 in the richest part of the country around Lima (INEI 1993). This means, in effect, that the places that are most expensive to reach for infrastructural services are also the least able to afford to pay for these services—with serious implications for the sustainability of electricity systems in these areas.

Electricity Sector Structure

Until the late 1970s, the GoP did not have systematic rural electrification policies or programs. Apart from a few pilot projects in rural communities during the late 1960s, extension of electricity access was generally ad hoc and politically driven, aimed at gaining political support in rural areas. Rural electrification projects were neither clearly defined nor prioritized according to potential rural electricity demand or financial viability.

Starting in the late 1970s, the government introduced measures to try to increase the population's access to electricity services**.** Early efforts focused on urban and peri-urban areas, especially along the more densely populated and prosperous coast, where connection costs are lower and communities could be easily connected to the national interconnected grid.

From the early 1970s, the electricity sector in Peru was run by the public enterprise ELECTROPERU (ELP). Recognizing the enormity of the task to provide electricity access to rural areas, ELP created a Directorate of Rural Electrification projects in 1976 to develop a national rural electrification plan, and the Ministry of Energy and Mines (MEM) declared rural electrification as a key goal (Carrasco 1989).

In 1982, the General Electricity Law was passed. One of its objectives was to expand the access to rural areas at the least cost. The model adopted by ELP was to connect rural areas to the national network wherever possible through the construction of mini-grid systems. Between 1980 and 1986, ELP constructed approximately 42 mini-grid systems, mostly located in peri-urban areas (Carrasco 1989). To finance the electrification projects, a tax was established on 25 percent of energy consumption above 160 kilowatt-hours (kWh) per month, 50 percent of which was earmarked for rural electrification. Despite this effort, bureaucratic complications and inadequate project information, combined with poor site selection and

[5] In 2000, 70 percent of indigenous households lived in poverty versus 54 percent for the total population. The secondary school completion rate in 2003 was 27 percent for indigenous peoples and 48 percent for non- indigenous peoples. The under-1 mortality rate in 2000 was 54 per 1,000 live births for indigenous people, versus 34 for the total population. In addition, wasting and stunting levels in 2000 were roughly twice as high for indigenous households as for the total population (World Bank 2005).
[6] Annual household expenditure: Conversion to dollars calculated using a rate of 3.23 soles/US$.

prioritization, made it difficult for ELP to reach its project goals. A failure to properly train local staff also resulted in poor administration, operation, and management of the mini-grid systems.

In 1992, a new legal and regulatory framework for the electricity sector was put in place through the Law of Electric Concessions (*Ley de Concesiones Eléctricas*, LCE). In line with then-President Alberto Fujimori's focus on economic reform, the LCE envisaged the private sector as the principal actor, with the public sector playing mainly a regulatory and supervisory role. As with many other Latin American countries during this period, the vertically integrated model was replaced with a new structure in which generation, transmission, and distribution were unbundled, with competitive markets operating in the generation and commercialization markets, while transmission and distribution was regulated, based on free-entry and open access. A privatization program was established to break up the vertically integrated ELP and transfer the assets into private hands.

Prices for small retail users (known as regulated users) were regulated, while a free market was created for large industrial and commercial customers with demand above 1,000 kW (free users). Price setting was done on the principle of a reasonable return to compensate the costs of an "economically efficient" service provider. The main regulatory body, responsible for tariff setting, supervising, and monitoring the legal and technical regulations for the electricity sector, was the Supervisory Commission for Energy Investments (*Organismo Supervisor de la Inversión en Energía*, OSINERG).

Despite attempts to extend privatization throughout Peru, factors such as high capital costs, low demand, and difficult geography have discouraged private investment outside Lima. There are two principal private distribution companies, EDELNOR and *Luz del Sur*, created when ELP was privatized in 1994. They serve approximately half of the total electric market in Peru, primarily in the areas around Lima.

Twelve other regional electric distribution companies provide service in Peru, as well as the few smaller-scale municipality electric companies—all of which are publicly owned. These companies hold concession areas concentrated in small areas around urban centers and have an obligation to meet service requests only within 100 meters of the existing network. There is thus no incentive for either public or private companies to extend service to households outside these concession areas. Areas with electric concessions in Peru are dwarfed by areas with no service from a distribution company. Connected areas are heavily concentrated in urban coastal areas, such as Lima, while the majority of the rural population remains unserved.

In the 1992 restructuring of the sector, the electricity tariff scheme was predicated on a full-cost recovery. This situation prevailed until the middle of 2001, with no explicit subsidies to electricity rates. In July 2001, the government announced legislation establishing a "social tariff" for electricity consumption (known as the *Fondo de Compensación Social Eléctrica*, FOSE). Since July 2004, the level of subsidy has consisted of tariff reductions for monthly consumption up to 30 kWh, set at 25 percent for urban users supplied by the interconnected system and 62.5 percent for rural users supplied by isolated systems. For consumption between 31 and 100 kWh, the reduction is gradual, from a maximum of 31.25 percent for rural users supplied by isolated systems to a minimum of 7.5 percent for urban users supplied by the interconnected system. Consumers who use more than 100 kWh per month pay a cross-subsidy in proportion to their energy consumption above 100 kWh/month to finance the FOSE discount.

Statistics show that about 33 percent of all residential users consume less than 30 kWh per month and another 35 percent have monthly consumption

Table 1.3

Residential Subsidized Tariffs (Soles/kWh)

Consumption kWh/month	Lima Consumer	Rural Consumer
Less or equal to 30 kWh	0.242	0.201
From 31 to 100 kWh	0.322	0.402

Source: INEI, 2005.

between 31 and 100 kWh. This means that 68 percent of all residential consumers receive some electricity price subsidy. This cost of the subsidy represents a surcharge of 3 percent cost of electricity to the users providing the subsidy (those with monthly consumption over 100 kWh.). Table 1.3 shows electricity tariffs, including the FOSE subsidy, for a residential user with monthly consumption up to 100 kWh.

It should also be noted that rural tariffs vary by location, based on the tariff calculated by OSINERG for the areas of each distribution company. The price paid per kWh from the Survey (including fixed and variable, as well as other charges such as lighting), varied from a low of 0.47 soles/kWh in the Coastal South Coast region to a high of 0.83 soles/kWh in the Andean South region. The fixed charge for connection, until recently paid by the customer, averaged about 320 soles per connection. Under the 2006 Rural Electrification law, the distribution company will pay the connection charge. The connection facilities (wire drop and meter) will be owned by the distribution company and will be recovered through the distribution value-added charge as part of the tariff.

The National Financing Fund supervises state-owned distribution companies for State Enterprise Activity (*Fondo Nacional de Financiamiento de la Actividad Empresarial del Estado, FONAFE)*. FONAFE is a state organization that holds assets, sets policies, and directs investments of regional distribution enterprises.

Rural Electrification to Date

Overall, electricity coverage rates are lower than in most countries in Latin America, at 78 percent. In comparison, the coverage rate is 89 percent in Ecuador, which has roughly the same per capita income (see Table 1.4). As noted earlier, an estimated 6 million people in the predominantly poor rural areas of Peru do not have access to electricity.

The low level of rural electrification in Peru reflects the fact that the framework under the Electricity Law failed to address rural electrification. To fill this gap, a 1993 Supreme Decree created the Executive Project Directorate (DEP) within the Ministry of Energy and Mines (MEM) as a project implementation branch whose principal objective is to extend electricity access, mainly in rural areas. The primary function of the DEP is to define and implement the rural electrification plan, financing or cofinancing the majority of these projects and directly implementing them by contracting with construction firms.

The DEP prepares a national rural electrification plan that sets out a list of projects to be developed, annual investment budgets, and sources of funding. The plan has a 10-year horizon and is updated annually, reflecting program progress, new policies, and prioritization and allocation of economic resources. The *Plan Nacional de Electrificación Rural 2006–2015* aims to increase the national coverage rate

Table 1.4

Latin American and Caribbean Region Electricity Coverage, by Percentage of Coverage

	Population, 2005 (millions)	Electricity Coverage (%)	Population w/o Electricity (millions)
Nicaragua	5.5	54	2.5
Bolivia	9.2	69	2.8
Honduras	7.2	69	2.2
Peru	28	78	6.3
El Salvador	6.9	82	1.2
Guatemala	12.6	83	2.1
Panama	3.2	86	0.5
Paraguay	6.2	87	0.8
Ecuador	13.2	89	1.5
Brazil	186.4	92	15.8
Venezuela	26.6	92	2.2
Mexico	103.2	93	6.8
Colombia	41.5	94	2.7
Argentina	38.7	95	2.1
Uruguay	3.5	95	0.2
Chile	16.3	98	0.3
Costa Rica	4.3	99	0.1
Total	512.4	90	50.1

Sources: CIER, ECLAC, Official statistics in the case of Colombia, Mexico, and Chile.

from 78 percent in 2006 to 93 percent in 2015, at a total cost of US$929 million (MEM 2007).

The DEP performs all of the administrative, technical, and/or financial activities required to develop projects (directly or through service contracting), including prefeasibility and feasibility studies, procurement, contracting, execution of the works, supervision, and inspection until the service begins. Financing for these projects comes from the central government's budget. The constructed systems are later transferred to distribution companies or to the Electric Infrastructure Administration Enterprise (ADINELSA), a government holding company, as described later in this chapter.

The first step in the DEP process is for the community, local or regional government to submit a letter of request to the DEP. The DEP evaluates the project based on technical criteria (actual project state, electric infrastructure, provincial electricity coefficient), economic criteria (actual social net value, investment/capita), and socioeconomic criteria (poverty index, geographic location). An engineer then visits and evaluates the site and draws up the technical plan for project implementation, followed by the preparation of prefeasibility and feasibility studies. The DEP then, through a bidding process, contracts the construction of selected projects. After the project is constructed, administration is transferred to the primary electricity distributor in the region or, if it is an isolated system, to ADINELSA.

In addition to the DEP, the National Fund for Compensation and Social Development of Peru (FONCODES) also played a part in rural access extension in the 1990s. Created in 1991 as a temporary autonomous, decentralized agency that reports directly to the executive branch of the GoP, it was designed to improve the living conditions of the poor, create jobs, help to meet the basic needs of the poor, and encourage the poor to take part in their own development. Between 1991 and 1996, FONCODES invested more than US$57 million in 1,733 energy infrastructure projects. FONCODES was originally given funds to cofinance rural development projects, but since decentralization, the funds are given directly to regional governments.

The activities of the electricity distribution companies within their concessions, and of the DEP and social funds such as FONCODES in rural areas, have increased national coverage levels from 57 percent in 1993 to 78 percent in 2006. Although coverage is at approximately 94 percent in urban areas, it is still only about 39 percent in rural areas (INEI, 2005). The total investment by the DEP to 2004 was just over US$600 million, with an annual average of about US$50 million. The DEP completed 608 projects during this time period. About 4.8 million people benefited from these projects (1 million households). The average amount of kilowatt-hours (kWh) consumed per month by each household that benefited from the DEP projects is around 20 kWh.

Once DEP or FONCODES projects are commissioned, ownership of the fixed assets is transferred to distribution companies. Where these assets cannot be transferred to electricity distribution companies—usually in areas located outside the geographical limits of the regional electricity companies—they are transferred to the Electric Infrastructure Administration Enterprise (*Empresa de Administración de Infraestructura Eléctrica S.A.*, ADINELSA), a state company formed to administer the fixed assets of the DEP program and supervise the operation of the isolated rural electricity systems. ADINELSA is in charge of administering the electricity installations and delegates the operation and maintenance of the facilities to concessionary enterprises or municipalities.

Key Rural Electrification Issues

The first and most important issue for the rural electrification program is adequate financing. There is a need for sustained and predictable financing of the subsidies required. Funding for the rural electrification projects constructed by the DEP or FONCODES has come almost entirely from the Treasury, with some contributions from other state entities and regional and local governments. The levels of investments have dropped significantly from a peak of US$135 million in 1996 to about $40 million per year in 2004–2005. Although it may be unrealistic to expect to reach the GoP's target, which would require almost a doubling of current budget levels, mobilizing cofinancing from distribution companies, as well as from local and regional governments, could help.

A second key concern for rural electrification projects has been financial and technical sustainability during the operation of the projects. Projects that are transferred to distribution companies, and especially ADINELSA, often have costs for operation and maintenance that are higher than the revenues from the tariff. ADINELSA, for example, must continuously subsidize the operators of its projects, and is, as a consequence, facing increasingly heavy losses, with operating losses at US$2.8 million in 2003 and US$4.7 million in 2004.

Part of the problem occurs because the weighting factors for project selection have resulted in priority being given to areas with low provincial electricity coverage and a high incidence of poverty as opposed to criteria such as economic efficiency, minimum subsidy, or maximum economic benefit. This undermines the long-run project sustainability and imposes an excessive burden on the distribution companies or ADINELSA, which must then subsidize projects whose operation and maintenance costs are higher than tariff revenues.

A third key issue is that the DEP and FONCODES have followed centralized processes with very limited participation of distribution companies in the process of identification, selection, and development of projects. The distribution companies, for their part, have generally lost interest in participation in the extension of rural electricity service, as there have been no incentives available to them to cover the capital costs for grid extension.

Despite MEM's significant achievements in improving electrification in Peru, limitations on fiscal budget allocations and problems with the existing approach suggest the need for an overhaul of the model. An improved strategy is required to promote the involvement of public and private distribution companies and to broaden the involvement of additional actors in project development. Aside from a few exceptions, the municipalities have also not participated in electric service provision. Instead, they have taken on the role of lobbying on behalf of local demands for obtaining electricity service and contributing to financing the electricity projects (Aragón 2004).

In the Rural Electrification Plan of 2007, the GoP aims to increase national coverage from 78 percent in 2006 to 88.5 percent in 2011 and 93 percent in 2015. To meet this commitment, investments benefiting 4.8 million people and totaling US$929 million between 2006 and 2015 are planned (MEM 2007). Most of these investments are planned in rural areas.

To accomplish this ambitious task, the GoP will need to improve the rural electrification framework to increase economic efficiency and attract broader participation and financing from communities, regional governments, and electricity service providers. Congress passed the General Law of Rural Electrification on July 1, 2006. The General Law creates a Rural Electrification Fund and provides a base from which specific regulations can be developed for an improved strategy.

The MEM initiated a World Bank- and GEF-assisted Rural Electrification Project in August 2006 to assist local distribution companies in reaching rural populations with well-targeted subsidies, aiming at financing projects that would be financially sustainable after receiving a subsidy of a substantial part of the capital costs (World Bank 2006). The project aims to provide financing for investments in subprojects to supply electricity services to about 160,000 currently unserved rural households, businesses, and public facilities, such as schools and health clinics (serving about 800,000 people), using both conventional grid extension and renewable energy sources. The Project also includes a component aimed at increasing productive uses of electricity. It is hoped that lessons learned during the implementation of this Project would assist the Ministry to develop a more sustainable and cost-effective strategy for rural electrification.

2 Household Energy Use and Expenditure

Knowledge about existing energy use and expenditure patterns of rural households is essential for formulating energy policies and programs to enhance living standards and alleviate poverty in rural Peru. It enables energy planners to determine the potential willingness and ability of rural households to pay for modern energy, such as electricity, kerosene, liquefied petroleum gas (LPG), and off-grid electricity sources such as car batteries. It also facilitates assessment of the potential demand for such modern and clean energy sources.

This chapter presents the information from the Survey on current energy use and expenditures in rural households in Peru. It compares energy usage among households in different regions, different household expenditure quintile classifications, and different categories of households, with and without access to grid electricity. It should be noted that the report uses total household monthly expenditure as a proxy for household monthly income.

Household Energy Use

The Survey shows that rural households in Peru, like rural households elsewhere in the world, rely on various sources of energy for lighting, cooking, and appliances, including agriculture residue, fuelwood, animal dung, candles, kerosene, electricity, liquid petroleum gas (LPG), dry cell batteries, car batteries, generators, and even solar home systems (Table 2.1). More than 84 percent of households rely on fuelwood for cooking, while 24 percent use dung and 11 percent use agriculture residue. An estimated 74 percent of all households use dry cells for small appliances such as radios and flashlights. About 60 percent of all households use candles and kerosene for lighting. Electricity is used by 39 percent of all households. A surprisingly high 11 percent of all households use car batteries to run electric appliances, indicating a high, unmet demand and willingness to pay for electricity services. LPG is used mainly for cooking by an estimated 14 percent of all households. A tiny fraction of households, 0.6 percent, have their own generators; and 0.5 percent have solar home systems.

There is a high degree of regional variation in these figures, particularly between the richer Coastal regions and the Andean and Amazon Regions that contain significant indigenous populations. Electricity use is highest in the Coastal Central at 60 percent and Coastal South at 71 percent, and lowest in the Amazon at 18 percent. Similarly, LPG use is also highest in the Coastal Central and South areas at 63 and 53 percent, and lowest in the Andean North and Amazon Regions at 5 and 7 percent. Car battery use is concentrated in the Coastal North and Central Regions. The use of dung is concentrated in the Andean South, and to a lesser extent in the Andean Central region.

More households in the three Andean Regions use candles and kerosene than households living in the three coastal regions. This is expected because fewer households living in the mountains have access to grid electricity than households on the coast. The percentage of households in the Andean Regions with access to grid electricity ranges from 22 percent in the North to 52 percent in the Central region. In the Coastal regions, coverage of grid electricity ranges from 35 percent in the North to about 71 percent in the South.

Kerosene is used by 57 percent of households for lighting and cooking, although the overwhelming majority of kerosene consumers use it only or mainly

Table 2.1

Percentage of Households that Use Each Type of Energy by Region

	Coastal Regions			Andean Regions				
	North	Central	South	North	Central	South	Amazon	All Regions
Grid Electricity	**35**	**60**	**71**	**22**	**52**	**44**	**18**	**39**
Fuelwood	85	74	68	94	92	64	95	84
Dry cell battery	71	51	55	78	66	74	91	74
Kerosene	71	32	31	71	44	52	73	57
Candles	47	53	60	56	69	66	46	60
Car battery	31	23	13	9	8	7	15	11
LPG	28	63	53	5	17	10	7	14
Ag. residue	8	7	5	5	18	13	3	11
Dung	0.4	0.5	15	3.6	26	65	0.1	25
Solar PV	0.3	0.1	0.1	0.4	–	0.9	1	0.5
Small generators	0.9	1	–	–	1	0.2	0.9	0.6
All households (000s)	156.4	75.3	27.8	362.0	634.2	565.0	383.4	2,204.2

Source: INEI, 2005.

for lighting. Among these kerosene users, about 83 percent use it exclusively for lighting. Only 4 percent use it for cooking and 3 percent use it for both lighting and cooking. The remaining 10 percent of kerosene users use it for other purposes including starting a fire, for home appliances, and home business purposes (Figure 2.1).

Significantly more households in the three Coastal regions use LPG than in other regions. These households use LPG almost exclusively as cooking fuel. Less than 1 percent of those households that use LPG report using it for lighting. This result is not surprising, given that LPG is more expensive than other fuels. Furthermore, LPG requires better roads to distribute it to end users. The Coastal regions have better road networks than the rest of the country.

Dry cell batteries are used extensively in rural households, despite a very high cost per equivalent kWh. The percentage of households using dry cell batteries is highest in the Amazon at 91 percent, where grid electricity penetration is lowest, and lowest in the Coastal Central and South regions, where grid electricity penetration is highest. The availability of grid electricity lowers but does not eliminate demand for dry cell batteries. This is due primarily to the unique, portable nature of the dry cell battery.

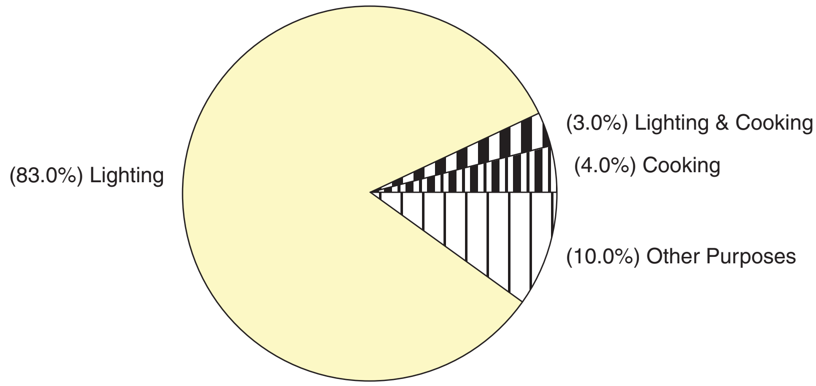
Over 80 percent of households in rural Peru rely on fuelwood for cooking. Not surprisingly, use of fuelwood varies by region, reflecting availability differences. Almost 95 percent of households in the Amazon region use fuelwood for cooking due to its abundance. In contrast, fuelwood use is lowest in the Andean South and Coastal South regions, at 64 and 68 percent.

At the bottom of the fuel ladder are agriculture residue and animal dung, both of which are used by a significantly smaller proportion of households than fuelwood. However, 65 percent of households in the Andean South and 26 percent in the Andean Central regions use animal dung as a cooking fuel (Table 2.1). These two regions have a high share of poor and indigenous households. Agriculture residue and animal dung are widely available and are typically the fuel of choice for the poor, since family members can collect these fuels. Furthermore, due to their terrain and topography, fuelwood is less abundant in these regions than in other parts of the country.

Many of the differences across regions can be explained by differences in income. As shown in Figure 2.2, the Coastal regions have a lower proportion

Figure 2.1

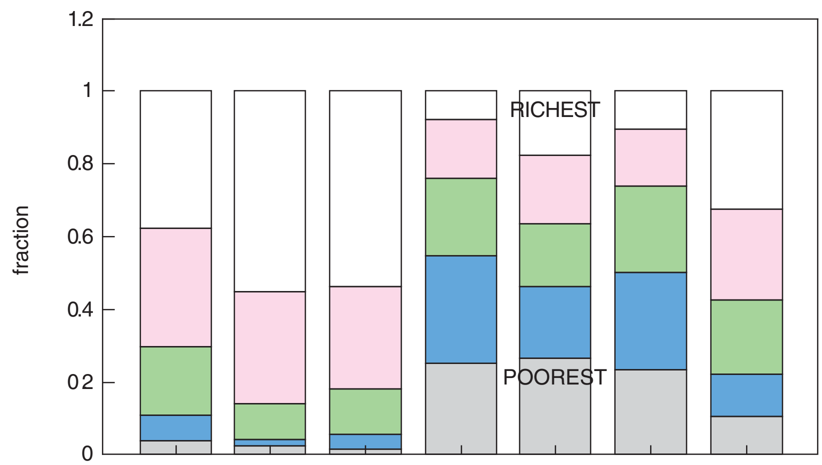
Application of Kerosene Users (Users Only)



Source: INEI, 2005.

Figure 2.2

Expenditure Differences Across Regions: Fraction of Households in Each Expenditure Quintile by Region



	Coastal North	Coastal Central	Coastal South	Andean North	Andean Central	Andean South	Amazon
5 (Richest)	38%	55%	54%	8%	18%	11%	32%
4	33%	31%	28%	16%	18%	16%	25%
3	19%	10%	13%	22%	18%	23%	21%
2	7%	2%	4%	30%	20%	27%	11%
1 (Poorest)	4%	2%	2%	25%	27%	42%	10%

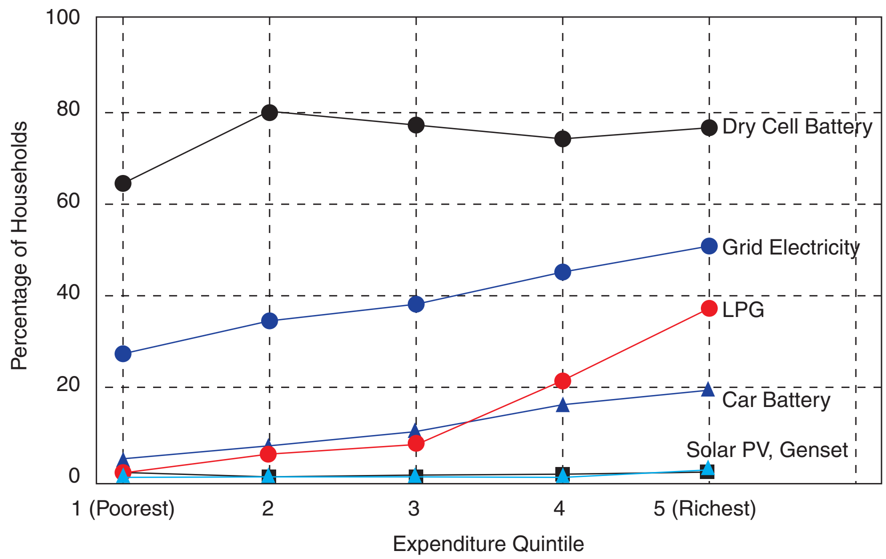
Source: INEI, 2005.

of poor households, while the proportion of poor households is much higher in the Andean Regions. For instance, 38 percent of households in the Coastal North are in the top expenditure quintile, compared with only 8 percent in the Andean North. Similarly, between 25 and 27 percent of households in the Andean regions are in the poorest quintile, compared with only 2 to 4 percent in the Coastal regions.

These patterns reflect the findings of the World Bank's Poverty Assessment (World Bank 2005a), which noted that poverty in rural Peru is higher in the Andean and Amazon regions than in the

Figure 2.3

Households Using Modern Energy by Expenditure Quintile



Source: INEI, 2005.

three Coastal Regions.[7] The report also pointed out that most of the regional variations in poverty rates can be attributed to variations in household characteristics and in access to basic services and road infrastructure, rather than to geographical differences *per se,* such as altitude and temperature. In other words, observationally equivalent households have similar probabilities of being poor irrespective of the geographic characteristics of their region of residence.

In relation to expenditures, energy used in rural areas can be classified in three main categories:

1. Modern energy forms (or energy such as grid electricity that requires higher income to purchase the appliances needed to utilize it), such as LPG, car batteries, and electricity, whose use increases with increasing expenditures/income (so-called normal goods).
2. Traditional energy forms whose use falls significantly with increasing expenditure levels, including dung and agriculture residue (so-called inferior goods).
3. Traditional energy forms that show remarkably small variation across expenditure quintiles, such as candles, kerosene, and fuelwood.

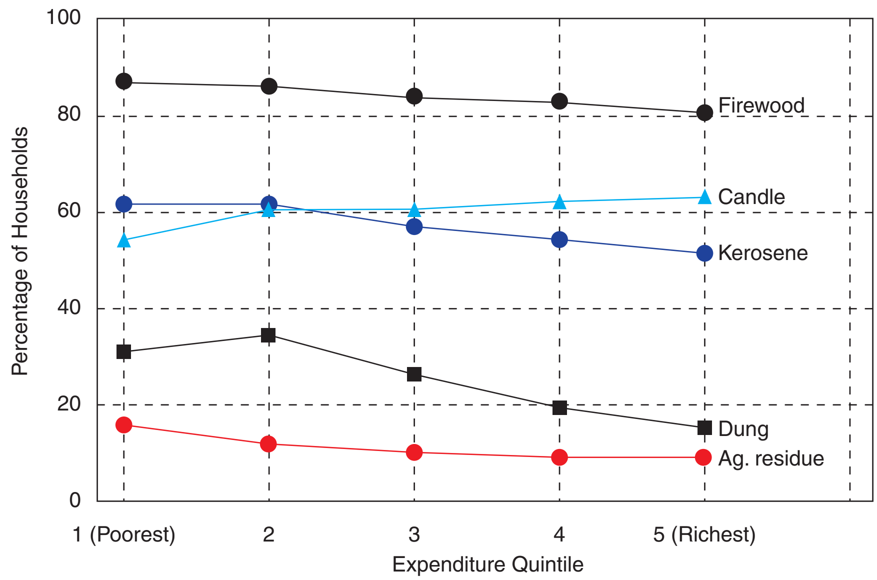
For the modern energy forms whose use increases with income, the results are consistent with worldwide experience. For example, only 27 percent of households in the lowest expenditure quintile use grid electricity, compared with 38 percent and 50 percent in the middle and top quintiles, respectively. LPG and car batteries exhibit similar trends, but at much lower initial levels. LPG use jumps from 1 percent of households in the poorest quintile to 27 percent in the richest. Car battery use goes from 4 percent in the poorest quintile to 19 percent in the richest. Use of solar photovoltaics (PV) and small generators are both extremely low at all expenditure levels (Figure 2.3).

The use of dung drops significantly from 31 percent of households in the poorest quintile to

[7]Comparing Table 1.2 and Figure 2.2, it can be seen that Quintiles 1 and 2 correspond to households living in extreme poverty in all regions; Quintile 3 in all regions and Quintile 4 in Coastal North and Amazon regions correspond to households living in poverty; and the remainder correspond to households that are not living in poverty, i.e. Quintile 5 in all regions and Quintile 4 in all regions except Coastal North and Amazon.

Figure 2.4

Households Using Traditional Fuel by Expenditure Quintile



Source: INEI, 2005.

15 percent of households in the richest (see Figure 2.4). The use of candles increases slightly with income levels, while kerosene use declines modestly. Yet, even in the top quintile, 51 percent of households report using kerosene. This reflects the substantial number of unelectrified households in the top quintile, as well as the fact that kerosene is still used for lighting in many electrified households (although as shown below, the quantities of kerosene used in electrified households and the corresponding expenditures are very small).

Energy Expenditure

Household surveys generally show that energy expenditures by households, for lighting, cooking, and appliance usage, account for 5 to 10 percent of all household expenditures. Based on the Survey, the total monthly cash expenditure for all types of energy used in the household is estimated to be 25 soles per month, on average. This amounts to about 9.7 percent of total household cash expenditures each month. However, household energy expenditure varies significantly among regions and between financially better-off households and poorer households. The following section provides a descriptive analysis of rural household energy expenditure in Peru, by region and then by expenditure quintile.

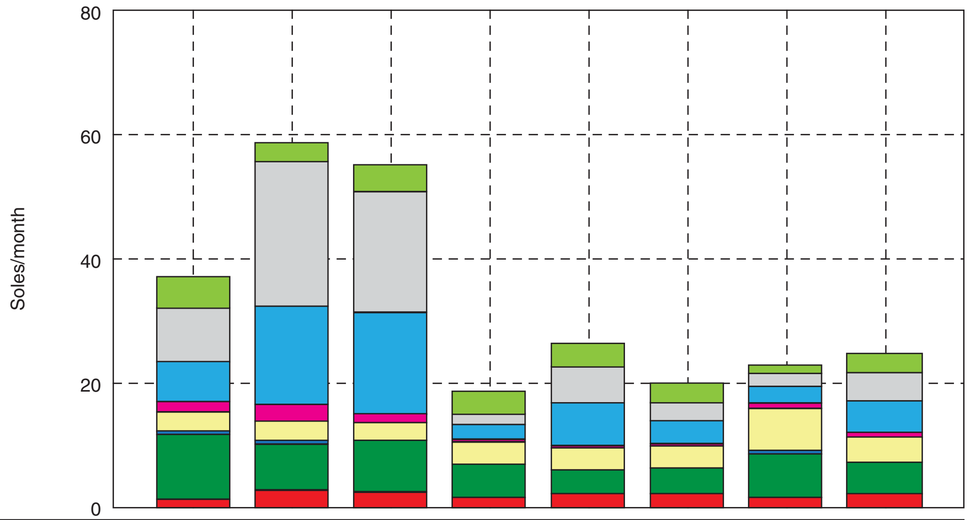
Household expenditures on energy are highest in the three Coastal regions and lowest in the Andean North (Figure 2.5). Energy expenditures for households living in the Coastal Central and South regions are about 2.5 times higher than those for households living in the three Andean regions and the Amazon region.

Regional disparities are partially explained by the fact that households from different regions rely on different types of fuel, which have different prices and varied availability (Figure 2.5). The biggest differences come from spending on kerosene, fuelwood, LPG, and electricity. Household spending on these four types of energy is much higher in the three Coastal regions.

Energy expenditure represents a heavier burden for households in the three Andean regions than for households in all other regions of the country. Although monthly expenditure of households in the Andean regions is significantly lower than that of households in the Coastal regions, their energy expenditure accounts for 10 to 12 percent of total

Figure 2.5

Household Monthly Spending on Energy by Region and Type (Soles/Month)



Region	Coastal N.	Coastal C.	Coastal S.	Andean N.	Andean C.	Andean S.	Amazon	all Regions
Candle	1.29	2.81	2.66	1.65	2.34	2.3	1.7	2.05
Kerosene	10.34	7.33	8.18	5.37	3.67	4.13	6.89	5.28
Gen-Set	0.38	0.44	—	—	—	0.05	0.29	0.1
Dry Cell Batt	3.18	3.22	2.9	3.39	3.57	3.24	6.79	3.97
Car Battery	1.89	2.83	1.14	0.51	0.43	0.39	0.99	0.72
Grid Electricity	6.5	15.71	16.63	2.34	6.91	3.84	2.66	5.03
LPG	8.55	23.19	19.34	1.68	5.63	2.73	2.31	4.64
Firewood	5.09	3.02	4.2	3.81	3.87	3.21	1.2	3.29

Source: INEI, 2005.

household expenditure. Conversely, the energy expenditure of households living in the Coastal regions accounts for only 8 to 10 percent of total household expenditure. The World Bank report *Opportunity for All: Peru Poverty Assessment* (World Bank 2005a) pointed out that poverty in rural Peru is higher in the Andean and Amazon region than in the three Coastal Regions. Therefore, the financial burden of energy expenditure on households in the Andean regions further exacerbates poverty conditions.

A comparison of household energy spending among households in different expenditure quintiles shows a positive relationship between household energy spending and household financial well being for all fuel types. Households in the lowest expenditure quintile spend an average of 9 soles per month on energy. Energy expenditures for the second, third, fourth, and richest quintile average 15, 21, 31, and close to 49 soles per month, respectively (see Table 2.2). Although poor households spend less on energy than nonpoor households, their energy spending accounts for a larger portion of their income. Households in the lowest quintile spend about 17 percent of their total monthly expenditures on energy, while households in all other quintiles spend less than 10 percent. Part of the reason for this discrepancy is that the poor often lack access to relatively cheap grid electricity.

Comparison of Households with and without Access to Grid Electricity

Socioeconomic Characteristics

Households with access to grid electricity are financially better off than households without access to grid electricity. As already mentioned, the average monthly expenditure for grid-connected households

Table 2.2

Total Household Monthly Cash Spending on Energy by Expenditure Quintiles (Users Only)

	1 (Poorest)	2	3	4	5 (Richest)	All
	< 113 Soles	113–201 Soles	201–321 Soles	321–533 Soles	> 533 Soles	
Grid Electricity	**7.4**	**8.5**	**10.4**	**14.2**	**22.5**	**13.6**
Candle	2.7	23.0	3.6	3.6	4.1	3.4
Kerosene	4.9	6.6	8.8	11.7	16.2	9.3
Small generators	–	–	13.0	29.0	38.1	33.2
Dry cell battery	3.4	4.5	5.3	6.0	7.3	5.4
Car battery	5.2	5.1	5.8	6.7	7.4	6.5
LPG	20.4	20.6	26.2	30.1	37.1	32.6
Fuelwood	13.6	17.9	22.9	27.7	36.0	26.6
All energy spending	9.4	15.3	20.6	31.1	49.1	25.1
% of total spending	17.1%	9.9%	8.2%	7.4%	5.8%	9.7%

Source: INEI, 2005.

Table 2.3

Total Household Expenditure and Education by Electrification Status

	Grid Electricity		
	With Access	Without Access	All Areas
No schooling	10%	16%	14%
Primary education	51%	63%	58%
Secondary education	30%	18%	23%
Above secondary education	9%	3%	5%
Population	*839,581*	*1,326,075*	*2,165,656*
Total Household Exp. (Soles/Month)	430	317	361
Population	*851,510*	*1,352,705*	*2,204,215*
Total Users (Electricity & Electricity Substitutes)	845,522	1,340,491	2,186,013

Source: INEI, 2005.

is 430 soles versus 317 soles for households without a grid connection. Another disparity between households with and without access to grid electricity is the educational level of the head of household. Thirty-nine percent of grid-connected households are headed by someone with at least a secondary education, compared with only 21 percent of unelectrified households (Table 2.3).

There are no differences in household size, number of children at home, education of children, or ethnic minority between households with and without access to grid electricity. Almost all children between ages 6 and 18 are attending school, regardless of their household's electrification status. However, studies have shown that electricity enhances children's education. For example, electricity allows children to study and/or do homework at night, allows schools to use modern educational equipment, and enables children to gain access to computers and the Internet. These benefits are further discussed in

Table 2.4

Percentage of Households that Use Each Type of Energy by Electrification Status

	Electrification Status		
	Electrified (%)	Unelectrified (%)	All Households (%)
Candle	51	65	60
Kerosene	20	80	57
Small generators	0.0	1	0.6
Dry cell battery	55	86	74
Car battery	0.7	18	11
LPG	28	6	14
Fuelwood	81	86	84
Solar PV	0.0	0.8	0.5
Ag. residue	12	10	11
Dung	26	24	25
All Households (000s)	851.5	1,352.7	2,204.2

Source: INEI, 2005.

Chapter 5. Children living in households without access to grid electricity would be at a disadvantage.

Energy Use

As previously noted, only 39 percent of rural households have access to grid electricity. Rural households without electricity rely on traditional fuels such as candles and kerosene for lighting. Among the 1.3 million rural households without electricity, the overwhelming majority—80 percent—use kerosene. Although kerosene can be used for both lighting and cooking, households without electricity that consume kerosene use it primarily for lighting. Similarly, about 65 percent of unelectrified households use candles for lighting (Table 2.4).

None of the rural households with access to electricity use it for cooking. This is similar to rural households elsewhere, since the use of electricity for cooking is still more expensive than traditional or fossil fuels. Switching to electricity for cooking usually takes decades, and households in rural Peru have not yet made this transition.

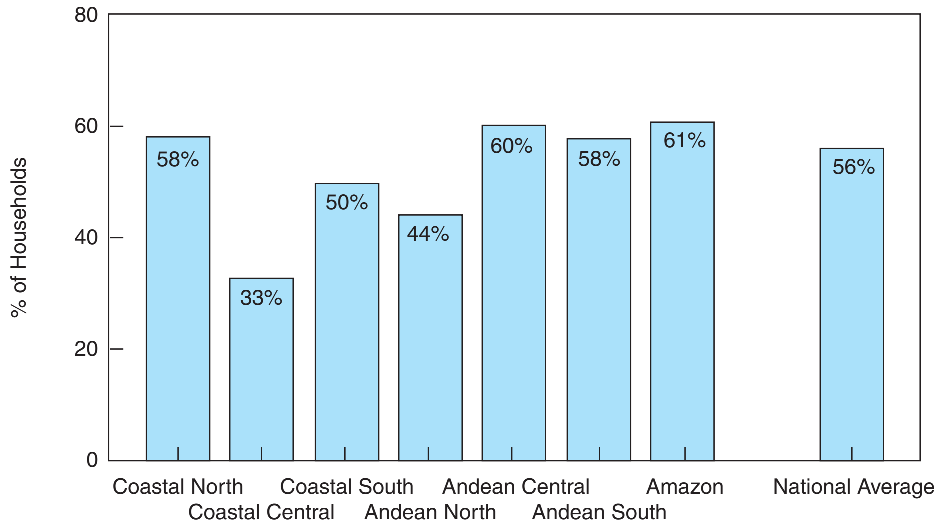
A comparison of LPG usage between households with and without access to a grid electricity connection shows significant differences between the two groups. These differences reflect the fact that electrified households are financially better off than unelectrified households. Therefore, a higher percentage of electrified households use LPG and lower percentage use fuelwood relative to unelectrified households. In rural Peru, LPG is used primarily as a cooking fuel, although a tiny fraction of households use it for lighting.[8] Availability of LPG is still limited in many rural areas, because it requires a good transportation network for distribution and high upfront costs, including a deposit for the LPG cylinder.

Over half of households with electricity continue to use kerosene, candles, or both to supplement electricity lighting, with significant differences by region (see Figure 2.6). This is likely a result of interruptions in electricity service in some rural areas (see discussion of small generators). The percentage of households with access to grid electricity who use candles and kerosene lamps ranges from 33 percent in the Coastal Central region to around 60 percent in the Coastal North, Andean Central, and Andean South regions. At 61 percent, the Amazon region has the highest proportion of grid-connected candle and kerosene lamp users.

[8] While about 27 percent of household surveyed, or 6,000 households, reported using LPG, only 9 households in the survey reported using LPG for lighting.

Figure 2.6

Percentage of Households Maintaining Kerosene and Candles to Supplement Electric Lighting



Source: INEI, 2005.

Table 2.5

Household Monthly Cash Expenditure on Electricity and Lighting Fuels/Energy by Electrification Status (Users Only)

	With Electricity (Soles/month/HH)	Without Electricity (Soles/month/HH)	All Households (Soles/month/HH)
Electricity (Grid)	**13.63**		**13.63**
Candles	1.32	4.49	3.43
Kerosene (light only)	3.92	7.98	7.67
LPG (light only)	18.26	16.24	17.05
Small generators	28.50	33.31	33.20
Dry cell batteries	3.68	6.04	5.36
Car batteries	5.72	6.61	6.60
All Expenditures (Electricity and electricity substitutes)	16.26	15.44	15.76

Source: INEI, 2005.

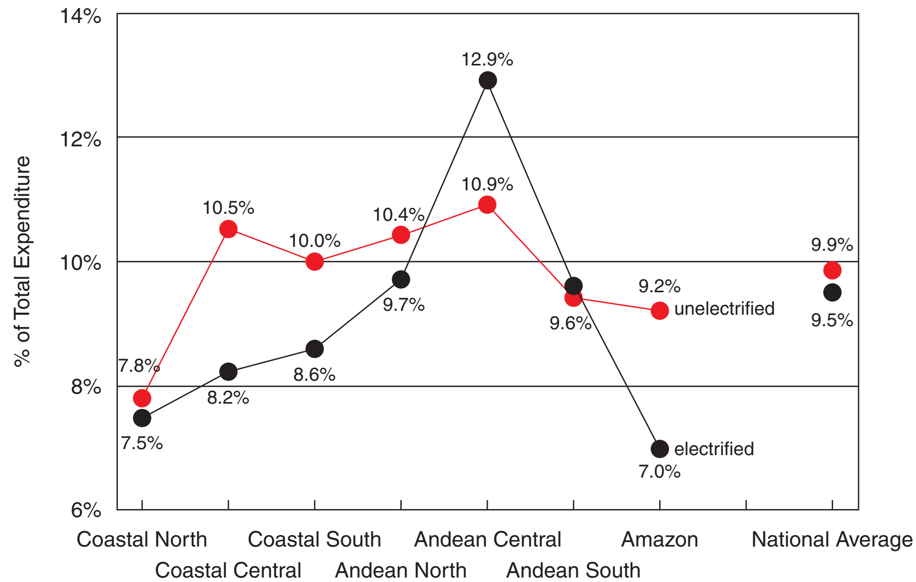
Energy Expenditures

Since electricity is not used for cooking in rural households in Peru, this section focuses primarily on household expenditures for noncooking energy use. The most important finding is that households with electricity spend only marginally more on grid electricity and electricity substitutes (16.3 soles per month) than households without electricity spend on electricity substitutes alone (15.4 soles per month) (Table 2.5). In other words, households without electricity are paying comparable amounts for much-lower-quality services.

There is much greater variation in energy expenditures as a fraction of total expenditures in households with electricity compared to households without electricity. In households with electricity, energy expenditures as a percentage of total expenditures range from a low of 7.0 percent in the

Figure 2.7

Household Energy Expenditure as a Percentage of Total Expenditure by Region



Source: INEI, 2005.

Amazon region to a high of 12.9 percent in the Andean Central region. In households without electricity, the range is between 7.8 percent in the Coastal North to 10.9 percent in the Andean Central region (Figure 2.7).

However, a comparison of spending by quintile shows that, with the exception of households in the lowest quintile, all households without access to grid electricity spend slightly more on lighting fuels/energy and other sources of electricity (Figure 2.8). This suggests that households that have no access to grid electricity have the ability to pay for monthly electricity services by reallocating their lighting fuels/energy monthly budget to electricity.

Households without access to grid electricity spend about 15 soles per month for lighting fuels and electric energy sources including candles, kerosene for lamp lighting, LPG for lighting, dry cell batteries, car battery recharging fees, and diesel or gasoline fuel for generators for electricity supply (see Table 2.5). Households with access to grid electricity spend about 16 soles per month for electricity and supplemental fuels for lighting such as candles, kerosene, and LPG, as well as supplemental sources of electricity including dry-cell batteries, car batteries, and diesel/gasoline fuel for generators.

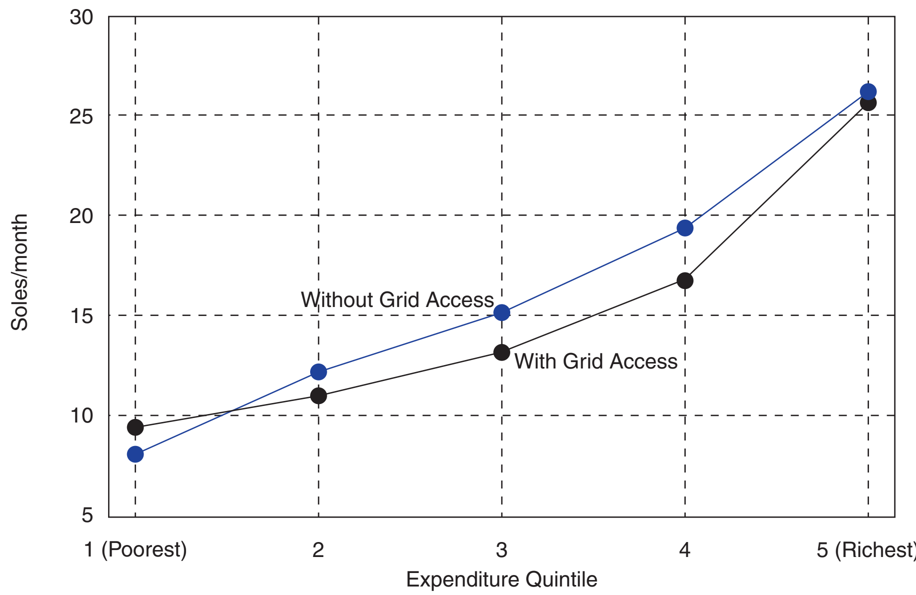
The average household with grid electricity spends 84 percent of its noncooking energy budget on electricity, while the remainder is spent on supplemental lighting fuels like candles, kerosene, and dry cell batteries. For households without grid electricity, the largest portion of noncooking energy spending is for candles and kerosene fuel for lamp lighting. The average monthly expenditure for candles and kerosene lamp lighting among households without access to grid electricity is close to 12 soles per month. The remaining 7 or 8 soles are spent on dry cell batteries and other sources. Households with no access to grid electricity that use car batteries for home electricity supply spend as much as 7 soles per month for car battery recharging fees alone.

Conclusions

Rural households in Peru still have limited access to modern fuels. The majority of lower-income households still rely on traditional fuels (kerosene, fuelwood, and agriculture residue) for lighting and cooking. Higher-income households rely more on modern fuels such as grid electricity, car batteries, and LPG. Since grid electricity is only available to

Figure 2.8

Household Expenditures on Electricity and Other Lighting Fuels/Energy by Expenditure Quintiles (Soles per Month)



Source: INEI, 2005.

less than half of rural households, the majority of rural households are still using kerosene lamps and candles for lighting.

For cooking, fuelwood is the preferred fuel choice for almost all rural households. Households in the Andean South region also use animal dung widely as a cooking fuel. However, LPG is becoming popular as a cooking fuel among higher-income households. Kerosene is used primarily for lamp lighting, but some higher-income households use it as their cooking fuel.

About 39 percent of all rural households have access to grid electricity, ranging from a high of 71 percent in the Coastal South to a low of 18 percent in the Amazon. To substitute for the lack of grid electricity, 11 percent of all households use car batteries to supply electricity, especially in the three Coastal and in the Amazon regions. Due to the cost of batteries and the recharging fee, the majority of car battery users tend to be financially better-off rural households. These households represent a significant unmet demand for grid electricity among households that can certainly afford to pay for the service.

Rural household energy expenditure shows significant variation, varying from 9 to 41 soles from the lowest to highest quintile, and similarly from 17 percent of all expenditures in the lowest quintile to less than 6 percent in the highest quintile. Energy expenditures also vary by region. Households in the Coastal Central and South regions spend about twice as much on energy as do households in the Andean and Amazon regions. However, the share of energy expenditure to total household expenditure is slightly lower in the Coastal regions. The disparity in energy expenditure and relative burden of energy costs are a result of household fuel choices, availability of fuels and energy sources, prices of energy sources, and income levels, all of which vary across regions.

Households with electricity spend only marginally more on grid electricity and electricity substitutes (16.3 soles per month) than households without electricity spend on electricity substitutes alone (15.4 soles per month). In other words, households without electricity are paying comparable amounts for much-lower-quality services. This implies that, on average, households without electricity could afford to pay for monthly electricity service if it were to become available. Households without electricity could reallocate their current expenditures on lighting fuels to an electric bill.

3 Electricity from the Grid

As noted in the Introduction, access to electricity services brings important benefits to rural areas. Lighting with electricity improves the quality of life, extends the time available for productive or leisure activity, and increases the time available for study and learning by students (Barnes 2002). Electricity improves health in homes by reducing indoor pollution associated with lighting from kerosene and lowering the number of burn injuries, especially among children, from fires caused by kerosene lamps and candles. It also improves health in rural communities through the improved efficacy of refrigerated vaccines and the lighting of rural health clinics. Home and community security is enhanced by illumination and the provision of public lighting. Finally, electricity also empowers the rural poor by increasing access to information and communication technologies (ICT). Electricity infrastructure is vital for development, alleviation of poverty, and improvement in the living conditions of rural populations.

Typically, electricity service from the grid is first extended to financially better-off households living in more densely populated rural areas that can afford to connect to the grid and pay for electricity. However, as rural electrification expansion progresses and grid electricity is extended further and further, poorer households eventually gain access to grid electricity. In Peru, grid electricity service has been provided to only 39 percent of rural households, partly because of the difficult geography and topography of the country.

This chapter provides detailed characteristics of electrified rural households. It also provides an assessment on how rural households utilize and benefit from electricity.

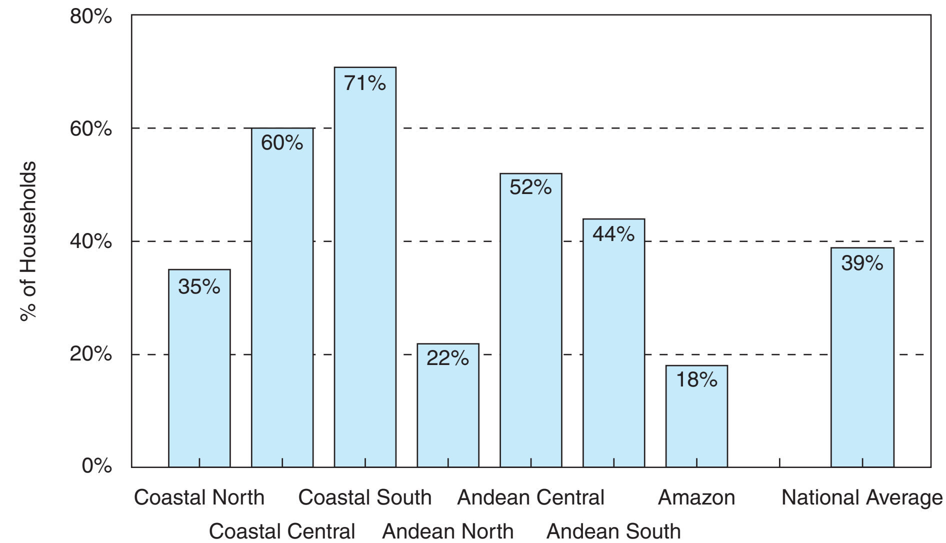
Access to Grid Electricity

Electrification varies significantly across regions. As shown in Figure 3.1, the Andean North and Amazon regions have the lowest rural electrification rates (22 and 18 percent, respectively). The next lowest rate is the Coastal North at 35 percent. In contrast, the more densely populated and more easily accessible Coastal Central and South regions have achieved the highest rural electrification rates, at 60 and 71 percent, respectively.

There is a direct positive relationship between a household's financial well being and access to grid electricity. The vast majority of the poor—measured in terms of total household expenditure—do not have access to grid electricity, while the vast majority of financially better-off households do have access. Access to electricity is strongly correlated with expenditure quintile: only 28 percent of households in the poorest quintile have access to electricity, compared with 49 percent in the top quintile (Figure 3.2). Poverty—measured in terms of low expenditure, low income, and low access to basic services—is a way of life for the majority of rural Peruvians. The lack of access to basic infrastructure services, including electricity, not only exacerbates poverty conditions, but also hampers efforts to alleviate poverty.

Figure 3.1

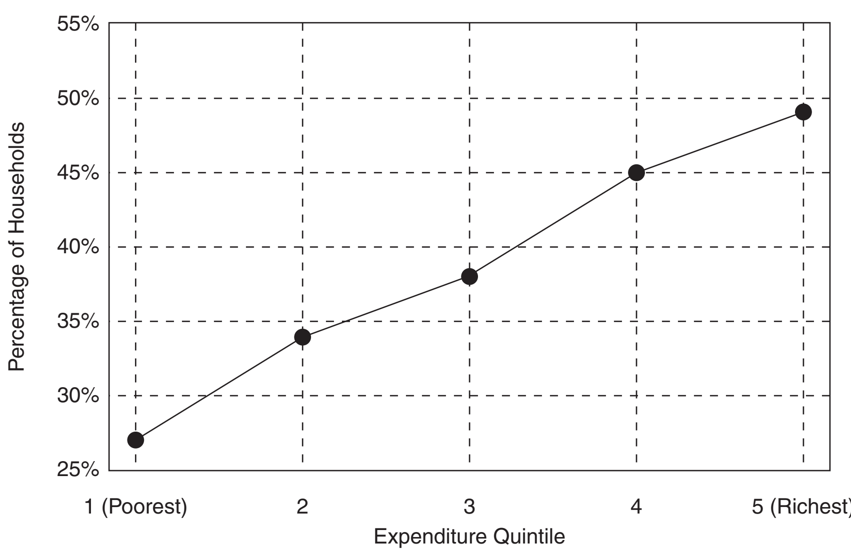
Percentage of Households with Access to Grid Electricity by Region



Source: INEI, 2005.

Figure 3.2

Percentage of Households with Access to Electricity by Expenditure Quintile



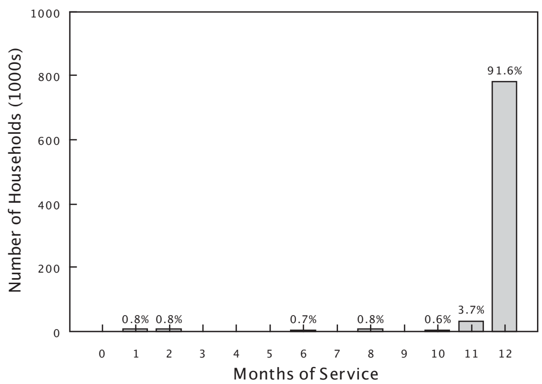
Source: INEI, 2005.

Service Reliability

Two ways of looking at reliability of electricity service are the number of months of service per year and the number of hours of service per day. The first relates to seasonal availability. As shown in Figure 3.3, more than 91.6 percent of households report year-round availability, and a further 3.7 percent report 11 months of service. Around 12,000 households (1.6 percent) experience only one or two months of service per year. Although the question of generation type was not specifically asked in the Survey, it is reasonable to

Figure 3.3

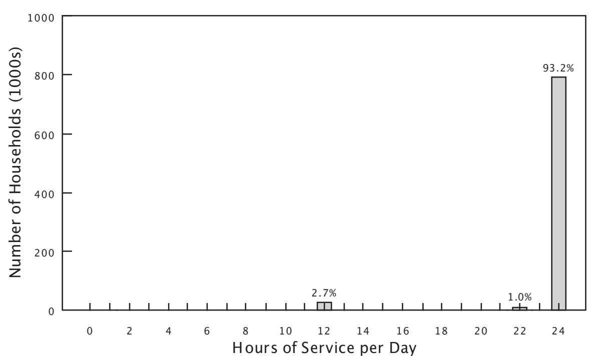
Months of Service per Year



Source: INEI, 2005.

Figure 3.4

Hours of Service per Day



Source: INEI, 2005.

assume that households with service just a few months per year are served by small hydro systems. In terms of hourly service reliability, 93.3 of households reported 24-hour service, and another 2.7 percent reported 12-hour service (Figure 3.4). However, only 80 percent of households reported 24-hour service throughout the year (i.e., 24-hour service in every month)

Overall Electricity Use and Expenditure

In Peru, the interaction of regional factors, income, and price play an important role in determining household electricity usage.[9] Electricity usage among rural households in Peru is relatively low, at an average of 27 kWh per month, compared to other rural households in countries such as Thailand, the Philippines, and Lao PDR. This may be due to several factors, including a high electricity tariff, unavailability of inexpensive electric appliances, and high prevalence of poverty in rural areas.

Electricity usage among rural households varies significantly among regions. As expected, rural households living in the Coastal Regions use significantly more electricity than households living in the Andean and Amazon Regions. Within the three major regions there are further disparities. For instance, electricity usage in the Coastal Central and South Regions is between 54 and 61 percent greater than in the Coastal North region (Table 3.1).

Households with a grid electricity connection spend on average 14 soles per month on electricity. As with the amount of electricity usage, the amount of money spent on electricity varies significantly across regions and expenditure quintiles, reflecting different usage levels as well as prices (Table 3.1 and Table 3.2).

Electricity Tariff by Usage Level

Aside from income and regional disparities that have a direct impact on variation of electricity consumption, electricity tariff structure, and ownership of electric appliances also play important roles in determining the level of consumption. As expected, the average effective electricity price per kWh each household has to pay depends on the level of usage. Larger electricity users that live in the Coastal Central and South regions pay an average of only 0.49 and 0.47 soles per kWh, respectively. By contrast, smaller users, who tend to be poorer customers who live in the Andean regions, pay about 0.60 to 0.80 soles per kWh. The variation of average effective electricity price per kWh is due directly to the tariff structure, which includes a fixed charge, maintenance charge, and public lighting

[9] Of the 3,098 households sampled that reported access to grid electricity, only 977 reported their quantity of electricity used. About half of electrified households in the sample reported only average monthly expenditure, making it possible to calculate usage when average tariff data are known. For the remainder of electrified households in the sample (637 households), neither quantity nor expenditure data are known. Of those 637 households, 274 are served by municipal utilities not regulated by OSINERG, meaning that tariff schedule information is not available.

Table 3.1

Household Electricity Consumption, Expenditure, and Average Effective Price per KWh by Region

	Coastal Regions			Andean Regions				
	North	Central	South	North	Central	South	Amazon	All Regions
kWh used/ month	38.3	61.7	59.1	21.7	26.9	16.7	31.6	27.2
Soles/month on electricity	19.8	27.0	24.7	10.9	13.4	9.4	16.0	13.6
Avg. price/kWh (soles)	0.57	0.49	0.47	0.60	0.62	0.83	0.71	0.67
% kWh used for lighting	28.0	24.0	24.2	43.7	41.1	54.6	38.5	42.9
kWh for lighting per month	7.0	10.4	9.3	6.4	7.7	5.8	6.9	7.1

Source: INEI, 2005.

Table 3.2

Household Electricity Consumption, Expenditure, and Average Effective Price per kWh by Expenditure Quintiles

	1 (Poorest)	2	3	4	5 (Richest)	All
KWh used per month	11.7	14.64	19.96	28.66	48.51	27.19
Spending per month (soles)	7.36	8.54	10.38	14.2	22.52	13.63
Effective price per KWh (soles)	0.83	0.76	0.69	0.62	0.55	0.67

Source: INEI, 2005.

fee that apply to all customers. Although a large number of distribution companies charge a public lighting fee for smaller users (those who consume less than 30 kWh per month), that is lower than for larger users, the overall fixed charges still play a significant role in the retail price of electricity. As a result of fixed charges, the average effective electricity for households that use small amounts of electricity each month is relatively high, even though the overall fixed charges for consumers using less than 30 kWh per month is lower than those using more than 30 kWh per month.

Currently, about 70 percent of households with grid electricity connection use less than 30 kWh per month. These households' average effective electricity price is 0.76 soles per kWh. However, the average effective price per kWh for households that use more than 30 kWh per month is only 0.46 soles per kWh.

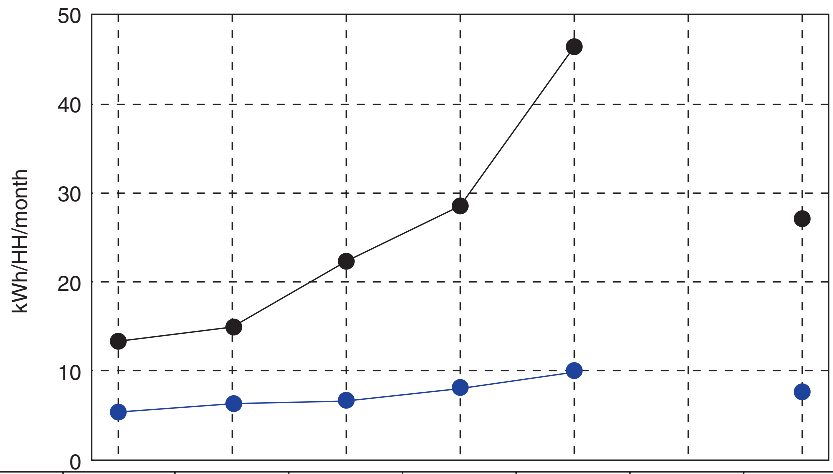
The impact of fixed charges among households that consume small amounts of electricity per month is very large. However, the effect of fixed charges on average effective electricity price becomes smaller and smaller as monthly electricity usage becomes larger. Given the level of monthly electricity usage among rural households in Peru, the impact of fixed charges on average effective electricity price is quite high. For example, the average effective price for a household that uses less than 10 kWh per month is about one sol (1.03 soles) per kWh. However, the impact of fixed charges on average effective price is minimized as consumption reaches 50 kWh per month.

Electricity Usage for Lighting

The proportion of total electricity used for lighting is strongly dependent on expenditure quintile (Figure 3.5). The bottom quintile uses 39 percent of total electricity consumption for lighting, while the top quintile uses only 21 percent. The explanation is simple: As income (expenditure) increases, the ability

Figure 3.5

Lighting versus Total kWh by Quintile



	1 (Poorest)	2	3	4	5 (Richest)		all H H
● lighting	5.1	6.4	6.5	8	9.7		7.7
● total	13.1	14.8	22.2	28.5	46.5		27.1

Source: INEI, 2005.

Table 3.3

Number and Type of Electric Lights Owned by Level of Usage

Usage per Month	Incandescent	Fluorescent	Compact Fluorescent	All Electric Lamp Lighting
≤ 30 kWh/month	2.6	1.9	2.0	3.1
> 30 kWh/month	2.9	2.6	2.6	4.6
All Levels of Usage	2.7	2.2	2.2	3.5

Source: INEI, 2005.

to purchase expensive electric appliances increases, and thus a greater fraction of electricity is used for color TV, sound equipment, and refrigerators.

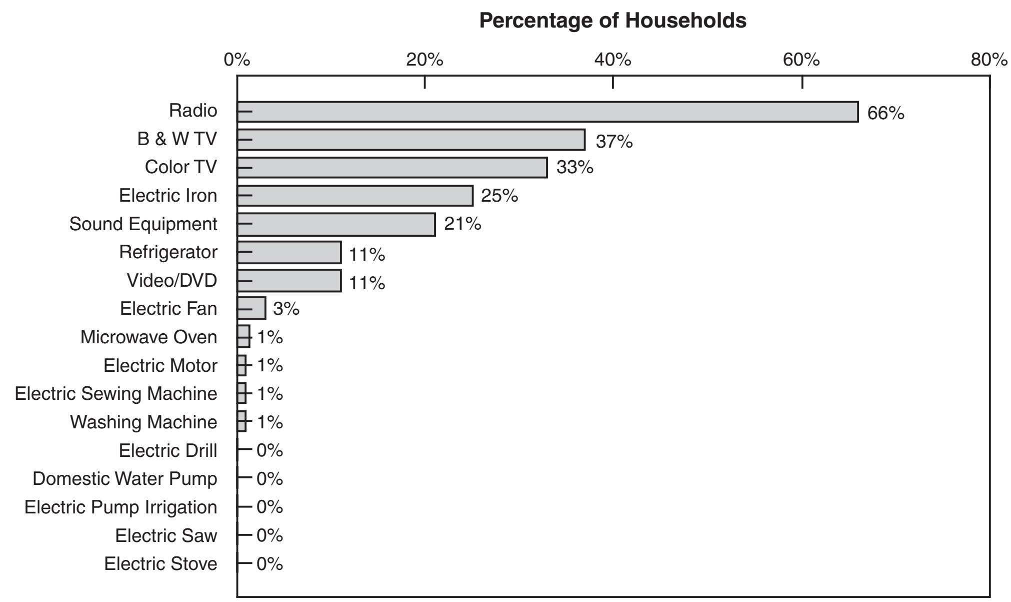
Income differences largely explain the regional variations as well. The Coastal South and Central regions have the highest proportion of upper quintile households. Therefore, the fraction of electricity used for lighting in those regions is lowest. For example, households in the Coastal Central region use 16 percent of their total electricity usage on lighting. In contrast, households in the less prosperous Andean South region use 35 percent.

The median rural household in Peru has three lights. However, this aggregate distribution masks significant differences by lamp types. Although there are a negligible 1,000 or so electrified households that report no lamps at all, the individual distributions reveal that 46 percent of all households with electricity have *no* fluorescent lamps, and therefore have *only* incandescent lamps. However, 23 percent of households have *no* incandescent lamps, and therefore have only the more efficient, but also more expensive, fluorescent lights.

Households that have exclusively fluorescent lights are disproportionately in the upper quintiles, and, not surprisingly, households with only inefficient incandescent lights are disproportionately in the bottom expenditure quintile. On average, households that consume less than 30 kWh of electricity per month have a greater share of incandescent bulbs as a percentage of total lights than households that consume more than 30 kWh (Table 3.3).

Figure 3.6

Appliance Use in Electrified Homes



Source: INEI, 2005.
Note: See Table A.2.43 in Annex 2 for data by region.

Household Appliances

Typical electric appliances used in rural households can be classified in three major categories: (1) radio, television, and other entertainment appliances; (2) refrigerators, fans, and other appliances that can be used for cooking or domestic work; and (3) electric appliances directly used for income-generating activities. The number and type of electric appliances in grid-connected rural households provide a good indication of living standards improvements made possible by electricity.

Figure 3.6 summarizes major appliance use in electrified homes. Radios are by far the most common type of appliance, with 66 percent of electrified households owning one or more. Radios are followed by black-and-white televisions (37 percent of households), color televisions (33 percent), and electric irons (25 percent).

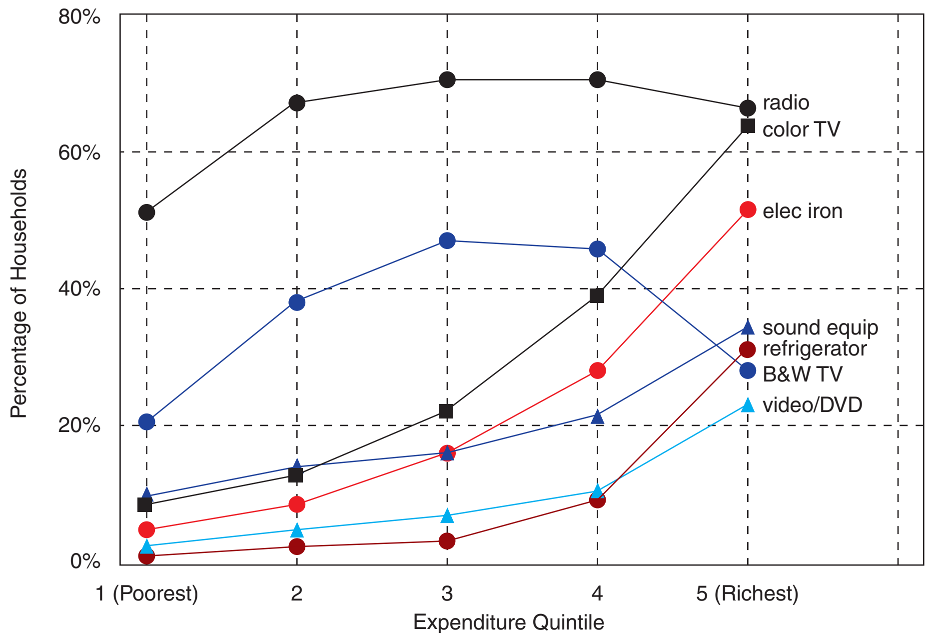
Ownership of almost all types of electrical appliances goes up as household income increases (Figure 3.7). The only exceptions are black and white televisions and radios to some degree, which show drops in ownership between the fourth and fifth quintiles. Black-and-white TVs are clearly replaced by color TVs. Appliance ownership variations by region are in line with regional income disparities (see Table A.2.44 in Annex 2 for the complete data).

Radio and television are two of the most important home appliances for both urban and rural households. For a large portion of rural households in Peru and the rest of the world, radio and television are the only means to gain access to news and information beyond their community. Radio and television are also a key source of entertainment in rural communities.

The Survey reveals that about 15 percent of rural households with electricity have neither plug-in radios nor plug-in television sets at home. Although plug-in radio and television are inexpensive to use, especially in comparison to radio and television powered by dry cell or automobile batteries, these households are unable to take full advantage of grid electricity. Of the households with neither plug-in radios nor TV, more than 60 percent are in the bottom two expenditure quintiles. The Survey also reveals that the vast majority—80 percent—of households without plug-in radio and/or television lives in the Andean and Amazon regions.

Figure 3.7

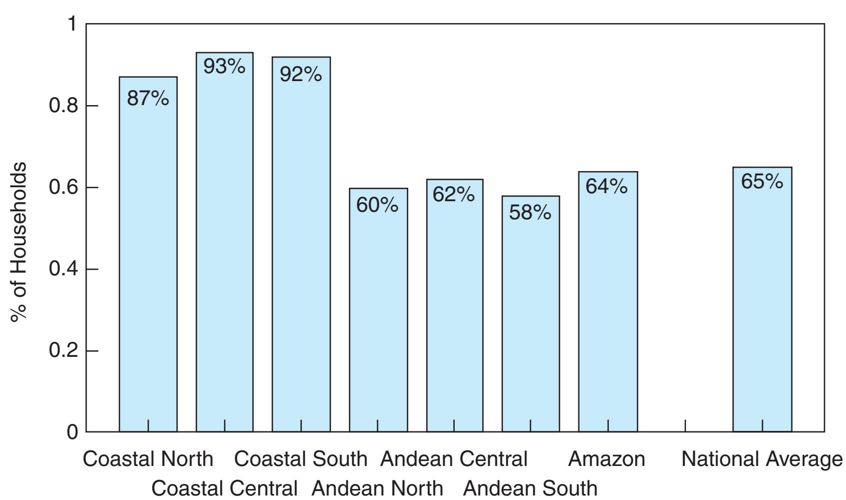
Appliance Ownership in Electrified Homes by Expenditure Quintile



Source: INEI, 2005.

Figure 3.8

Television Ownership in Electrified Households by Region

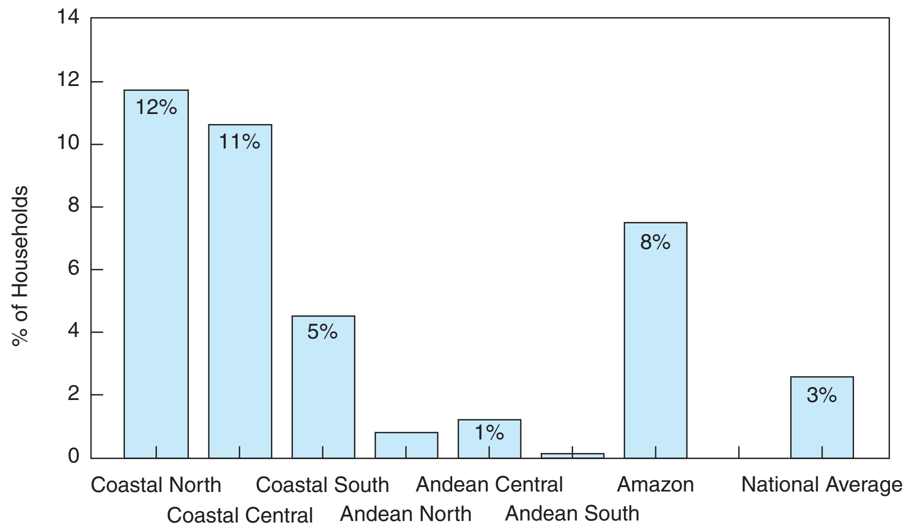


Source: INEI, 2005.

Among rural households with access to grid electricity, 65 percent reported having a television set at home. As seen in Figure 3.7, television—and especially color television—ownership is positively related to financial well being. Television ownership varies widely by region (Figure 3.8). Over 90 percent of households living in the Coastal regions own plug-in television sets, while only about 60 percent of household living in the Andean and Amazon regions own them. The low percentage of television ownership among households in the Andean and Amazon regions is due to both lower incomes and

Figure 3.9

Fan Ownership by Region



Source: INEI, 2005.

poor reception of television signals for households living high in the mountains or deep in the jungle.

Aside from radio and television, many rural households have acquired audio and video (A/V) equipment for entertainment in recent years. This is a result of declining prices as well as the topography of the country, which means that radio and television reception is not possible in many areas. Empirical evidence in other countries, such as the Philippines, Mexico, and Thailand, has also shown that family members who have left home to work in the city or abroad usually bring home electric appliances as gifts. In Peru, the Survey shows that 20 percent of rural households with a grid electricity connection own audio equipment and 11 percent own video/DVD equipment. Audiovideo equipment ownership is positively related to household financial well being (see the sound equipment and Video/DVD lines in Figure 4.4). Furthermore, A/V equipment ownership shows regional variation similar to that of radios and television. A higher proportion of households living in the Coastal regions own such equipment than grid-connected households living in the Andean and Amazon regions.

Other home appliance ownership among grid electricity-connected rural households is relatively low (Figure 3.6). Electric irons and refrigerators are the most prevalent, with 25 percent and 11 percent of rural electrified households owning them respectively. Electric fans are a distant third, with only 2.6 percent of households owning one. Ownership of these home appliances is highly correlated with income. In other words, very few households in the lower expenditure quintiles own any of these home appliances.

Ownership of electric fans varies across regions (Figure 3.9), reflecting climatic differences. In the relatively hot and humid regions, including the Coastal North, Coastal Central, and Amazon regions, fan ownership is significant. In contrast, fan ownership is low or negligible in the Coastal South and Andean regions.

Ownership of all other home appliances, including stoves, microwave ovens, washing machines, and domestic water pumps, is minimal. The ownership for each appliance is less than 1 percent. Ownership of electric appliances used for income-generating activities is also small: less than 1 percent of households with grid electricity own any of these appliances.

Conclusions

Electrification varies significantly across regions. As shown in Figure 3.1, the Andean North and Amazon regions have the lowest rural electrification rates

(22 and 18 percent respectively). The next lowest rate is the Coastal North at 35 percent. In contrast, the more densely populated and more easily accessible Coastal Central and South regions have achieved the highest rural electrification rates, at 60 and 71 percent, respectively.

Access to electricity is strongly correlated with expenditure quintile: only 28 percent of households in the poorest quintile have access to electricity, compared with 49 percent in the top quintile. Poverty—measured in terms of low expenditure, low income, and low access to basic services—is a way of life for the majority of rural Peruvians. The lack of access to basic infrastructure services, including electricity, not only exacerbates poverty conditions, but also hampers efforts to alleviate poverty.

Over 91 percent of households report year-round availability, and a further 4 percent report 11 months service. Around 12,000 households (1.6 percent) experience only 1 or 2 months service per year (presumably from isolated hydro systems). In terms of hourly service reliability, 93 of households reported 24-hour service, and another 3 percent reported 12-hour service. However, only 80 percent of households reported 24-hour service throughout the year (i.e., 24 hour service in every month).

An estimated 46 percent of all households with electricity have *no* fluorescent lamps, and therefore have *only incandescent lamps.* By contrast, 23 percent of households have *no* incandescent lamps, and therefore have only the more efficient, but also more expensive, fluorescent lights. Households that have exclusively fluorescent lights are disproportionately in the upper quintiles; and, not surprisingly, households with only inefficient incandescent lights are disproportionately in the bottom expenditure quintile.

Radios are the most common appliance used, with 66 percent of all households using radios. About 65 percent of households with grid electricity service reported having a television set at home. Over 90 percent of households living in the Coastal regions own plug-in television sets, while only about 60 percent of households living in the Andean and Amazon regions own plug-in television sets. The low percentage of television ownership among households in the Andean and Amazon regions is due to both lower incomes and poor reception of television signals for households living high in the mountains or deep in the jungle. Radios and TVs are followed by electric irons (25 percent), sound equipment (20 percent), refrigerators (11 percent), and video/DVDs (11 percent). Use of other equipment is negligible.

The Survey showed that electricity consumption of rural households in Peru is relatively low at 27 kWh/month (ranging from 17 kWh is the Andean South to 61.7 kWh in the Coastal Central region). However, the price of rural electricity is high, averaging 13.6 soles per kWh (ranging from 16 soles per kWh in the Andean South to 25 soles per kWh in the Coastal Central region). There is a strong association between level of usage and household financial well being as measured by total household cash expenditure. The application of electricity varies strongly with income: for example, 39 percent of kilowatt-hours consumed in the poorest expenditure quintile are for lighting, as opposed to only 21 percent in the richest quintile. Eight percent of the poorest electrified households have color TVs, as opposed to 64 percent in the richest quintile.

Because of the role of fixed charges in the pricing structure, the effective price paid by lower-level electricity users is quite high: Consumers using 15 kWh per month typically pay about 0.7 soles per kWh, as opposed to 0.5 soles per kWh when consumption is 50 kWh/month. While this does (to some extent) reflect the actual cost of providing service to small consumers, it raises the more general question of the targeting performance of the FOSE, the main mechanism for providing cross-subsidies to poor rural consumers. This is examined in more detail in Chapter 6.

4 Off-Grid Electricity

People often assume that households without access to the electricity service from the grid do not use electricity. This is not the case. The electricity may cost them more and they may use less of it, but almost all households have some form of off-grid electricity use. The use of car batteries for powering televisions and lights is one common way to obtain off-grid electricity. There is also the ever-present use of small batteries for flashlights and radios. This is evidence of a pent-up consumer demand for electricity and an indication that people are willing to pay high prices for small amounts of it. Most common calculations for the price per kilowatt hour (kWh) of a D-cell battery show that the price is about US$50–60 per kWh, and it is even higher in remote areas of Peru. Thus, the use of electricity even in small quantities is an indication of the value that household place on having some form of electricity.

The main types of off-grid electricity used in rural Peru are car and dry cell batteries. In addition, a small number of people use generators and solar home systems. Car batteries in particular are a significant energy source for areas without grid service that are near enough to the grid to enable users to charge the batteries within a short distance. An estimated 18 percent of all households that do not have grid electricity (approximately 240,000 households) use batteries as their main source of electricity. Both households with and without electricity use dry cell batteries, but the use is more prevalent in households without grid electricity. This chapter examines the alternatives for households in rural Peru that do not have access to electricity from the national or local grids.

Car Batteries

Close to one-fifth of the households in rural Peru without electricity use car batteries for televisions and lights. This is an important indication of the very high value of electricity for people in rural areas. The work and expense involved in charging car batteries is not trivial. The batteries have to be transported either to an area with grid electricity for charging or to the place of business of someone with a generator. Such batteries are heavy and have corrosive chemicals in them. This section profiles the use of car batteries followed by the cost. Car battery use by rural households is an indication of demand for electricity in areas without grid electricity, and this is a first step for estimating the benefits of grid electrification explored in a subsequent chapter.

Car batteries are quite common in rural Peru, especially in the Coastal regions where as many as one-half of households without electricity use them (Table 4.1). Incomes are comparatively high in the rural areas surrounding Lima, and car battery recharging is relatively easy due to the presence of good roads. The two other Coastal regions also have very high levels of car battery use in households without electricity—47 percent in the North and 37 percent in the South. In the Amazon, about 18 percent of households use car batteries, while in the Andean regions, usage levels among households without electricity range from 11 to 16 percent. Even some households with electricity from the grid have car batteries. We presume they are used primarily in case of grid supply brownouts or blackouts. Again, this reflects consumers' willingness to pay high costs to maintain a high level of service. Such redundant systems are fairly expensive.

Table 4.1

Use of Car Batteries (% of Households)

	Electrified	Unelectrified	All
Coastal North	0.3	47.3	30.8
Coastal Central	0.2	56.4	22.5
Coastal South	3.5	37.2	13.4
Andean North	1.0	11.7	9.4
Andean Central	0.4	16.2	7.9
Andean South	0.8	11.1	6.5
Amazon	1.5	17.7	14.7
All	0.7	17.8	11.2

Source: INEI, 2005.

Note: Based on households that reported use of car batteries during the last month. All national averages are weighted to reflect the number of households in each region.

The regions with the lowest absolute numbers of car batteries have the highest percentage of off-grid households using them. The Coastal South and Central regions have high grid electrification rates, and a high percentage of off-grid households using car batteries for electricity supply. This is likely to be an income and perhaps a demonstration effect, as people see the benefits of using electricity in nearby communities.

The main barriers to the use of car batteries are that they are expensive, bulky, and difficult to transport. The cost can be broken into three components. First is the cost of battery charging, which averages 5.2 soles per kilowatt-hour (kWh). Second is the cost of transportation to the charging station, which in many cases exceeds the charging fee itself (e.g., in the Andean and Amazon regions) and averages 7.1 soles/month, or 5.8 S/kWh. Third is the battery amortization cost (obtained by dividing the purchase price by the number of months of battery life), which averages 10.2 S/kWh. Total cost per kWh is therefore estimated at 21.2 S/kWh.

There are wide variations in battery amortization costs, in part due to the way in which car batteries are used in rural areas. A car battery is designed for constant recharging while in use. However, the use of a car battery to supply electricity at home means that many households use the battery until it runs out of energy completely.[10] This practice shortens the battery life to less than the technical specifications suggest: The average service life of batteries is around 20 months.

Battery costs vary across the expenditure quintiles (Table 4.2), with the poor paying higher prices per kilowatt-hour than the more wealthy households. The poorest quintile seems to purchase batteries of significantly lower capacity, while paying similar prices as the richer quintiles do for better batteries. Monthly battery amortization cost is inversely proportional to battery capacity, reflecting the advantage of buying higher-capacity batteries (also reflected in the higher number of lifetime recharges in the higher-capacity batteries). As a consequence, the poor pay about double the amount of money per kWh from car batteries compared to more well-off households. However, as indicated, the cost of the battery itself for the poorer households is similar, which means that they may not have good access to quality suppliers.

Table 4.2 shows the relationship between Watt-hours consumed, and effective price paid for recharging and transportation for each expenditure quintile. (Note that this calculation excludes amortization costs, which are roughly at about 10 soles per kWh.)

Thus, as might be expected, the poor consume the least energy and pay the most per kWh. Their effective kWh use is close to 1 kWh per month from car batteries compared to over 1.5 kWh for more well-to-do households. This analysis explains why car battery use plummets to almost zero when grid electricity is introduced into a community. The use of car batteries is more than 10 to 20 times more expensive than electricity from the grid system. Clearly, there is a high willingness to pay for electricity services in Peru, at least among the close to one-fifth of off-grid households that are using car batteries.

[10] The calculations of kWh provided each month, as used in Table 3.10 to derive costs per kWh, is based on this assumption (and derived by volts × amp-hr = Wh per charge × number of recharges per month). If the battery is not fully drawn down before recharging, then the monthly kWh would be larger than that assumed, making the actual cost of car battery use in terms of soles/kWh even higher.

Table 4.2

Car-Battery Statistics by Expenditure Quintile

Quintile	Battery Cost (Soles)	Battery Capacity (amp-hours)	Effective Monthly Energy (kWh/Month)	Lifetime Recharges	Monthly Battery Cost (S/Month)	Average Operating Cost per kWh (Soles/kWh)
1 (Poorest)	121	48.7	0.9	33.7	11.4	12.7
2	123	58.9	1.1	33.0	9.3	8.5
3	123	60.8	1.4	41.5	9.0	6.4
4	122	62.2	1.6	44.2	9.9	6.2
5 (Richest)	124	59.8	1.7	46.3	8.5	5.0
All Households	123	59.4	1.4	42.0	9.4	6.7

Source: INEI, 2005.

Dry Cell Batteries

Dry cell batteries are commonly used for specific purposes in both grid and off-grid households in rural areas. Often, such batteries fulfill an energy niche that cannot be entirely met though the use of grid electricity. Flashlights and radios can be carried both inside and outside of the house, something that is impractical for grid electricity. However, it is also evident that households with grid electricity are less reliant on batteries for their electricity needs as households without access to it. As a consequence, they save having to pay for what is a very expensive form of energy.

The main uses of batteries are for flashlights and radios. As can be seen in Table 4.3., over one-half of rural households have flashlights and radios. The use of these appliances is quite important to rural households, even though their operation is fairly expensive. Dry cell batteries, although the most expensive way of providing electricity from nongrid sources, are used by 74 percent of all households for highly valued appliances such as radios and flashlights.[11] Table 4.4 provides a breakdown of dry cell battery costs. Not surprisingly, the costs per kWh decrease inversely with battery size, going from US$890 per kWh for AAA batteries to US$80 per kWh for D batteries.

Table 4.3

Uses of Dry Cell Batteries (% of Users Only)

Income Quintile	1	2	3	4	5
Clock	2%	4%	4%	6%	10%
Flashlight	46%	61%	61%	53%	66%
Radio	46%	61%	60%	54%	53%

Source: INEI, 2005.

Despite very high costs compared to other electricity sources, dry cells continue to be used by households with electricity. Fifty-five percent of households with electricity report use of dry cell batteries, as opposed to 86 percent of households without electricity (Figure 4.1). This difference is consistent across expenditure quintiles. It is clear from the figure that the percentage of households using dry cells in the poorest quintile is substantially less than in the other quintiles, but still remains quite high.

The general pattern is for households with higher incomes to use a larger number of batteries, and therefore more watt-hours of electricity. In Figure 4.2, the watt-hours (Wh) consumption per month for households with and without electricity increases with the income of the household. However, those households without electricity

[11] The Survey does not record the devices used with AA and AAA batteries, but radio is likely the predominant use.

Table 4.4

Dry Cell Battery Costs

	Unit	AAA	AA	C	D
MilliAmpere Hour[1]	mAh	1,250	2,850	8,350	20,500
Watt-Hours at Nominal 1.5 Volts[1]	Watt-hour	1.9	4.3	12.5	30.8
Watt-Hour at Actual[2]	Watt-hour	1.4	3.2	9.4	23.1
Typical U.S. Cost	$US/battery	1.25	1.00	1.60	1.80
Typical U.S. Cost per kWh	$/kWh	890	310	170	80

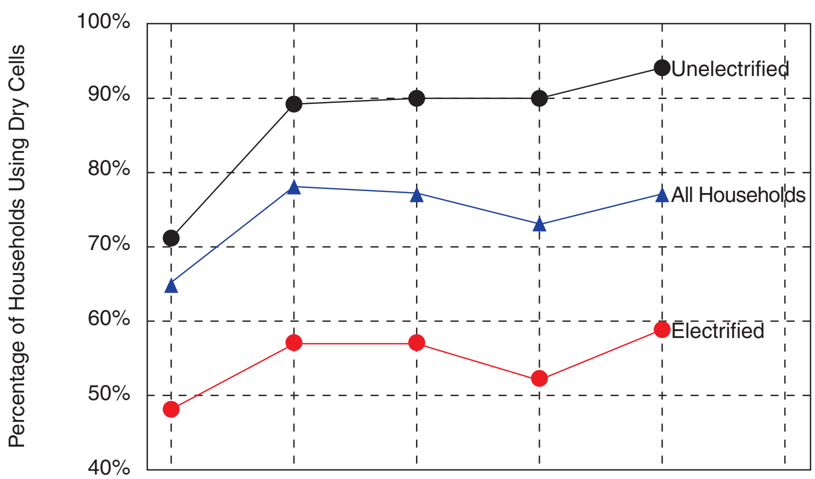
Source: INEI, 2005.

(1) From Energizer battery Web site, www.energizer.com (high-quality alkaline batteries).

(2) Actual Watt-hours likely in practice, given fall in voltage over time.

Figure 4.1

Percentage of Households Reporting Use of Dry Cells



	1 (Poorest)	2	3	4	5 (Richest)	
● Electrified	48%	57%	57%	52%	59%	
● Unelectrified	71%	89%	90%	90%	94%	
▲ All HH	65%	78%	77%	73%	77%	

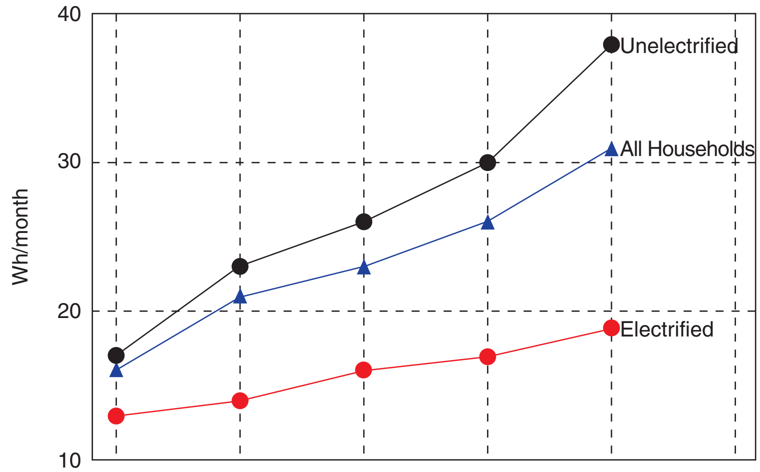
Source: INEI, 2005.

actually consume an increasing amount of batteries. In the highest-expenditure quintile, monthly Watt-hours in dry cells decreases by half, from 38 Wh/month to 19Wh/month, once a household has received electricity service from the grid. In the poorest quintile, it decreases by much less, from 17Wh/month to 13 Wh/month.

The use of dry cell batteries in Peru is pervasive. Households without electricity pay about 6 soles per month on dry cell batteries, compared to 3 soles per month for households with electricity. Thus, grid electricity does, to a degree, reduce expenditures on batteries. In a later section, we will use the consumer surplus method to estimate the lighting and radio use benefits of electrification, based on both the extent of use and the price of the service. The evidence is strong that dry cell batteries are a significant expenditure for rural households.

Figure 4.2

Dry Cell Watt-Hour Consumption by Expenditure Quintile



	1 (Poorest)	2	3	4	5 (Richest)	
● Electrified	13	14	16	17	19	
● Unelectrified	17	23	26	30	38	
▲ All HH	16	21	23	26	31	

Source: INEI, 2005.

Small Generators

Small generators in rural Peru are uncommon. As indicated in the previous sections, the main alternatives to grid electrification for electricity involve a variety of different energy sources such as kerosene, candles, or batteries. Although they are not common, it is worthwhile to examine those households that do use generators in rural Peru.

Overall, 0.6 percent of rural households, or an estimated 13,100 households, use small gasoline or diesel generators. In most regions, the generators are used by households without electricity as an alternative to grid supply. However, in the Amazon region, the result is the opposite: A greater proportion of households with small generators also have electricity service than do not have service. This is likely a result of the lack of electricity service reliability, which is much lower in the Amazon than in other regions. In the Amazon region, rural electricity service is unreliable: Only 58 percent of rural households have 24-hour service 12 months a year, compared to 90 percent in the Coastal regions, and 80 percent nationwide.

For those who obtain access to small generator-electricity from a third party (neighbor, relative, etc.), only 16 sampled households provided cost information. Twelve of the households, all in Canchabamba, reported paying 10 soles per month, while the other 4 households reported monthly fees ranging from 21 to 80 soles per month.

For small generator *owners*, there are cost data for only 23 of the surveyed households (representing 6,537 households when weighted). As shown in Table 4.5, owners report generator costs averaging around 1,919 soles (US$610), and gasoline operating hours appear to be somewhat higher than diesel operating hours (average diesel price reported is about 10.4 soles/U.S. gallon, and that for gasoline 11.6 soles/U.S. gallon).

Given the low number of sampled households with small generators, the data do not permit reliable reporting at the regional level. However, an indicative calculation for small generator costs at the national level can be made. Small diesel generators consume around 3 gallons (11.5 liters) per month and gasoline generators about 5 gallons (19 liters) per month. A typical small 2.6KW Honda domestic generator

Table 4.5

Small Generator Users, Cost Data

	Owned Small Generator Cost (Soles)	Diesel Fuel Cost (Soles/Month)	Gasoline Fuel Cost (Soles/Month)(1)	Maintenance and Repair Cost (Soles/Month)
Coastal North	2,375	17	78	12
Coastal Central	1,716	44	59	
Coastal South				
Andean North				
Andean Central				
Andean South	928		18	3
Amazon	2,140	25	60	
All	1,919	29	53	7

Source: INEI, 2005.

(1) Average cost of gasoline generators = 1,703 soles

Table 4.6

Percentage of Households that Use Solar PV Systems by Electrification Status and Expenditure Quintile

	< 113.25 S/month	113.26–201.00 S/month	201.01–321.13 S/month	321.14–533.22 S/month	> 533.22 S/month	All
With access to grid electricity	0	0	0	0	0.1%	0.0%
Without access to grid electricity	0.3%	0.1%	0.8%	0.4%	2.9%	0.8%

Source: INEI, 2005.

consumes about 1.2 liters/kWh, so 19 liters generates 15.8kWh/month, or 190kWh/year. Assuming a 10-year life and no maintenance costs, the capital cost (at a 12 percent discount rate) is 301 soles/year, or S1.58/kWh. The cost of fuel is 3.06 soles/liter, or 3.68 soles/kWh, for a total of 5.26 soles/kWh. This is 10 times the typical cost of grid electricity.

The estimated cost of using a generator is much lower than the cost of using a car battery, and it would give far better service levels. It is likely that a significant barrier to the adoption of generators is their high upfront costs, which are 10 to 15 times higher than purchasing a car battery. Also, in other countries, generators are used mainly by families that either have a business or can provide electricity to a small shop to help pay for the operation of the system.

Solar Home Systems

Solar photovoltaic (PV) systems represent an option for providing electricity to households in remote rural areas, where the costs of grid extension are particularly high. For whatever reason, the use of solar systems is quite rare in rural Peru. Most of the households that would use a solar PV system now use car batteries.

Solar systems are estimated to be present in 0.8 percent of all households, or about 16,700 rural households. Of this total, 13,345 are in households without electricity service from the grid, while 3,373, or 20.2 percent of the total, are in households with electricity service from the grid. As shown in Table 4.6, almost all solar systems are in households in the top expenditure quintile. Solar home systems are concentrated in the Andean Central, Andean South, and Amazon regions.

Of the 42 households sampled reporting PV systems, only 22 households reported use in the previous month. Of the 20 systems not used, 14 of the households have grid access. Since only four of the systems were reported to be installed before the year 2000, this indicates that the programs installing the systems did not target well to ensure that the solar home systems were destined for areas that would not be connected to the grid. Five systems appear to be out of service since the households have no grid access and report no use in the previous month. Three of the systems in use were more than 12 years old, and the oldest was installed in 1982. The four systems reported to be installed before 2000 were still in use, including the one installed in 1982. In terms of appliance use, most of the systems are used for lighting and communications, especially radio and black and white TV, while no uses for color TVs or VCRs were reported. Only one of the systems operated during the last month also had grid access.

Conclusions

The main types of off-grid electricity used in rural Peru are car and dry cell batteries. In addition, a small number of people use generators and solar home systems. An estimated 18 percent of all households that do not have grid electricity are using batteries as their main source of electricity, and this amounts to approximately 240,000 households. More than half of households without electricity in the Coastal Central region use car batteries. Incomes are comparatively high in the rural areas surrounding Lima, and car battery recharging would be relatively easy due to the presence of good roads. The two other Coastal regions also have very high levels of car battery use in households without electricity—47 percent in the North and 37 percent in the South. In the Amazon, about 18 percent of households use car batteries, while in the Andean regions, usage levels among households without electricity range from 11 to 16 percent. Costs are high, estimated at 5 to 13 soles per kWh for operation, plus 10 soles per kWh for amortization of the battery.

Both households with and without electricity use dry cell batteries, but their use is more prevalent in households without grid electricity. Less than 1 percent of all households have either a generator or a solar home system, and these are mainly concentrated in households with higher incomes.

The off-grid use of electricity in rural Peru is both pervasive and expensive. A significant proportion of households that are not receiving electricity from the grid consume electricity that is available from other energy sources, such as car batteries, small generators, solar home systems, and dry cell batteries. Such electricity is generally of lesser quantity and poorer quality than that available from the grid, and has much higher cost per energy unit. The common use of this rather expensive electricity by households with no connection to the grid is an indication that they place a high value on the services provided by electricity. This is a testament to the strong desire for electricity in rural Peru due to the benefits it can bring to rural households. In the next section, the benefits of grid electricity are quantified.

5 Benefits of Rural Electrification

The benefits of rural electrification are well recognized. However, there are few empirical studies that provide a firm economic *quantification* of these benefits, particularly in rural areas. In part, this is because of the difficulties of quantifying benefits that may take decades to be realized—as in the case of improved educational outcomes from better study habits or improved income generation opportunities. Long-term outcomes are further blurred by migration from rural to urban areas. Difficulties in quantifying benefits are also due to the intrinsic difficulty of quantifying health and safety benefits, such as measuring the benefits of avoided burn injuries to children. Gathering reliable information in remote areas through household surveys also presents challenges. If establishing reliable estimates of household and energy *expenditures* is difficult where there is at least the common basis of money, establishing quantitative estimates of the diversity of services provided by electricity, such as lighting, television viewing, and refrigeration, is more difficult still.

In this chapter, we examine the benefits of providing electricity to people in rural areas. This is not a trivial task, and it involves both understanding demand behavior and making some assumptions about how households without grid electricity will change their behavior once they have access to it. Implicit in this work is that electricity is valued not in and of itself, but rather, for the services that are provided. In some cases, these services already are provided though the use of other fuels. Candles and kerosene are used for lighting before households gain access to electricity. In other cases, there are new uses that are just not possible without electricity. Fortunately, we have evidence from households that already have electricity concerning how they use it and how much they are paying for these services, so comparisons become possible.

Background on Rural Electrification Benefit Estimation

The goal of determining the benefits of projects is hampered by the fact that "benefit" has no natural measure. Psychologists, sociologists, and economists may imagine a measure, such as the "value" or "utility." Yet, no physical meter or device can measure the increased value or utility enjoyed by individuals and households that results from the significant change in lifestyle that occurs once grid electricity is delivered into a home.

The benefits of electricity consumption can be broken into two categories: direct and indirect. Direct benefits include improvements to lighting and television viewing. Indirect benefits include improved educational outcomes for children in homes with electricity and improved income-generation opportunities. Most of the quantitative work described in the literature relates to estimating the *direct* benefits, and most of this section is devoted to assessing these direct benefits using techniques that have been increasingly used in similar studies in other countries. However, there is evidence that some of the direct benefits, such as improved lighting give rise to indirect benefits, such as improved education or school attendance. Thus, even though measuring and quantifying indirect benefits may be problematic, some of them may be embedded in some of the direct benefits measured. As an example, lighting may allow children to read in the evening and parents may then see a long-term benefit of sending their children to school because they will perform better.

There are two basic approaches for estimating the *direct* economic benefits of rural electrification. The first—which is well-established in the applied economics literature—is to set benefits equal to the avoided costs of the various devices that are replaced by electrification, including kerosene, diesel generation for auto battery charging, candles, and dry cells batteries. This *avoided cost* method is easily applied because it needs only expenditure information. It also has the advantage that the estimates of benefits are empirical and demonstrable. For example, if electricity displaces a certain amount of kerosene and candles, then it is reasonable to assume that the monetary benefits of electrification will be *at least* equal to those avoided costs.

The avoided cost method generally *under*estimates the actual benefits, for two reasons. The first is that the *quality* of service from electrification is far superior to that from most alternative devices: The illumination derived from a compact fluorescent lamp is far superior to that provided by candles or kerosene lamps. Moreover, electric lighting eliminates many harmful side effects, such as smoke, odor, and the risk of fire and injury. Individuals are prepared to pay more for high-quality service, which is to say that they value a given number of lumens from an electric bulb much more than the equivalent number of lumens from candles and kerosene. For this reason, the benefits are greater than those that may be inferred from replacement costs alone.

The second reason why benefits can be underestimated is that it is well established that individuals are prepared to pay very high prices for the first few kWh of electricity (or lumens). The evidence is that people commonly use kerosene and dry cell batteries with a very high cost per kilolumen hour. They are also prepared to pay high prices for enough electricity to power a small television. But the amount they are prepared to pay, for example, for the tenth and eleventh compact fluorescent lamp (CFL) will be much less than that which they are willing to pay for the first and second CFL. This demand curve—the representation of quantity demanded as a function of price—is therefore downward sloping, and the total benefits from some level of consumption is given by the area under the demand curve (to that level of consumption).

To circumvent the underestimation problem of the "avoided cost" method, another direct benefit calculation method can be used that involves estimating a demand curve. However, this is generally difficult because few actual data points may be available to accurately determine the *shape* of the curve. In many cases, there are only two points: one of which corresponds to the quantity consumed and price paid by households with electricity, and the other for the quantity/price combination of households without electricity. Despite the additional uncertainty, this method of estimating the demand curve and the formalization of willingness to pay is generally accepted as a more realistic measure of the benefits of electrification than the avoided costs method and has been widely adopted.

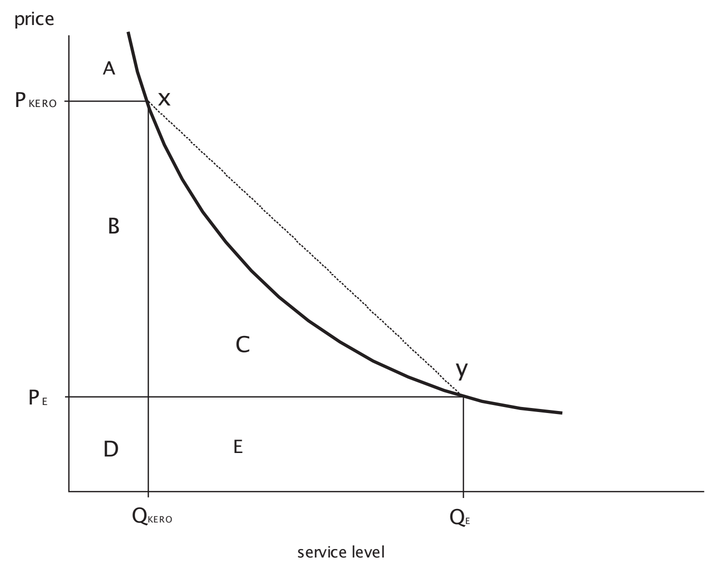
Economic theory holds that the total benefit of consuming a given quantity of a good at a given price is equal to the area under the demand curve. Such a demand curve is illustrated in Figure 5.1 for the case of lighting: For the purpose of this illustrative example, it is assumed that lighting in households without electricity is provided by kerosene lamps only, and is represented by the point x on the demand curve. The quantity of service consumed is therefore Q_{KERO}, at the price P_{KERO}. Thus, the total household expenditure on lighting is $Q_{KERO} \times P_{KERO}$, equal to the area $B + D$.

The total willingness to pay (WTP) for the service at level Q_{KERO} is the total area under the demand curve to that level of consumption (i.e., areas $A + B + D$). This is the total *benefit* to the consumer. However, the *cost* is area $B + D$, and therefore the *net benefit* of consuming Q_{KERO}, also called the *consumer surplus*, is the difference between the two, namely, the area A.

After electrification, the level of service (in the case of lighting, the number of lumen-hours) typically increases substantially and is represented by the point **y**. Consumption therefore increases from Q_{KERO} to Q_E, but the price paid for the electricity service also falls (typically) from P_{KERO} to P_E. Now the household's expenditure for electricity is $P_E \times Q_E$, equal to the area $D + E$. At this level of consumption, the total area under the demand curve to Q_E (i.e., the total benefit), is now the area $A + B + C + D + E$. Therefore, the net benefit, or consumer surplus, after subtracting the cost $D + E$, is $A + B + C$. Thus, it follows that the

Figure 5.1

Demand Curve for Lighting (Theoretical)



Source: INEI, 2005.

net economic benefit of electrification is the *increase* in consumer surplus, which is the area ***B*** + ***C***.

Areas ***B***, ***D***, and ***E*** are readily calculated from knowledge of consumption before and after electrification, from the household budget for kerosene (and battery charging), and from electricity tariffs. In other words, given knowledge of the two points on the demand curve, ***x*** and ***y***, the areas ***B***, ***D***, and ***E*** are immediately calculable. Area ***C*** is more difficult to estimate, since it requires knowledge of the *shape* of the demand curve between points ***x*** and ***y***. The most convenient assumption is that the demand curve is linear. However, as shown next in the case of the demand for lighting, for which several points on the curve are available (each representing different steps in the lighting ladder), the shape is concave.

This approach of estimating changes in welfare by consumer surplus has a number of issues and limitations that are rarely acknowledged, and needs to be applied with some caution. Consumer surplus is an approximation of real benefit increase that lies somewhere between the area under the demand as measured by old prices and benefit increases associated with new prices. One must recognize that the demand curve shifts outward with increases in income. For most so-called *normal* goods at a given price, higher income would mean an increase in demand. However, in the case of an *inferior* good, consumption *decreases* with increase of income.[12] It will be seen later in this chapter that radio listening decreases when households with electricity start using television. But for lighting, it is possible to estimate the benefits by calculating the increase in consumer surplus from the relevant demand curve.

Thus, the methodology requires estimates of the cost and quantity of a service before and after electrification, described in the following sections for a number of the important services provided by electricity—lighting, television-viewing, radio, and refrigeration.

Measuring the Benefits of Better Lighting

Ideally, to measure the benefits of electrification, one would collect data on lighting utilization

[12] These limitations are discussed further in Annex 3.

(and corresponding expenditure data) for a set of households prior to grid connection and compare this with electric lighting utilization (and expenditure data) of the *same* set of households *after* the households have been connected to the grid. Unfortunately, collecting such time-series data is time-consuming and expensive, and is simply not practicable for large numbers of households. Instead, the standard approach is to simplify data collection through a *cross-sectional* survey of a randomly selected set of households with and without electricity.

The underlying behavioral assumption is that, once connected to the grid, the households currently without electricity will utilize it in a manner analogous to those households currently with electricity—all other things equal (such as income). The Peru Survey was designed to measure the amount of light purchased through various sources of energy. As indicated, households in rural Peru light their homes with candles, kerosene, batteries, and electricity. Households use various types of lamps to change the energy in fuel to light. Lamps have varying efficiencies in converting energy into light, which is measured in lumens. For instance, kerosene lamps are very inefficient in producing light. Electric lamps, by contrast, provide as much as 100 times more lighting than a kerosene lamp.

By asking households how many hours they used these various types of electric and nonelectric lamps per day, we are able to estimate the total lumen-hours of lighting that a households uses from the different sources (candles, wick lamps, etc.). In this way it is possible to compare the level and cost of lighting in households that rely on various types of energy sources. The vast majority of rural households without access to grid electricity rely on candles and kerosene for lighting. Small numbers of households also use car batteries, LPG, solar PV home systems, and small generators.

Understanding the assumptions of the lighting estimates employed in this analysis is important. As indicated, the quantity of lighting is most commonly measured by the lumen-flux, the measure of light intensity. As shown in Table 5.1 a 10-watt incandescent bulb provides 50 lumens, so 1 hour of use requires 10 watt-hours of electricity and provides 50 lumen-hours of light. In contrast, a 10-watt compact fluorescent lamp provides 600 lumens, and a simple kerosene wick lamp provides about 10 lumens of light.

Survey questions establish the inventory of lights present in a home (number and wattage), and typically ask how much each device was used over the last 24 hours. Analogous calculations are made for homes without electricity. For example, in the case of candles, one establishes how many candles were bought (used) over the last month. Using the

Table 5.1

Lumen Output for Lighting Devices

Type of Lighting	Lumen-Flux (lm)
Incandescent lamp	
10 watts	50
15 watts	100
25 watts	230
50 watts	580
75 watts	1,080
100 watts	1,280
Fluorescent lamp	
10 watts (straight)	600
20 watts (straight)	1,200
40 watts (straight)	1,613
22 watts (circular)	1,480
32 watts (circular)	1,506
Compact fluorescent lamp	
10 watts	600
12 watts	1,200
18 watts	1,613
20 watts	1,480
25 watts	1,506
Kerosene lamp	
1 kerosene simple wick lamp	11.4
1 hurricane lantern	32.4
1 pressurized kerosene lamp (Petromax)	2,040
Candle	
1 candle weight 30–50 gram	
Candle use 0.5 kg.	1 kilolumen hour

Source: The Netherlands Energy Research Foundation (ECN), Rural Lighting Services: A Comparison of Lamps for Domestic Lighting in Developing Countries, ECN-CX—98-032, July 1998.

Table 5.2

Lighting Ownership and Hours of Utilization by Households (Unweighted)

	Number of Electric Lamps for Lighting	Average Number of Hours per Day Used	Number of Survey Households Using Lamp
HH without Grid Access			
Candle	NA	2.05	2,195
Kerosene			
Single wick kerosene	1.7	3.36	1,616
Hurricane wick kerosene	1.5	4.27	1,306
Pressurized kerosene	1.17	2.04	109
All types of kerosene lamps	1.92	4.44	2,519
Car Battery			
Incandescent	1.4	2.3	156
Fluorescent	1.2	2.2	61
Compact fluorescent	1.6	2.4	25
All types of lamps	1.4	2.4	227
Grid-electrified HH			
Incandescent	2.7	4.3	2,183
Fluorescent	2.4	5.2	1,282
Compact fluorescent	2.5	4.7	1,148
All types of lamps	3.8	6.5	3,094

Source: INEI, 2005.

conversion factors in Figure 5.1, each 40-gram candle may be said to provide 0.08 klmh (kilolumen hours) of light, from which follows the total klmh provided each month from candles.

The distribution of lighting appliances and their estimated average usage in households with electricity in rural Peru is fairly similar to other countries, with the exception of greater use of more efficient electric lamps (Table 5.2). There is significant overlap of the figures in the table: for instance, many households with electricity still use kerosene for candles as a backup source of lighting. However, the findings show that a significant number of households use candles, kerosene, and grid electricity. A significant finding is that a relatively high percentage of households without electricity use car batteries for both lighting and television. The results confirm a high demand for lighting services in all expenditure quintiles.

To construct a demand curve for lighting, we examine all of the lighting sources for households in rural Peru. It is necessary to take several things into consideration when constructing this demand curve. The first is that there is more variation between households with different sources of energy than within them. For instance, the kerosene price differences for households at different income levels are largely explained by the relationship between the size of purchase and cost. The average price per liter of kerosene bought in small bottles (between one quarter and one third of a liter) is 3.25 soles per liter. However, kerosene bought in 1-liter bottles costs 2.84 soles per liter, and is only 2.60 soles per liter when purchased in larger gallon containers.

The procedure for estimating the lighting costs is similar for all classes of lamps. The survey provides information on both the use of the lamps and the total energy use for all households. But households use energy for multiple types of activities within the household. For instance, kerosene is used for both lighting and cooking and electricity is used for lighting and to power many other household appliances. As a consequence, the lighting cost is first estimated based on the hours of use of various types of lamps for the households, and then cross-checked against the total quantity of energy used by the households. The prices used for lighting are derived from the actual prices that households paid for each type of energy.

The process begins with users of simple wick-lamps, the most common form of kerosene-based lighting device (Table 5.3), for which lumen-hours and price per lumen-hour are estimated.[13]

The next step on the lighting ladder is hurricane lamps. Hurricane lamps provide more lumen-hours in all quintiles and have a cost advantage that derives from a somewhat higher efficiency. Similar calculations can be made for lighting from car batteries and petromax lamps, though compared to wick and hurricane lamps they are used by only a small number of households. Finally, there are the points that represent grid-connected households. These are shown in Figure 5.2: the five points shown in the figure for each device represent the points for the five expenditure quintiles.

The lighting demand curve based on the individual steps of the lighting ladder match the theoretical shape extremely well, as shown in Figure 5.2: the overall shape is clearly concave, not linear.

Nevertheless, the estimates of WTP depend critically on assumptions about the shape of the

Table 5.3

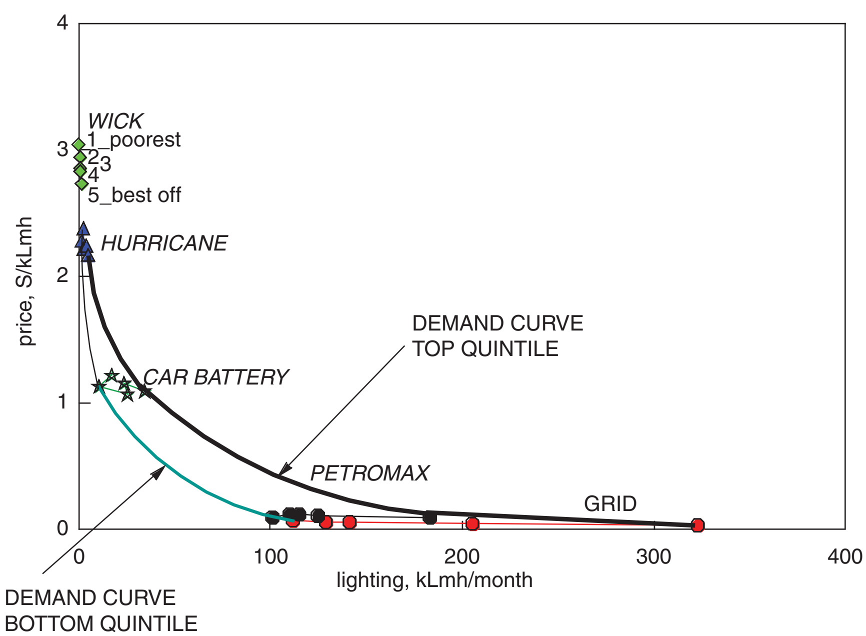
Percentage of Households Reporting Use of Lamps

	Wick	Hurricane	Petromax
1_poorest	49.1%	30.2%	1.0%
2	55.4%	30.6%	0.8%
3	59.3%	26.7%	2.2%
4	56.2%	31.3%	3.0%
5_richest	57.6%	39.7%	5.3%
Lumens	11.4	32	2,040

Source: INEI, 2005.

Figure 5.2

Demand Curve for Lighting (Actual)



Source: INEI, 2005.

[13] The quantity of lumen-hours provided by candles is even smaller than that provided by wick lamps, and the cost per lumen hours is more than four times than that of kerosene (see Figure 5.6).

demand curve between individual points. Small changes in the degree to which the actual curve is concave will result in large changes in the resulting consumer surplus estimates. There are many issues of data reliability, since the calculation of service demands (such as lumen-hours) depend on numerous behavioral and technical assumptions in addition to the usual problems of survey variance. The estimates for the costs of battery charging are particularly uncertain because it is difficult to establish the costs associated with transportation (to the charging station), and the small number of users, particularly in the low expenditure quintiles, raises the question of whether the car battery point can validly be included in the curve.

Only 1 percent of unelectrified households in the lowest expenditure group use car batteries (with 15 observations), as compared to 79 percent (and 1,094 observations) for kerosene. However, in the Coastal North regions, between 37 and 56 percent of all households without electricity service use car batteries, indicating a high degree of acceptance. Car battery use is greatest in these regions where access to grid electricity is relatively closer than in the mountain and Amazon areas and incomes are higher.

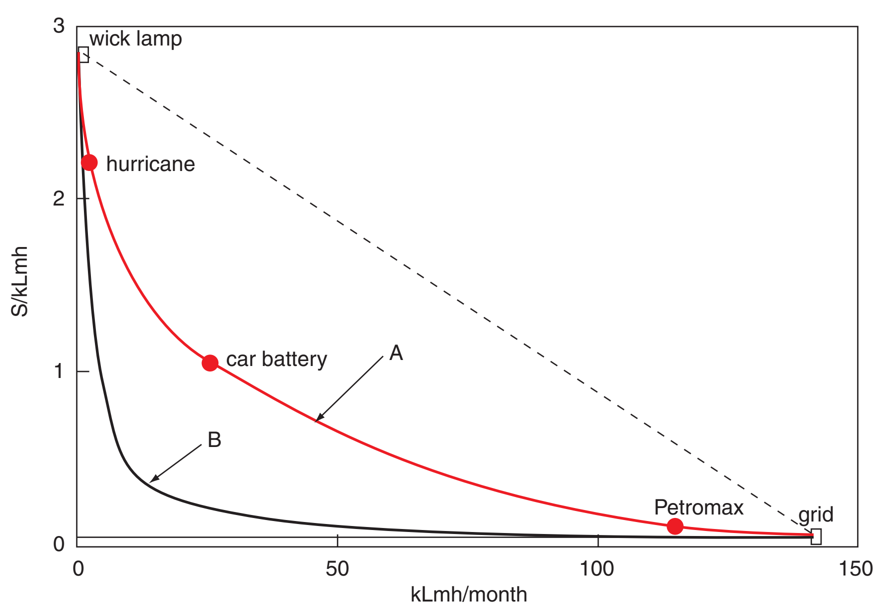
The nature of the problem of the shape of the demand curve is illustrated in Figure 5.3. If one includes the car battery point, curve *A* might apply. But if one excludes the car battery point, then curve *B* (which corresponds to a much higher constant price elasticity of around –1.1) results in much lower estimates of consumer surplus (with the area under the curve representing less than 10 percent of the area of the linear triangle, rather than around 33 percent in the case of curve *A*).

If one takes the conservative stand and excludes the car battery point, and assumes constant price elasticity between the points between kerosene users and grid-electrified households, then the estimates of consumer surplus range from US$1.54 (for the lowest quintile, with a price elasticity of –1.3), to $1.23/kWh (for the highest quintile, with a price elasticity of –1.1) (Table 5.4). Further details of these calculations are provided in Annex 3.

This methodology is consistent with that used in similar studies in other countries. However, recognizing the uncertainties of the shape of the demand curve, an alternative approach was also applied to estimate the benefits associated with

Figure 5.3

The Impact of Assumptions



Source: INEI, 2005.

Table 5.4

WTP Estimates

	Unit	1 (Poorest)	2	3	4	5 (Richest)
Assumptions						
Q_{KERO} [wick-lamp]	kLmh	0.8	1.1	1.1	1.2	1.7
Q_E	kLmh	111.9	129.5	141.9	205.6	323.5
P_{KERO} [wick-lamp]	S/kLmh	3.0	2.9	2.8	2.8	2.7
P_E	S/kLmh	0.061	0.053	0.048	0.034	0.026
Results						
Elasticity	[ ]	–1.3	–1.2	–1.2	–1.2	–1.1
Total willingness to pay	S	23.9	26.2	26.4	29.0	38.0
Net Benefit	**S**	**17.1**	**19.3**	**19.6**	**21.9**	**29.7**
Average kWh	kWh	4.8	5.6	6.5	7.4	9.6
Average WTP/kWh	S/kWh	5.0	4.7	4.1	3.9	4.0
	US$/kWh	1.54	1.46	1.26	1.21	1.23

Source: INEI, 2005.

the curve that includes the car battery point. The differences in approach are as follows:

- In place of the conventional expenditure quintile disaggregation of households (as used elsewhere in this report), a three-way categorization of HH is used (increasing the number of HH in each category).
- The assumption of constant elasticity between kerosene lighting and grid electricity lighting is relaxed, and each segment of the demand curve, including that for car batteries, is separately calculated.
- Households relying mainly on candles alone was added as a category (and petromax lamp user deleted, in view of the small numbers of households that use petromax lamps).
- In place of estimating prices and quantities for each observation (so a household using more than one lighting method is represented in each lighting category), households were first classified according to their principal lighting method. This categorization is shown in Table 5.5: for example, 79 percent of off-grid HH in the poorest category use kerosene as their principal source of lighting, and 1.1 percent use car batteries as their principal source.

The demand curves for the three income groups are depicted in Figure 5.4: as expected, they shift outward with increasing expenditure (income): for example, in the case of grid-connected households, the highest expenditure group consumes three times the quantity of lumen-hours of the lowest group). In each linear segment, the area under the corresponding curve is estimated not by the corresponding (linear) triangle, but by the lesser area corresponding to a concave curve of demand elasticity of around –0.65.[14]

Table 5.6 shows the corresponding values for price and quantities.

Table 5.7 shows the results of the consumer surplus calculations. For each income group the increase in consumer surplus is shown for each step in the lighting ladder. For instance, a household with a car battery would only have an increase in consumer surplus for the demand segment from the car battery

[14] This value is suggested by a statistical analysis for the approximately 900 households with electricity bills: the relationship is: ln (kilolumen-hour consumption per month) = .66 + 0.05*region + 0.32*ln (expenditures per month) –0.63 ln (price per kilolumen-hour) + error. The regional variable is not significant, and the overall R^2 is 0.45.

Table 5.5

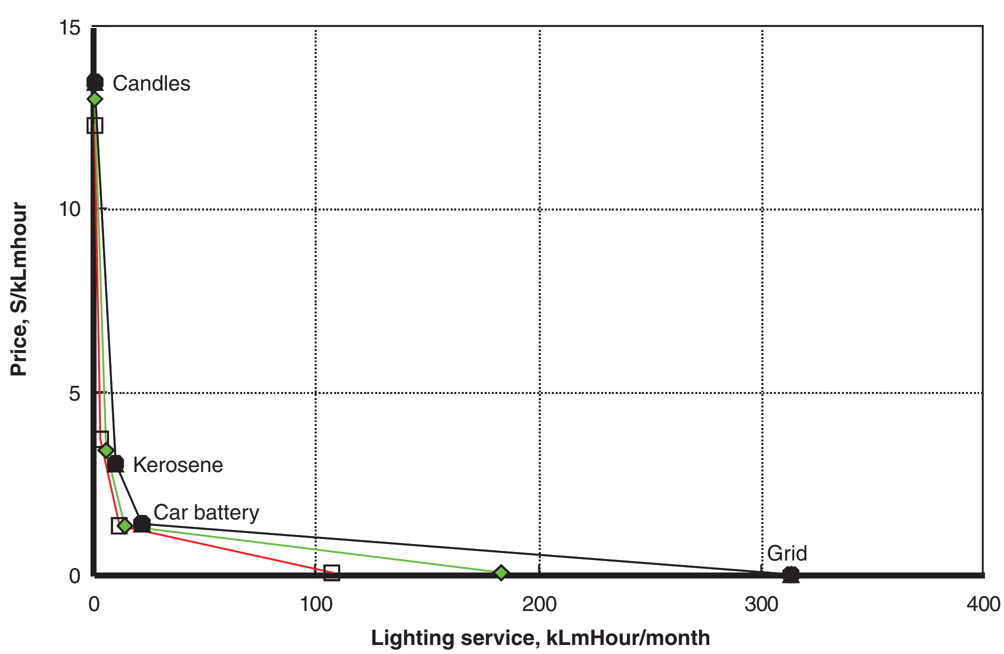
Number of Households Using Lighting Energy by Income Class, 2005

	Low	Medium	High	Total Expenditure per Month
Candle only	128.69	360.37	899.34	401.22
Number of households	274	245	170	689
Kerosene and candle	128.03	353.26	826.3	355.27
Number of households	1,094	762	531	2,387
(% of off-grid HH)	**79%**	**70%**	**65%**	
Car battery	154.95	381.25	1,199.97	823.86
Number of households	15	81	122	218
(% of off-grid HH)	**1.1%**	**7.4%**	**14.8%**	
All Off-grid Households	128.46	356.94	896.78	395.89
Number of households	1,383	1,088	823	3,294
Grid Electric	140.14	372.93	973.81	572.26
Number of households	739	1,045	1,314	3,098
Total Households	131.75	364.71	946.7	481.09
Number of Households	2,159	2,158	2,159	6,476

Source: INEI, 2005.

Figure 5.4

Demand Curve Based on Price and Quantity of Energy Use by Income Class



Source: INEI, 2005.

to grid electricity. Only a household switching from a candle to grid electricity would gain the consumer surplus of all segments. Households also experience a real income gain because the total expenditure on lighting decreases (e.g., by four soles/month for a low income household moving from kerosene to grid electricity), even though the quantity of service (Kilolumen-hours) increases.

Table 5.6

Estimates of Lighting Service and Price

	Low Expenditure		Medium Expenditure		High Expenditure	
	Q kLmhrs	**Price S/kLmh**	**Q Klmhrs**	**Price S/klmh**	**Q KLmh**	**Price S/kLmh**
Candles	0.48	12.28	0.68	13.01	0.83	13.45
Kerosene	3.16	3.69	5.76	3.41	10.28	3.03
Car battery	11.17	1.35	14.37	1.2	22.03	1.23
Electricity grid	107.66	0.048	183.64	0.031	313.48	0.021

Source: INEI, 2005.

Table 5.7

Increases of Consumer Surplus by Income Class (Soles/month)

Expenditure Class	Increase in Consumer Surplus	Ending Expenditure on Lighting	Difference in Expenditures
Low Expenditure (<236.11S/.)			
Candle to kerosene and candle	8	7	2
Kerosen and candle to car battery	10	13	6
Car battery to electric grid electricity	34	3	–10
Total: Candle to Grid Electricity CS	52	3	–4
Medium Expenditure (236.11–511.33 S/.)			
Candle to kerosene and candle	14	12	4
Kerosene and candle to car battery	15	17	5
Car battery to electric grid electricity	51	4	–13
Total: Candle to Grid Electricity CS	79	4	–4
High Expenditure (>511.33 S/.)			
Candle to kerosene and candle	23	18	8
Kerosene and candle to car battery	20	22	4
Car battery to electric grid electricity	88	5	–17
Total: Candle to Grid Electricity CS	132	5	–5

Source: INEI, 2005.

When the results are weighted by the proportion of households in each starting category, the calculations for average WTP per kWh and total monthly benefits are as shown in Table 5.8. These estimates of benefit are significantly higher than those derived in Table 5.4 (e.g., US$2.25/kWh for the lowest expenditure group, as opposed to US$1.54).[15]

Despite the uncertainties and the substantial range of the estimates of benefit, the conclusion is that households switching from candles, kerosene, or car batteries to grid electricity for lighting enjoy high economic benefits. The estimates have high variance, but even at the low end of the range, the economic benefits are substantial. Not only do electrified

[15] One of the issues in these calculations is that the expenditure, defined by Average kLmhrs consumed × Average price/kLmhr, does not equal the estimate of expenditure derived from the expenditure data. When the kLmhr and price/kLmhr estimates are scaled to expenditure estimates, the resulting values of consumer surplus would be about 20 percent lower.

Table 5.8

WTP per kWh (Alternate Method)

		Low	Medium	High	Avg
Net benefit	Soles/month	46.5	67.5	110.2	74.7
Expenditure	Soles/month	3.0	4.0	5.0	
Total WTP	Soles/month	49.5	71.5	115.2	
Average kWh	kWh/month	6.82	10.00	10.42	
Average price	S/kWh	0.44	0.4	0.48	
Average WTP	S/kWh	7.26	7.15	11.05	
	$/kWh	2.25	2.21	3.42	
Annual Net Benefit	S/year	558	810	1,322	897
	$/year	173	251	409	278

Source: INEI, 2005.

households enjoy much greater levels of lighting service, they also obtain a real income gain since their total expenditure on lighting service decreases. In the interest of using conservative assumptions, the economic analysis of the new rural electrification approach has used the lower values of WTP, but the results suggest that actual returns may be greater.

Benefits of Communications

Radio and television are among the most important sources of communication and entertainment for rural households. Typically, after electric lighting, plug-in radio and television are the most common appliances in households with electricity. Without electricity, the cost to operate radio and/or television is extremely high, and the total hours listening to radio and viewing television tend to be relatively low or limited.

Television

Television viewing is one of the most desired aspects of electrification. Almost 20 percent of households without electricity in rural Peru have a television set operated by car batteries, which requires significant money and time (because battery recharging is often at considerable distance to the home). Television viewing (and particularly color TV) is a normal good, so it is possible to estimate the consumer surplus of television viewing in a similar manner to household lighting. The survey finds that about 158,000 rural households without electricity in Peru—or about 12 percent of all rural households without electricity—are still using black-and-white (B&W) television. Table 5.9 shows the viewing hours and costs of the three main television types: B&W powered by car batteries, plug-in B&W, and plug-in color.

With these input assumptions, the total monthly benefit of television viewing is estimated at 24.2 soles/month. Alternatively, the benefit associated with 212 viewing-hours per month of plug-in color television averages to 0.11 soles/viewing-hour. The *net* benefit, namely, the increase in consumer surplus, is 14.7 soles/month.

These estimates of net benefit may be overstated, because they include only the lower cost of electricity itself. The cost of acquiring a color television is significantly greater than that of the black-and-white television that it replaces. Assuming a price difference of US$100 (cost of a new color television less the cost of selling the existing B&W television on the secondhand market), and assuming a five-year life, the transition to color television translates into an additional cost of 0.0226 soles/viewing hour,[16] or 5.17 soles per month. However, it should be kept in mind that this is the value of moving from using car batteries for watching television to using grid electricity. The benefits of television viewing for households without car batteries (that do not have television) would be higher.

Table 5.9

Cost and Viewing Hours for Television

	Unit	Car Battery, B&W TV	Grid, Plug-In B&W	Grid, Plug-In Color TV
Viewing hours	Hours/Day	2.81	2.59	6.83
	Hours/Month	87	80	212
Power rating of TV	Watts	24	48	75
KWh	kWh/Month	2.09	3.85	15.88
Cost per month	Soles/Month	13.58	2.312	9.528
Cost per viewing hour	Soles/Viewing-hour	0.16	0.0288	0.0450

Source: INEI, 2005.

Table 5.10

Cost per Radio Listening Hour Based on Energy Source

	Unit	Dry Cell	Car Battery	Plug-in, Grid Connected
Listening hours	Hours/day	4.64	3.68	2.87
	Hours/month	141	112	87
Power rating of device	Watts	3	9	18
kWh	kWh/month	0.42	1.01	1.57
Price/kWh		164	6.5	0.6
Cost per month		69.4	6.6	0.9
Cost per listening hour		0.49	0.06	0.01

Source: INEI, 2005.
Note: Price per kWh for car battery and dry cell use is derived in Chapter 3.

Radio

Radios are the most widely used non-lighting appliance among rural households. Table 5.10 and Table 5.11 show the time spent listening to the radio, as well as costs. Even though dry cell batteries cost more than 25 times more than car batteries and 270 times more than grid electricity per kilowatt-hour, they are still the energy source of choice for radio listening in rural households.

The apparent anomaly of the most expensive form of radio listening being used the most is simply a reflection of the mobility of dry cell-powered radios (Table 5.11). Indeed, as noted previously, dry cell battery radios are used even after electrification. However, it is reasonable to assume that almost all of the households using car battery-powered radios—126,200 households, or 9 percent of the total rural households without electricity, according to the Survey—would switch to grid plug-in models once grid electricity became available.

The analysis used for lighting that estimated changes in consumer surplus from downward-sloping demand curves cannot be used given the shift from radio to television viewing, since this would require a multivariate function to properly model both goods. Radio listening is arguably an *inferior*

[16] 310 soles divided by (229 viewing hours per month × 12 months/year × 5 years = 13,740) = 0.0226.

Table 5.11

Price and Quantity of Radio Listening

Price and Quantity	Value	Unit	Radio by Sources of Electricity
P_{rdc}	0.49	Cost per listening hour (soles)	Radio using dry cell batteries
Q_{rdc}	4.64	Listening hours per day	
P_{rcb}	0.06	Cost per listening hour (soles)	Radio using car battery
Q_{rcb}	3.68	Listening hours per day	
P_{rge}	0.01	Cost per listening hour (soles)	Radio using grid electricity (for plug-in radio)
Q_{rge}	2.87	Listening hours per day	

Source: INEI, 2005.

Note: Assumption of wattage for radio is as follows: dry cell batteries is 3 watts; car battery is 9 watts, and plug-in radio is 18 watts. Assumption of dry cell battery capacity: size C and D size supplies 6 Wh of electricity; AA and AAA supplies 4 Wh.

good, with evidence that consumption *decreases* with increases in income, as households generally prefer to increase television viewing. Hence, the benefits of the transition from car battery to grid radios are best estimated as the financial savings per listening hour of switching to grid electricity. For the 2.87 listening hours/day for grid-connected households, the benefit per listening hour is simply the difference in cost between a car battery (0.059 soles/listening hour) and grid radio (0.011 soles/listening hour), namely 0.048 soles/listening hour.

Table 5.12

Use of Refrigerators in Unelectrified Households

	LPG	Kerosene
Number of actually sampled households	8	11
Number of households (weighted)	1,422	1,100
As % of unelectrified households	0.1%	0.07%

Source: INEI, 2005.

Refrigeration

The Survey reports a very low proportion of unelectrified households using refrigerators (Table 5.12). Households using small generators or car batteries were not asked whether they were used to power refrigerators, and it is unlikely that they would do so. With fewer than 0.1 percent of unelectrified households using refrigerators, even if there were a sufficient number of households for which expenditure data could be used with confidence, the impact on the overall average willingness-to-pay calculation (i.e., once the expenditure is weighted by the fraction of households incurring this expenditure) is very small. Therefore, expenditures of unelectrified households on refrigerators may be ignored in the overall benefit estimation of potential rural electrification projects. Lack of refrigeration in unelectrified households also makes it impossible to estimate a demand curve and undertake consumer surplus/willingness-to-pay calculations.

NRECA reports an estimate of WTP for refrigeration of US$0.86/kWh (3 soles/kWh) in the Amazon and Coastal regions (and zero in the Andean regions). However, neither the data nor the details of the calculations that underlie these estimates are available (Box 5.1).

Box 5.1

Comparison of Survey Results with an NRECA Study

In 1999, the National Rural Electric Cooperative Association (NRECA) estimated willingness-to-pay (WTP) values based on a limited survey. It used a methodology for estimating demand curves similar to that used in this chapter.

The NRECA estimates of willingness-to-pay are significanty higher than those suggested by this Survey. The reasons appear to be in the sample of households surveyed: NRECA surveyed areas closer to better-off urban areas, resulting in higher consumption estimates. The average monthly consumption of households surveyed by NRECA is 58.8kWh/household/month, over twice the average consumption in the rural areas recorded by this Survey (Table A).

Table A

Average Monthly Consumption, kWh/Households/Month

	NRECA					Current Survey
	Lighting	Radio & TV	Refrigeration	Other	Total	
Andean	7.3	5.4		23.4	36.1	**15–26**
Amazon	9.2	5.4	13.5	20.2	48.3	**31**
Coastal	8.8	5.4	22.5	58.5	95.2	**39–59**
All	8.4	5.4	10.7	34.3	58.8	**26**

NRECA reported significant consumption for refrigeration, whereas in this Survey, the proportion of households reporting refrigeration is very small, making demand curve estimates impossible.

The NRECA estimates for WTP in soles/kWh are shown in Table B. However, there is little supporting evidence for these values in the NRECA report. The NRECA estimate of willingness-to-pay for radio and television is 3.5 soles/kWh and for lighting is 4.6 soles/kWh. The comparison of total monthly WTP against the results of the Survey show the NRECA results to be comparable for TV, and within the overall range for lighting.

Table B

NRECA Average WTP Estimates, Soles/kWh

	Lighting	Radio & TV	Refrigeration	Other
Andean	4.8	3.3	0.0	0.5
Amazon	4.9	3.1	3.0	0.5
Coastal	3.2	4.8	3.0	0.5
All	4.6	3.5	3.0	0.5
Total monthly WTP, soles/month				
NRECA	38.6	18.9		
Survey, low estimate	24–38	19.0 (color TV)*		
Survey, high estimate	40–90			

*Adjusted for cost of color TV.

Source: NRECA, *Estrategia Integral de Electrificación Rural.* Lima. September 1999.

Benefits of Education and Health

This section describes the indirect benefits of electrification, including education, health, and environmental benefits. Given the difficulties noted previously, a formal quantification of these benefits is not attempted. Indeed one of the major problems in such a quantification is double-counting: for example, it is likely that households internalize the benefit associated with the reduction in kerosene lamp-related burn injuries to children in their WTP for electric lighting.

Education

Empirical data on the indirect economic benefits of electrification for education are not as well documented as the direct economic benefits of education. It is clear that electricity extends evening lighting hours, making it easier for children to study, do homework, and read. The survey found that children aged 6 to 18 in households with electricity who are currently attending school spend an average of 65 minutes per night reading and/or studying, whereas in households without electricity, the figure is only 51 minutes (Table 5.13). The increase of 27 percent in reading/study time is statistically significant. However, caution should be used when interpreting this result since the correlation could be due to a third variable, such as household income, and not necessarily demonstrate a causal relationship.

The survey shows that there is no difference in levels of school enrollment of children aged 6 to 12: almost all children aged 6 to 12 are reported to be attending school regardless of their home electrification status. This appears to confirm that the educational campaign in Peru during the past decade is working. Undoubtedly, electrification will reinforce this success and make it sustainable, since it is reasonable to assume that electrification gives children more flexibility in choosing when to do schoolwork. Empirical evidence elsewhere has also shown that children who are doing well at school or can keep up with their peers are more likely to stay in school longer than those who do not do well at school. Similarly, electricity enables schools to be equipped with modern teaching equipment and information and communication technologies, especially access to the Internet.

Unlike at the primary school level, school enrollment at the secondary level is significantly higher for households with a grid electricity connection. The survey reveals that school enrollment of children aged 13 to 18 from households with a grid connection is about 82 percent, which is 20 percent higher than in households without electricity (Table 5.14). Thus, there is strong evidence that having electricity in rural households involves educational benefits. There is a strong likelihood that these educational benefits are already quantified as part of the consumer surplus for household lighting. As a consequence, we do not make an attempt to quantify those benefits for this chapter.

Table 5.13

Average Number of Hours per Night Household Members Read/Study (Weighted)

	No Grid Access	Grid Access
Children Aged 6 to 18 Attending School Read/Study (Hours/Night)	0.86	1.09
Number of households	*750,283*	*496,154*
All Household Members Read (Hours/Night)	0.33	0.47
Number of households	1,339,829	845,03

Source: INEI, 2005.

Table 5.14

Percentage of Children in the Household Attending School (Weighted)

	Without Grid Access	Grid Access
Children 6 to 12 Years Old	93.6%	92%
Population	*415,112*	*695,010*
Children 13 to 18 Years Old	62%	82%
Population	*517,277*	*326,547*

Source: INEI, 2005.

Health and Environmental Benefits[17]

Seventy-three percent of rural households (987,000 households) use kerosene for lamp lighting. Based on the Survey data, it is estimated that about 3 liters of kerosene per household per month are used specifically for lamp lighting, or 2.96 million liters of kerosene per month for the entire rural population. The negative health effects associated with this level of kerosene use are significantly greater than the health effects associated with grid-generation. Even with increases in the share of gas-fired generation from the large electricity generation companies or small diesel sets for isolated systems, the health damages caused by the emissions from such facilities are two orders of magnitude smaller than those from burning kerosene in wick lamps inside the home.

Grid electrification will directly contribute to a reduction of respiratory illness among the rural population, reducing both public and private healthcare costs. Although there is no specific documentation for Peru, in other countries, the avoidance of children's burn injuries from kerosene lamps—particularly from generally unsafe simple wick lamps—is a major benefit of rural electrification.[18]

Benefits to Home Business

Slightly more than 13 percent of all sampled households reported a home business (Table 5.15). However, the proportion is much greater in grid-electrified households (18.3 percent) than in unelectrified households (7.7 percent). For car-battery electrified households, the proportion (16.1 percent) is close to that of grid-electrified households—which suggests that what is important is electrification, rather than whether electricity is provided by the grid or by car batteries. This is surprising, given the difference in cost: as noted in the previous section, electrification by car battery costs an average 24 soles/kWh, as against an average of 0.6 soles/kWh for grid electricity.

However, it is virtually impossible to separate home and business use of lighting in homes that do report a home business. Moreover, as shown in Table 5.16, among home businesses, only 4.2 percent are in households predominantly lit by car batteries, as opposed to 28.4 percent without electricity. Whatever are the causalities, it is certainly clear that home businesses are concentrated in households connected to the grid.

Table 5.15

Home Business Incidence by Major Lighting Type

Major Lighting Type	Home Business		Total Sampled HH
	Number	Percent	Number
Candle	59	8.6%	689
Kerosene and candle	179	7.5%	2387
Total unelectrified	*238*	*7.7%*	*3076*
Car battery	35	16.1%	218
Grid electricity	566	18.3%	3098
Total	839	13.1%	6392

Source: INEI, 2005.

Table 5.16

Distribution of Households with Home Business by Major Lighting Type

	Number	Percent
Candle	59	7.0%
Kerosene and candle	179	21.3%
Total unelectrified	*238*	*28.4%*
Car battery	35	4.2%
Grid electricity	566	67.5%
Total	*839*	*100.0%*

Source: INEI, 2005.

[17] The analysis of kerosene fuel savings is based on weighted survey results.
[18] For example, in Sri Lanka, in December 2000 a new burns unit was opened at the Lady Ridgeway Children's Hospital north of Colombo. By August 2001, 176 children had been treated for burn wounds. The majority of the victims were from the rural villages without electricity of Chilaw, Puttalam, and Karapitiya, which are dependent on kerosene for lighting (*Sri Lanka Sunday Observer,* September 23, 2001).

Willingness to Pay for Electricity in Enterprises

Willingness-to-pay (WTP) for electricity in nondomestic applications may be estimated from the results of the business survey, which sampled 192 rural enterprises. Of the 135 rural businesses sampled 93 had access to grid electricity (69 percent), considerably greater than the 40 percent of households sampled. Even a simple consideration of the incidence of energy sources (Table 5.17) suggests that WTP for electricity is much greater than in domestic households. Specifically, 26 percent of unelectrified businesses use car batteries (versus 11 percent of households), and 24 percent use small generators (compared to just 2 percent of households).

The differences in fuel sources between electrified and unelectrified enterprises are similar to that encountered in households: significant decreases in electricity substitutes (e.g., 45 percent to 10 percent for kerosene use), and significant increases in LPG use (from 2 percent to 20 percent), as shown in Figure 5.5.

The average electrified enterprise consumes 94 kWh per month of electricity. Table 5.18 shows the corresponding average expenditures for rural enterprises in electrified and unelectrified households. Total energy expenditures remain largely unchanged: 154 soles per month for electrified enterprises versus 155 soles per month for unelectrified enterprises.

However, the overall pattern of expenditure does change. In an electrified enterprise, the average additional expenditure for electricity (50 soles per month) is offset by sharp decreases in expenditures for wood (Figure 5.6). In short, LPG and electricity replace wood and kerosene. Electrification also brings increased expenditures for self-generation. Businesses used to the availability of electricity are willing to pay the high costs of small generators to secure their businesses against a lack of electricity service.

These energy expenditure data do not take into account the dramatic difference in enterprise *incomes*. The average monthly turnover (gross sales) in electrified enterprises is 3,520 soles/month, as opposed to 1,140 soles/month in unelectrified enterprises. Therefore, even though average energy expenditures are roughly the same (155 soles/month), the energy expenditure per unit of sales is much lower in electrified enterprises.

Table 5.17

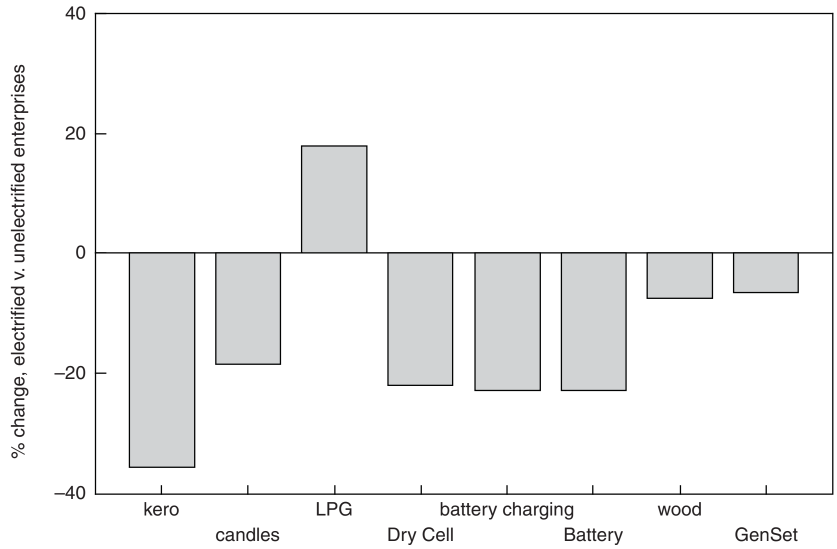
Energy Sources in Rural Enterprises

	Unelectrified Enterprises		Electrified Enterprises	
	Number of Enterprises	Percentage of Total	Number of Enterprises	Percentage of Total
Kerosene	19	45.2	9	9.7
Candles	24	57.1	36	38.7
Dry cell batteries	21	50.0	26	28.0
Car battery	11	26.2	3	3.2
LPG	1	2.4	19	20.4
Solar panels	2	4.8	2	2.2
Electric generator	10	23.8	16	17.2
Fuelwood	9	21.4	13	14.0
Animal dung	2	4.8	2	2.2
Crop residuals	1	2.4	1	1.1
Charcoal	0	0.0	0	0.0
Coal	0	0.0	1	1.1
Total	42		93	

Source: INEI, 2005.

Figure 5.5

Energy Source Differences Between Electrified versus Unelectrified Enterprises



Source: INEI, 2005.

Table 5.18

Average Energy Expenditures in Rural Enterprise

	Electrified			Unelectrified		
	Expenditure (Soles/Month)	% Using Fuel (%)	Average (Soles/Month)	Expenditure (Soles/Month)	% Using Fuel (%)	Average (Soles/Month)
Kerosene	12.5	10	1.2	25.8	45	11.7
Candles	1.3	39	0.5	6.0	57	3.4
LPG	55.3	20	11.3	37.0	2	0.9
Dry cell	4.2	28	1.2	5.7	50	2.8
Battery charging	5.0	3	0.2	8.5	26	2.2
Battery	10.0	3	0.3	6.6	26	1.7
Wood	320.7	14	24.1	387	21	82.9
Small generator	375.1	17	64.5	208	24	49.5
Subtotal: Nonelectricity			103.3			155.2
Electricity			50.4			
Total			**153.8**			**155.2**

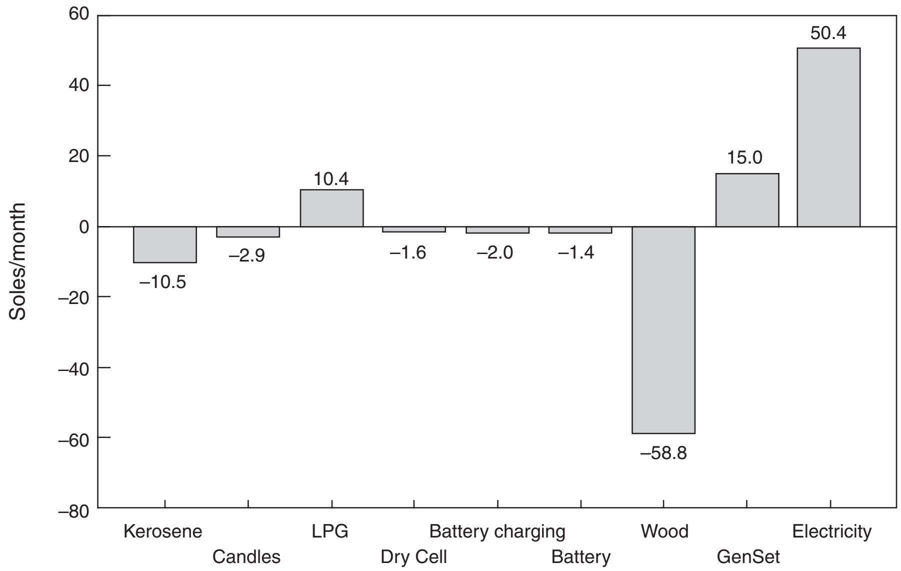
Source: INEI, 2005.

The increase in business productivity should be incorporated into WTP calculations. If income is held constant, then the average expenditures of electrified household enterprises must be divided by the corresponding ratios of income (3,520/1,140 = 3.1). Therefore, for constant income, electrification reduces energy expenditure from 155 soles per month to 56.5 soles per month. The resulting net benefit is 98.7 soles per month, which, when divided by the average kWh consumption (of 31.2 kWh/month if income is kept constant), is 3.2 soles/kWh (Table 5.19).[19]

[19] The small sample size does not permit reliable estimates of willingness to pay by region.

Figure 5.6

Change in Monthly Expenditure with Electrification



Source: INEI, 2005.

Table 5.19

Enterprise Willingness to Pay for Electricity

	Electrified				Unelectrified		
	Expenditure (Soles/ Month)	% Using Fuel	Average (Soles/ Month)	Income Adjusted Average (Soles/Month)	Expenditure (Soles/ Month)	% Using Fuel	Average (Soles/ Month)
Kerosene	12.5	10	1.2	0.4	25.8	45	11.7
Candles	1.3	39	0.5	0.2	6.0	57	3.4
LPG	55.3	20	11.3	3.7	37.0	2	0.9
Dry cell	4.2	28	1.2	0.4	5.7	50	2.8
Battery charging	5.0	3	0.2	0.1	8.5	26	2.2
Battery	10.0	3	0.3	0.1	6.6	26	1.7
Wood	320.7	14	44.8	14.5	387	21	82.9
Small generator	375.1	17	64.5	20.9	208	24	49.5
Subtotal: Nonelectricity			124.0	40.2			155.2
Electricity			50.4	16.3			
Total			**174.5**	**56.5**			**155**
Minus Electrified Average							–56.5
Net Benefit							**98.7**
KWh			93.6	31.2			31.2
WTP, Soles/kWh							**3.2**

Source: INEI, 2005.

Conclusions

The evidence shows electrification brings high benefits to rural Peru. In this chapter, we have estimated the direct economic benefits of rural electrification by comparing demand for services of households with and without grid electricity. Although these estimates of direct benefit are subject to uncertainty, they are an incomplete measure of total social benefit because they do not capture the many indirect benefits to income and education that are evident only over the long term.

Based on the consumer surplus calculations already presented above, benefits from lighting are in the range of 40–90 soles/month/household, depending on expenditure level. For radio (an inferior good), similar demand-curve calculations are not possible, but more basic calculations suggest that unelectrified households would save 0.048 soles per listening hour with grid electricity, or a total of 4.6 soles per month (based on 87 listening hours per month). For TV viewing, demand curve calculations find a total benefit or willingness-to-pay of 24.2 soles per month. The net benefit, or increase in consumer surplus, due to plug-in color TV is 14.7 soles/month, but this drops to 9.5 soles per month after subtracting amortized costs of upgrading to a color TV. Given the lack of equivalent expenditures in unelectrified households, it was not possible to calculate benefits for refrigeration. Table 5.20 summarizes the net benefits of grid electrification.

Notwithstanding the various uncertainties associated with calculations based on survey data, some of which have high variance, the estimate of benefits derived in this chapter are sufficiently robust to permit their use in benefit-cost analysis of potential rural electrification schemes (for which estimated economic rates of return for most projects in Peru are in the 15.25 percent range, using values of benefits at the low end of the range estimated in this report). The 1999 NRECA estimates (Box 5.1) are near the low end of the range, even though the NRECA estimates were based on an unrepresentative sample of peri-urban areas, where consumption levels are much higher than those established by the rigorous sampling design for rural areas in this Survey.

Table 5.20

Net Benefits of Grid Electrification (per HH/month)

	Soles	$US
Lighting (low estimates), range across expenditure groups	17–30	5.3–9.3
(high estimates), range across expenditure groups	46–100	14–34
Radio	4.6	1.4
Color TV	9.5–14.7	2.9–4.6

Source: INEI, 2005.

While indirect benefits, such as those related to education, health, and the environment are hard to calculate, it is clear that they exist, and therefore the estimates of Table 5.20 should be regarded as conservative. Furthermore, it is clear that commercial enterprises experience substantial benefits from electrification. Calculations based on the rural enterprise survey data indicate a net benefit of 99 soles per month.

The challenge in Peru is to have the appropriate connection, pricing, and subsidy policies to make sure that electricity can be provided to rural people without negatively impacting the electricity distribution companies. Given the high cost of providing service in remote areas of difficult terrain, distribution companies must have the right incentives to serve rural customers if consumers are to receive reliable service. That close to 20 percent of off-grid households have a car battery suggests significant pent-up demand in rural areas for electricity service that might be met more efficiently from alternative technologies. These and other issues are the topic of the next chapter on policy issues involving rural electrification in Peru.

6 Policy Implications of Survey Results

This chapter uses data from the Survey to consider policy issues relevant to rural electrification programs. First, the chapter examines connection rates in electrified villages and reasons why over 20 percent of households in electrified villages do not have grid connections. Next, the breakdown of average village electricity consumption is considered. Estimated growth in rural electricity consumption is also examined, since this can be important when making financial feasibility assumptions for potential new projects as well as generation requirement projections. Pricing policy is discussed, with a special focus on the targeting performance of the social subsidy through the Fondo de Compensación Social Eléctrica (FOSE). The chapter concludes with a brief discussion of efficient lighting programs and the rate of return of replacing incandescent light bulbs with compact fluorescent lamps (CFLs).

Connection Rates in Electrified Villages

Connection rates and average consumption at the village level are critical variables in the design of rural electrification projects. The financial viability of a rural electrification scheme depends on the ability of the tariff to generate sufficient revenue to cover operations and maintenance (O&M) and energy purchases, which in turn is a function of how many households in a village actually connect to the grid if extended, and the average level of consumption of the connected households (World Bank 2005b).

The Survey sampled 764 villages and an average of about 9 households per village. If an electrified village is defined as one where at least one of the sampled households is connected, then 374, or 48.9 percent of villages, may be considered electrified. In only 30 percent of villages are 100 percent of households actually connected. There is very little variation in connection rates within electrified villages across regions (Table 6.1), although the village electrification rate varies from a low of 26 percent in the Amazon region to a high of 71 percent in the Coastal Central region.

Of the 3,378 households surveyed that are without electricity, 727, or 21.5 percent, are in villages that *are* electrified. In other words, almost one-quarter of households that have *no* grid connection are in villages that *are* electrified. This is a high rate of nonconnection that has important implications for future rural electrification projects.

There are significant differences in explanations given for having no access between households in electrified villages and households in unelectrified villages (Table 6.2). In electrified villages, 44 percent of respondents stated that they could not pay the connection fee, versus 10 percent in unelectrified villages. In electrified villages, 35 percent of respondents considered the costs of house wiring to be a constraint, while 28 percent stated that they could not pay the monthly bill; equivalent numbers in unelectrified villages were 8 percent for house wiring and 7 percent for the monthly bill.

This confirms the widely held view that *the upfront costs of connection, wiring, and equipment* represent the predominant constraint to connection. The financial sustainability of projects is strongly influenced by having as many households connect as possible, from which follows that connection costs, perhaps including house-wiring, should be included as part of the overall cost eligible for subsidy.

Table 6.1

Connection Rates by Region

	Connection Rates in Electrified Villages (%)	Fraction of Electrified Villages (%)	Number of Electrified Villages	Number of Total Villages
Coastal North	80	40	44	109
Coastal Central	79	71	82	116
Coastal South	84	70	55	79
Andean North	83	32	36	114
Andean Central	80	58	64	111
Andean South	77	54	61	114
Amazon	74	26	32	121
All	80	49	374	764

Source: INEI, 2005.

Table 6.2

Major Reasons Cited for Households Lack of Grid Access: Electrified Villages versus Unelectrified Villages (% of Respondents)[20]

	Electrified Village	Unelectrified Village
Electricity is not available in my area	34	94
Cannot pay connection fee	44	10
Cannot pay house wiring	35	8
Cannot pay monthly bill	28	7
Cannot pay electric appliance	12	5
Satisfied with present energy source	6	3
Cannot see application of electricity	5	3

Source: INEI, 2005.

Distribution of Electricity Consumption by Village

For rural electrification schemes to be financially sustainable, tariff revenues should exceed operations and maintenance (O&M) and power purchase costs. An indicative consumption threshold of 22 kWh/household/month is used in this report for whether most rural electrification schemes would be financially viable. Although this figure is significantly below the *average* monthly consumption of electrified rural households, what matters to the design of a rural electrification project is the likely average consumption in given candidate areas.

The average consumption in each of the 374 electrified villages was estimated. As shown in Table 6.3, the average consumption of electrified villages is 35 kWh/household/month. However, these averages show significant variation across regions: In the Andean South region, the average is only 15 kWh/household/month, whereas the Coastal Central region has the highest average of 55 kWh/household/month. Note again that these are the averages at the *village* level, which differ from the *household* averages shown in Table 3.1. As in the case of individual households, the regional differences in consumption can be explained by regional differences in income.

Table 6.3 also suggests that there is likely to be a significant problem with financial viability, particularly in the Andean South, since only 23 percent of villages meet the minimum consumption threshold. In contrast, 93 percent of villages in the Coastal South meet the threshold. Figure 6.1 shows

[20]Survey respondents were allowed to answer "major reason," "minor reason," or "no" to each question. Table 6.2 shows the proportion of respondents who cited any given issue as a "major reason." For instance, 34% of households indicated that "Electricity is not available in my area" as a major reason for lack of access to the grid. In Table 6.2, columns do not therefore add up to 100 percent.

Table 6.3

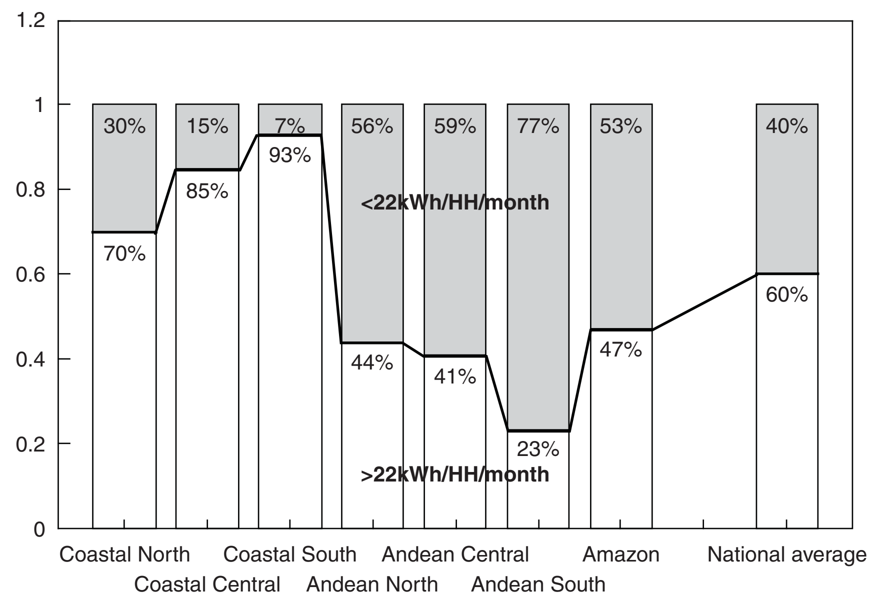
Average Consumption in Electrified Villages

	kWh per Connected Household	Number of Villages with Average Monthly Consumption >=22 kWh/Month	As Fraction of Electrified Villages (%)
Coastal North	36	31	70
Coastal Central	54	70	85
Coastal South	55	51	93
Andean North	23	16	44
Andean Central	25	26	41
Andean South	15	14	23
Amazon	24	15	47
All	35	223	60

Source: INEI, 2005.

Figure 6.1

Breakdown of Villages with Average Consumption above and below 22 kWh/Month by Region



Source: INEI, 2005.

the breakdown of villages with consumption above and below 22 kWh per month by region.

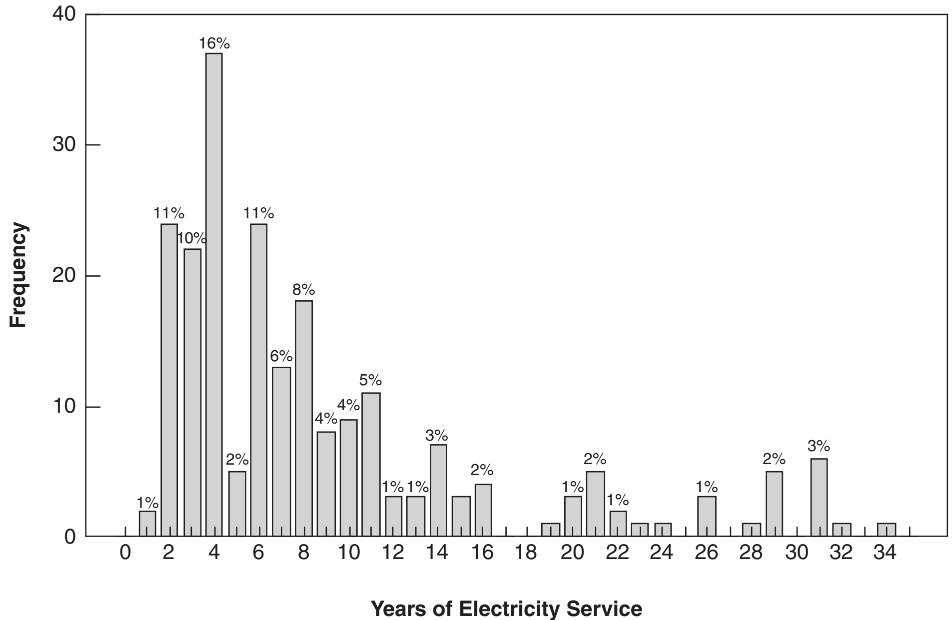
Growth of Electricity Consumption

One of the important assumptions in making financial projections of the viability of rural electrification projects is the rate of growth in household electricity consumption. It is generally supposed that consumption increases with household income (or with household expenditure, the proxy used in this study), and, therefore, all other things equal, consumption per connection should increase over time.

However, it is widely reported that growth rates in consumption per connection in rural areas of

Figure 6.2

Distribution of Years of Electricity Service



Source: INEI, 2005.

Peru are very small—often less than 1 percent per connection per year. This observation is consistent with much slower economic growth in rural areas than in urban areas, where electricity consumption growth per domestic connection grows much faster.

Inferring growth rates from a cross-sectional survey requires caution. Nevertheless, one could reasonably hypothesize that all other things equal, monthly consumption would be higher the greater the age of the electrical connection. Figure 6.2 shows the age distribution of electrical connections: 67 percent of rural connections are less than 10 years old, testimony to the rural electrification efforts over the past decade. The peak rate of rural electrification appears to have been achieved four years ago.

There is little correlation between the age of a connection and the kWh/household consumed (Figure 6.3); the trend line shown is not statistically significant.[21]

Projections of consumption growth in rural areas that are presented in proposed rural electrification schemes require careful scrutiny. At least based on the experience of those communities prioritized by the current scheme (often the poorest, and most lacking in infrastructure access), there is no evidence from the Survey that annual consumption growth per connected household would be much higher than the commonly assumed 0.5 to 1.0 percent per year.

Pricing Policy

The electricity tariff faced by low-income rural households is a complex nonlinear function of monthly consumption, a consequence of the approach to rate-making adopted by the regulator, *Organismo Supervisor de la Inversión en Energía* (OSINERG), and the cross-subsidy system adopted to finance the lifeline tariff rate, the *Fondo de Compensacion Social Electrica* (FOSE).

Nevertheless, as noted in Chapter 3, the broad pattern is clear: Those who consume small amounts of electricity pay relatively high prices per kWh,

[21]The ordinary least squares relationship is: [kWh/household/month] = 28 + 1.105 [age of connection]; $R^2 = 0.04$ which suggests every year of connection increases monthly consumption by 1.1 kWh. However, the relationship is not statistically significant.

Figure 6.3

Monthly kWh of Consumption versus Age of Connection

Source: INEI, 2005.

Table 6.4

FOSE Subsidy Rates

	Sector	Discount for Households Consumption of 30 kWh/Month or Less	Discount for Households Consuming Between 30 and 100 kWh/Month
Interconnected System	Urban Urban-rural & rural	25% of energy charge 50% of energy charge	7.5 kWh/month 15 kWh/month
Isolated Systems	Urban Urban-rural & rural	50% of energy charge 62.5% of energy charge	15 kWh/month 18.75 kWh/month

Source: OSINERG Ayuda Memoria FOSE.

notwithstanding the FOSE mechanism. Households in the lowest expenditure quintile use, on average, 12 kWh/month, at an average price of 0.83 soles/kWh, while households in the top quintile use on average 49 kWh/month at an average price of 0.55 soles/kWh (Table 3.1). Without FOSE, the average price for the lowest quintile would increase to 1.3 soles/kWh.[22]

FOSE

The rationale for the FOSE is regional equalization of tariffs for those at the lower levels of consumption, with the general objective of reducing the differential between the high tariffs of the outlying provinces and the lowest tariff in Lima. The FOSE subsidy rates are shown in Table 6.4 most households sampled in the Survey lie in rural and urban-rural zones.

[22] If one subtracts typical fixed charges from the average bill (10.34 soles –1.88 Soles (basic fixed charge) –1.0 soles (public lighting) – 0.64 Soles (connection maintenance) = 6.8 soles/month for the energy charge; divided by 13.25 kWh = 0.514 soles/kWh. Since this reflects at least a 50 percent FOSE discount, without FOSE the monthly bill would be 6.8 soles higher; therefore without FOSE the average price per kWh = (10.34 + 6.8)/13.25 = 1.3 soles/kWh.

Table 6.5

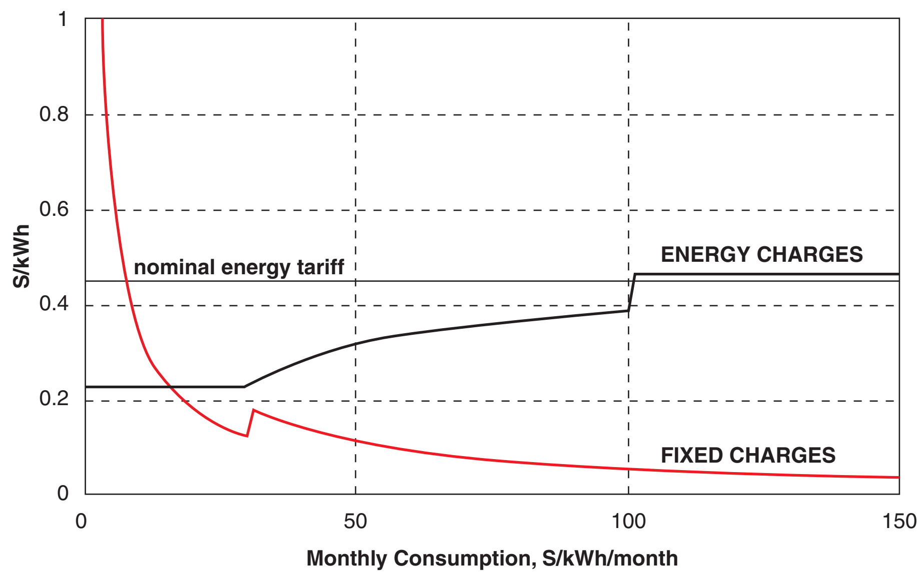
Number of Connections Benefiting from FOSE, 2004

Monthly Consumption	FOSE Benefit	Interconnected System	Isolated Systems	Total	Participation (%)
0–30 kWh	Yes	1,026,108	149,376	1,175,484	60.1
30–100 kWh	Yes	1,071,963	86,026	1,157,989	
>100 kWh	No	1,486,349	59,825	1,546,174	39.9
Total		3,584,420	295,227	3,879,647	100

Source: OSINERG Ayuda Memoria FOSE.

Figure 6.4

Components of the Tariff



Source: INEI, 2005.

Sixty percent of all customers benefit from FOSE (Table 6.5). The total FOSE transfer in 2004 was US$18 million (compared to a total consumer bill of US$600 million). The recovery mechanism increases bills to all consumers with consumption greater than 100 kWh/month by 2.5 to 3 percent.[23]

Tariff Structure

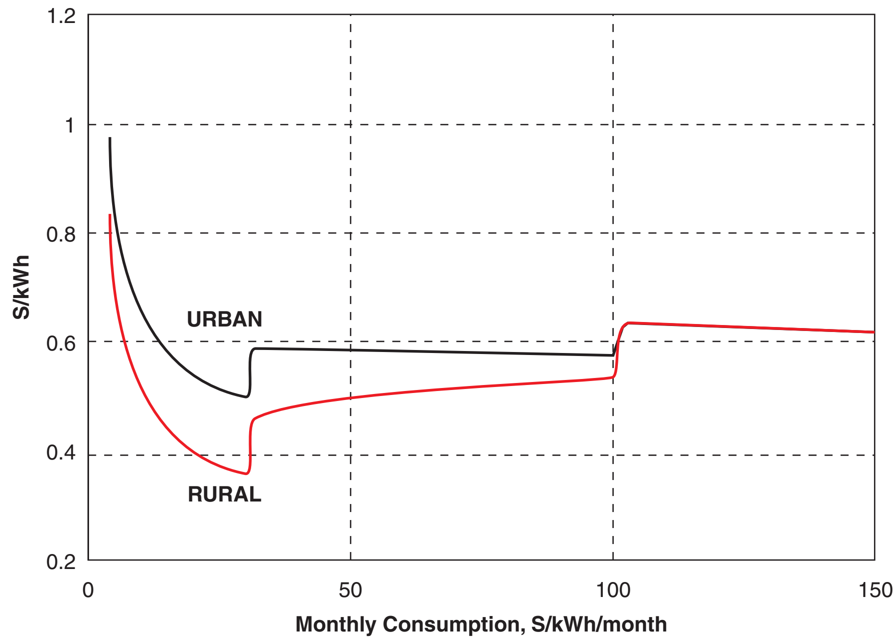
The tariff consists of an energy charge, as adjusted by FOSE, and a fixed charge (*cargo fijo*), a charge for public lighting (typically between 0.8 and 1 soles per month for consumption below 30kWh/month, and 2.8 to 3.0 soles per month for households with consumption greater than 30 kWh/month), and a connection maintenance charge (typically between 0.58 and 0.64 soles per month). These tariff components are illustrated in Figure 6.4.

For a given nominal energy tariff, the resulting tariff curves have the shape shown in Figure 6.5. However, in practice, urban and rural areas will in

[23]The FOSE accounts are rebalanced every quarter. The sum of the FOSE subsidy paid is recovered from consumers (in the regulated market) with consumption greater than 100kWh/month as an *ad valorem* surcharge. At the time of the survey in June 2005, the "FOSE *Factor de Recargo*" was 1.026.

Figure 6.5

Typical Tariff Curves



Source: INEI, 2005.

Table 6.6

Fixed Charges

	Fixed Charge	Public Lighting, <30kwh/Month	Public Lighting, >30 kWh/Month	Connection Charges
Electrosur	1.87–2.00	0.79	2.37	0.64
ElectroCentro	1.87	1.01	3.04	0.64
ENOSA	1.87	1.05	3.15	0.64
Hidrandina	1.88	0.87	2.58	0.67
ElectroOriente	1.87	1.24	3.81	0.64

Source: INEI, 2005.

general have different nominal energy tariffs, so the two curves do not in fact converge as suggested here.[24]

Table 6.6 shows the fixed charges for five distribution companies for which a sample of actual consumer bills have been obtained.

Although there is little variation in fixed charges, the nominal energy charge shows large variation across the country. This is in part due to the complexity of tariff setting, in which every major area has its own tariff based on the assignment of *sector tipicos* for distribution costs and for various power generation costs. There are five *sectors tipicos* based on the degree of urbanization. For example, sector 1 applies to Lima (high-density urban) while sector 5 is for rural areas.

[24]See Figure 6.6 for Electrosur, for example.

Thus, the OSINERG Annual Report lists 166 tariffs for the 20 regulated distribution companies, based on 133 distinct tariff schedules.

To cross-check the results from the Survey, a sample of actual consumer bills were obtained from five distribution companies. Table 6.7 shows the data from 12 such bills from Electrosur for April 2005 (a few months before the Survey was conducted in June 2005).

Several points may be noted:

- The 12 bills in the sample fall into one of two tariff categories: the first 8 households have a fixed charge (*cargo fijo*) of 1.87 soles/month and a variable charge of 0.3504 soles/kWh, and represent *urban* households; the second four have a fixed charge of 2.00 soles/month, and a variable charge of 0.449 soles/kWh, representing *rural* households.
- The FOSE discount in the first eight bills is a 25 percent discount on the first 30 kWh, and a 7.5 kWh discount for consumption in the 31.100 kWh/month range. The discount in the rural bills (columns 8–12) is a 50 percent discount on the first 30 kWh, and a 15 kWh discount on the subsequent tranche from 31 to 100kWh/month.
- Cost recovery for public lighting is a step function: Bills with more than 30 kWh of monthly consumption are charged 2.37 soles/month; those with less than 30 kWh/month are charged 0.79 soles/month.

The corresponding tariff curves are readily calculated. The monthly bill (including 19 percent VAT) T is

$$T = 1.19[F + A + M + (1 - \phi)\alpha Q_1 + \alpha Q_2 - \beta\alpha]$$

- T Monthly bill in soles
- F Fixed monthly charge, soles/month
- A Charge for public lighting, soles/month
- M Charge for maintenance of the connection, soles/month
- β FOSE discount applicable to bills with consumption of 30–100 kWh/month (= 7.5 for urban areas, 15 for rural and urban-rural areas), and zero if $Q2>100$
- ϕ FOSE discount applicable to the first 30 kWh of monthly consumption
- α Tariff variable charge, soles/kWh (before FOSE discount)
- Q_1 Monthly consumption if less than or equal to 30 kWh, zero if greater than 30 kWh
- Q_2 Monthly consumption if greater than 30 kWh/month, zero otherwise

from which follows the average cost per kWh, C, as

$$C = \frac{T}{Q_1 + Q_2}$$

The result for the two tariff regimes reflected in the billing data of Table 6.7 is shown in Figure 6.6. The actual sample points fall almost exactly on the predicted tariff curves. Such variation as remains is due to the small miscellaneous adjustments shown in Table 6.7.

This example, and the way that the tariff is structured, raise several issues for pricing policy:

- The jump (in both rural and urban tariffs) at the 30 kWh/households/month consumption threshold is due not to FOSE, but to the way in which public lighting is billed. Twenty-three percent of all households have monthly consumption between 20 and 40 kWh. These households are potentially affected by the tariff increment at 30 kWh/month.
- In the range of 31 to 100 kWh/month, the incentives in rural and urban areas are quite different. In urban areas, the average costs per kWh decline with increasing consumption, while in rural areas they increase.
- The size of the step increase at 100 kWh/month—due to the FOSE—is far greater in rural areas than in urban areas. Less than 3 percent of rural households reported consumption between 90 and 110 kWh/month. Hence, the pool of households whose consumption might be affected by the tariff increment at 100 kWh/month is quite small, and the question of the extent to which the present FOSE structure might distort consumption at around 100 kWh/month is of lesser importance.

The issue from the standpoint of pricing policy is whether the tariff jump at 30 kWh/month—a

Table 6.7

Sample Electricity Bills from Electrosur, April 2005

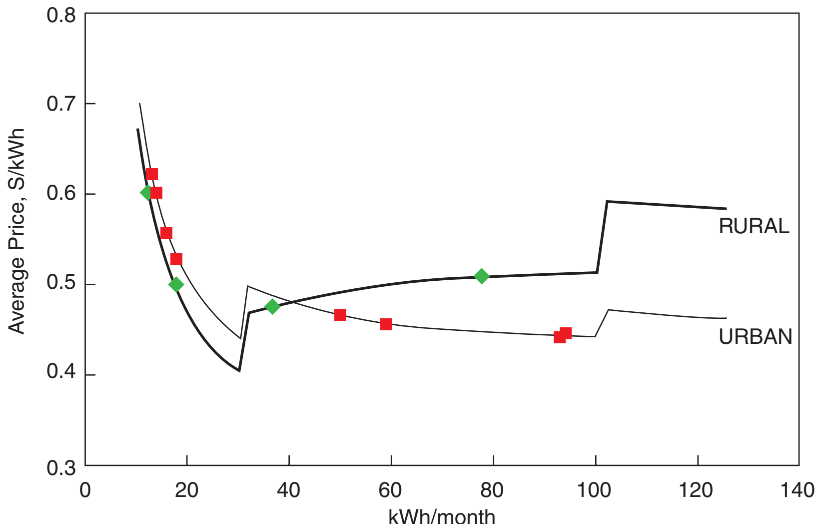
		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
consumption	[kWh]	94	18	50	14	59	13	93	16	18	78	12	37
first 30 kWh	[S/kWh]		0.2628		0.2628		0.2628		0.2627	0.2249		0.2249	
first 30 kWh	[S]	7.888		7.88		7.8793		7.8787			6.75		6.75
31–100 kWh	[S/kWh]	0.3504		0.3504		0.3504		0.3503			0.4498		0.4497
FOSE discount	[S]	2.63	1.58	2.63	1.21	2.63	1.14	2.63	1.4	4.05	6.74	2.7	6.74
cargo fijo	[S]	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	2	2	2	2
energy	[S]	30.31	4.73	14.89	3.68	18.04	3.42	29.95	4.2	4.05	28.34	2.7	9.9
public lighting	[S]	2.37	0.79	2.37	0.79	2.37	0.79	2.37	0.79	0.79	2.37	0.79	2.37
Mant. y Reposic de C	[S]	0.64	0.58	0.58	0.64	0.58	0.64	0.64	0.58	0.64	0.64	0.64	0.64
interes compensatorio	[S]			0.03	0.05		0.06		0.04	0.05	0.12	0.11	
Aj AL PUB	[S]	0.06		0.13	0.04						0.06		
total	[S]	35.25	7.97	19.87	7.07	22.86	6.78	34.83	7.48	7.53	33.53	6.24	14.91
VAT	[%]	19.0%	19.0%	19.0%	19.0%	19.0%	19.0%	19.0%	19.0%	19.0%	19.0%	19.0%	19.0%
	[S]	6.70	1.51	3.78	1.34	4.34	1.29	6.62	1.42	1.43	6.37	1.19	2.83
Aj AL PUB	[S]									0.02		0.01	
comp.Int I/I	[S]							–0.33					
Int.Moratorio	[S]									0.01		–0.20	
total facturado	[S]	41.95	9.48	23.65	8.41	27.20	8.07	41.12	8.90	8.99	39.90	7.24	17.74
average S/kWh	[S/kWh]	0.45	0.53	0.47	0.60	0.46	0.62	0.44	0.56	0.50	0.51	0.60	0.48

Source: INEI, 2005.

Notes: Mantenimiento y Reposición Conexión (Connection Maintenance and Replacement) refers to the charge for maintenance and replacement (at the end of its service life) of the service drop and meter that belongs to the customer. *Interes Compensatorio* (Compensation Interest) refers to interest paid in case of delay in payment of the bill. *AJ.AL.PUB* refers to an adjustment in the public lighting charge.

Figure 6.6

Average Cost/kWh, Electrosur



Source: INEI, 2005.
Note: The square boxes represent the urban households in, the diamonds the rural households.

consequence of the way that public lighting is billed—significantly discourages households from increasing their consumption from less than (or equal to) 30 kWh/month to more than 30 kWh/month. Figure 6.7 suggests that, indeed, the consumption in the 30 to 35 KWh/month interval is smaller than would be expected from a smooth regression of consumption.

However, when the deviations between 25 To 35 kWh/month are compared to other parts of the frequency distribution curve, similar deviations from a smooth consumption curve (for example between 40 and 60 kWh/month) make it more difficult to argue that the first deviation is actually caused by the tariff jump at 30kWh/month. In short, there is no evidence that the present billing practice limits consumption to below 30 kWh/month.

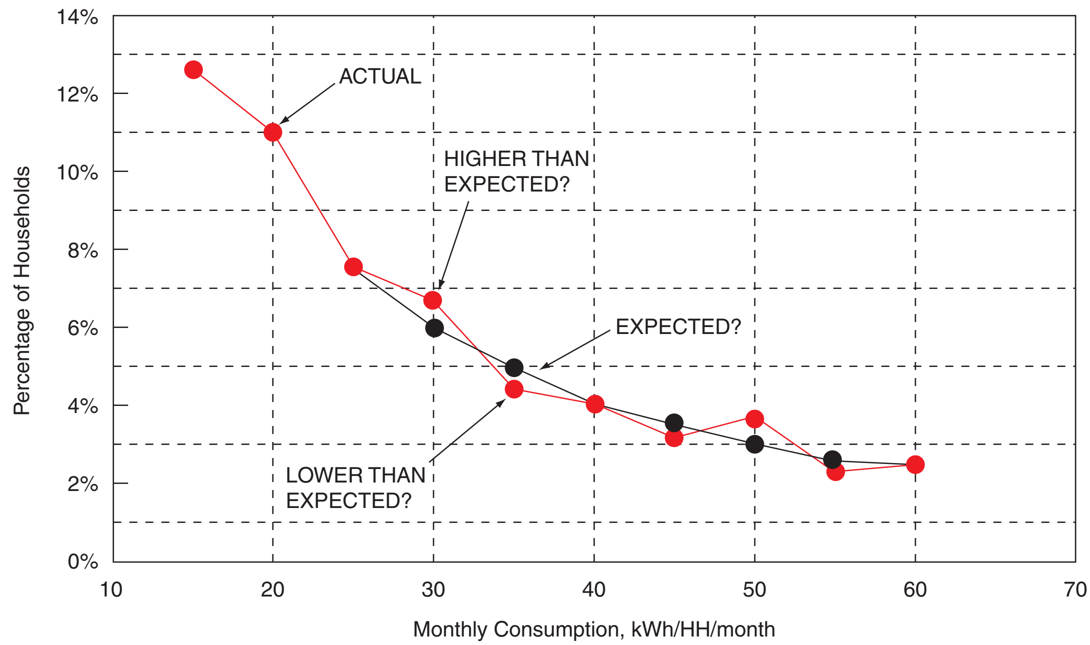
Targeting Performance of FOSE

There is no question that FOSE significantly reduces the energy charge to rural consumers (by 50 percent if supplied by the interconnected system, 62.5 percent in the case of isolated systems) (Figure 6.8). However, marginalized end-users who consume less than 15 kWh/month (the average monthly consumption of the poorest quintile is 13.3 kWh) benefit much less in terms of the value of the subsidy in Soles than the average consumer with 25 to 35 kWh/month, because at low consumption levels it is the *fixed charges* that dominate the bill. The fixed charges are *not* subject to FOSE.

Indeed, recent research raises some questions about the targeting performance of cross-subsidies such as FOSE to achieve lifeline rates (Komives et al. 2005). The effectiveness of a subsidy to reduce income inequality can be gauged by the proportion of each sole of subsidy that reaches the poor. Since the Survey does not cover urban areas, the overall targeting performance of the FOSE cannot be assessed. However, one can assess the targeting performance within rural households as a whole by calculating how much of the total FOSE transfer reaches the poorer rural households. Using the tariff curves discussed above, the FOSE benefit received by households in each quintile can be assessed and the

Figure 6.7

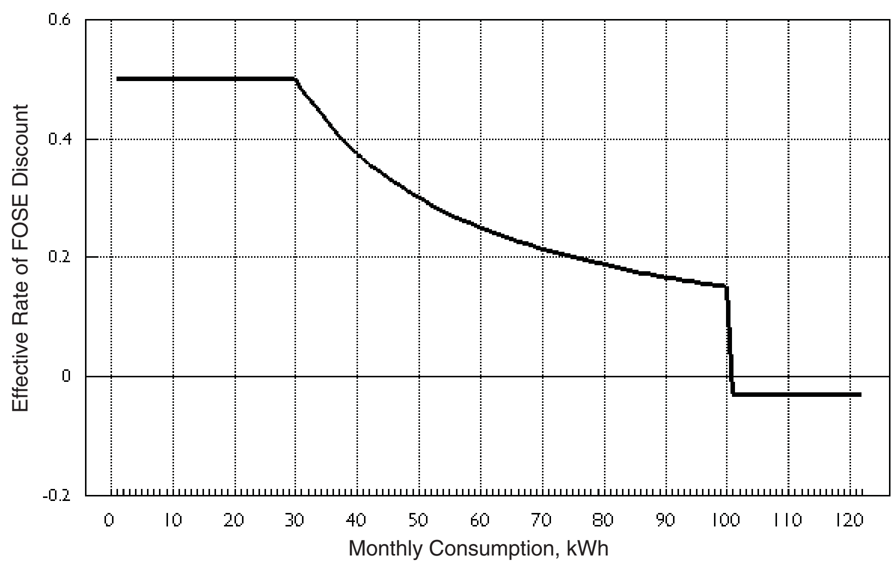
Proportion of Households Reporting Given Levels of Consumption



Source: INEI, 2005.

Figure 6.8

Effective Rate of FOSE Discount



Source: INEI, 2005.

Table 6.8

Targeting Performance for FOSE Transfer

Expenditure Quintile	Average kWh/Month	Average FOSE Benefit, Soles/kWh	Average FOSE Benefit, Soles/Month/ Household	% of Total FOSE Benefit
1 (Poorest)	14.5	0.27	3.9	7.7
2	19.1	0.25	4.8	12.2
3	30.1	0.21	6.4	22.0
4	37.8	0.18	6.7	25.5
5 (Richest)	58.1	0.11	6.4	32.6
All	36.8	0.27	5.9	100

Source: INEI, 2005.

total benefit that accrues to each expenditure quintile can be calculated.[25]

The results of the targeting performance calculations are shown in Table 6.8. Households in the lowest quintile capture only 7.7 percent of the total FOSE subsidy received by all rural households, yet this quintile constitute 20 percent of all households. The highest quintile captures 32.6 percent of the benefit. Indeed, households in the top quintile get an average benefit of 6.4 soles/month, versus 3.9 soles/month in the bottom quintile. In short, the targeting performance of the FOSE is poor.

These results are consistent with the findings of a recent OSINERG study (Gallardo and Bendezu 2005). The study found that a significant proportion of the total subsidy reaches the nonpoor, though it also found that errors of exclusion and inclusion[26] are lower in rural than in urban areas.

The impact of a revenue-neutral adjustment on targeting performance is readily simulated. If the total FOSE subsidy to rural households is held constant, the FOSE discount on qualifying households could be raised. For example, if the FOSE were phased out at 50 kWh/household/month rather than 100 kWh but the rate of the discount was held constant, the fraction of the subsidy captured by the lower quintiles would increase. The top quintile's share would decline from 33 to 23 percent and the bottom quintile's share would increase from 8 to 11 percent.

Additional improvements in the targeting performance could be achieved by further lowering the FOSE cap. If the 50 percent discount was limited to 15 kWh/month and phased out completely at 25 kWh/month, the share of benefits going to the lowest quintile would be 19 percent, while the richest quintile would receive less than 10 percent.

Efficient Lighting

As noted earlier, the poor use electricity very inefficiently for lighting. Because they cannot afford the higher cost of fluorescent lights, most of their lighting is provided by incandescent bulbs that consume four times the kWh per lumen than do fluorescent lamps. In fact, 46 percent of electrified rural households in Peru report only incandescent lights.

The *economic* case for linking future rural electrification projects with an efficient lighting program is compelling. The rate of return on replacing an incandescent bulb with a CFL, under conservative assumptions, is 100 percent (Box 6.1.) This is significantly higher than the economic returns

[25]This is done by: (1) subtracting from each monthly expenditure the fixed charges; (2) estimating the average energy charge; (3) applying the rate of FOSE discount to each household's monthly kWh consumption—which is either 50 percent or 62.5 percent of the average energy charge for rural customers, depending upon whether the customer is served by the interconnected system or an isolated system; (4) calculating the aggregate amount of the FOSE transfer received; and (5) sorting the FOSE amounts by expenditure quintile.

[26]The *error of exclusion* is the fraction of the poor that do *not* benefit from a subsidy; the *error of inclusion* is the fraction of the nonpoor that *do* benefit from a subsidy.

Box 6.1

Rate of Return for Replacement of Incandescent Lighting with CFLs

Compact fluorescent lamps (CFLs) are typically guaranteed for 8,000 hours. At 3 hours of use per day, a 15-watt CFL should last 7 years. The equivalent incandescent bulb typically lasts from 500 to 4,000 hours, depending on exposure to voltage spikes. If the economic cost of electricity delivered to the distribution company is taken at US$0.04/kWh (actual costs are in the range of 0.13 to 0.3 soles/kWh, or US$0.04 to 0.09/kWh), a cost of $2.75 for a 15 watt CFL, and US$0.75 for a 60 watt incandescent, then the rate of return can be calculated as shown in Table A.

Table A

Rate of Return Calculations for Replacement of Incandescent Bulbs with CFLs

	Year	0	1	2	3	4	5	6	7
Assumptions									
Cost of electricity	US$/kWh		0.04	0.04	0.04	0.04	0.04	0.04	0.04
Usage per day	Hours/day		3	3	3	3	3	3	3
Usage per year	Hours/year		1,095	1,095	1,095	1,095	1,095	1,095	1,095
Cumulative hours	Hours		1,095	2,190	3,285	4,380	5,475	6,570	7,665
15-Watt CFL									
Energy	kWh/year		16.4	16.4	16.4	16.4	16.4	16.4	16.4
Cost of electricity	$		0.657	0.657	0.657	0.657	0.657	0.657	0.657
CFL cost	$	2.75							
Total costs	$	2.75	0.657	0.657	0.657	0.657	0.657	0.657	0.657
60-Watt Incandescent									
Energy	kWh/year		65.7	65.7	65.7	65.7	65.7	65.7	65.7
Cost of electricity	$		2.628	2.628	2.628	2.628	2.628	2.628	2.628
Incandescent cost	$	0.75			0.75			0.75	
Total costs	$	0.75	2.628	2.628	3.378	2.628	2.628	3.378	2.628
Net Flows	**$**	**–2.00**	**1.97**	**1.97**	**2.72**	**1.97**	**1.97**	**2.72**	**1.97**
Rate of Return	%	**103%**							

The estimated return of 103 percent is conservative insofar as the capacity benefits and avoided distribution losses are ignored.

on rural electrification *per se* (which is in the range of 26 to 59 percent for individual schemes, according to the World Bank's Peru Rural Electrification Project (2005b) economic analysis). It necessarily follows that including an efficient lighting component would improve the aggregate economic returns.

The impact of an efficient lighting scheme on the finances of distribution companies would also have to be analyzed. The key question would be whether households with fluorescent lights would have lower electricity bills than those with incandescent lights (i.e., the savings from efficient lighting would be spent on nonenergy items), or whether household energy expenditure would be roughly the same (i.e., savings from efficient lighting would be spent on more TV, radio, or appliance use).

Table 6.9 shows that households with only fluorescent lamps spend *more* per month on their *total* electricity bill than households with incandescent lamps only—a finding that is common to *all* quintiles.

Table 6.9

Average Monthly Electricity Bill, Soles/Month

	Households with Fluorescent Lamps Only	Households with Both Fluorescent and Incandescent Lamps	Households with Incandescent Lamps Only
1 (Poorest)	9.0	8.1	7.6
2	9.7	10.3	7.4
3	13.2	12.7	10.2
4	16.4	15.5	11.3
5 (Richest)	25.7	23.4	14.1

Source: INEI, 2005.

In other words, households that use the more efficient lighting may value electricity more (and therefore spend more of their income on electricity) than households that use inefficient incandescent lighting.

In urban areas, where consumption levels are much higher, worldwide experience with efficient lighting programs shows a reduction in consumption (and peak demands). Indeed, the energy conservation impact is the principle rationale. But in poor rural areas where household budget constraints limit electricity use, the evidence of the Survey suggests that this might not necessarily be true.

But does this finding negate the argument of high *economic* returns, which are premised on energy savings? The answer is no: There is clearly an increase in household welfare if for the same number of kilowatt-hours of electricity, higher levels of service (more lighting, more TV viewing, more radio, or other uses) are obtainable.

Clearly, the incremental capital costs of providing CFLs to consumers as part of a rural electrification scheme are small. Rural electrification costs per household are between US$445 and $600, so an additional US$8 to $9 for three CFLs per household would have little impact on rural electrification project budgets.

Issues for Further Research

The results of the Survey suggest a number of areas that would benefit from further research, to assist in developing policies of rural electrification. Examples of areas for further research could include the following:

- *Reasons for low electricity consumption*. These could include cultural preferences, lack of resources to buy appliances, lack of easily available appliances in rural areas, or lack of promotion of electricity use in rural areas by the distribution companies and authorities.
- *Reasons for low number of solar home systems in rural areas*. These could include a lack of promotion by government authorities, donor agencies and commercial solar photovoltaic companies.
- *Ways to promote productive electricity use*. Given the low level of usage of income-generating equipment reported in the Survey, it would be useful to investigate how productive uses of electricity could be best be promoted, including experiences in other countries.

Conclusions

This chapter uses data from the Survey to consider policy issues relevant to the creation and sustainability of rural electrification programs:

- *Connection rates in electrified villages.* Almost one-quarter of households without electricity are in villages that are electrified. The most common reason given for non-connection in these villages is the upfront costs of connection, wiring, and equipment. The financial sustainability of projects is strongly influenced by connecting as many households as possible, from which follows that connection costs, perhaps including house wiring, should be part of the overall cost eligible for subsidy.

- *Distribution of electricity consumption by village.* An indicative consumption threshold of 22 kWh/household is used in this report for whether most rural electrification schemes would be financially viable. Although the average consumption in 374 electrified villages is 35 kWh/household/month, these averages show significant variation across regions. In the Andean South region, the average is only 15 kWh/household/month. As in the case of individual households, the regional differences in consumption can be explained by regional differences in income.
- *Growth of electricity consumption.* One of the important assumptions in making financial projections of the viability of rural electrification projects is the rate of growth in consumption. At least based on the experience of those communities prioritized by the current scheme (often the poorest and most lacking in infrastructure access), there is no evidence that annual consumption growth per connected household would be much higher than the commonly assumed 0.5 to 1.0 percent per year.
- *Pricing policy.* Those who consume small amounts of electricity pay relatively high prices per kWh, notwithstanding the FOSE mechanism. Households in the lowest quintile capture only 7.7 percent of the total FOSE subsidy received by all rural households, yet this quintile constitutes 20 percent of all households. The highest quintile captures 32.6 percent of the benefit. In short, the targeting performance of the FOSE is poor. Additional improvements in the targeting performance could be achieved by further lowering the FOSE cap. If the 50 percent discount were limited to 15 kWh/month and phased out at 25 kWh/month, the share of benefits going to the lowest quintile would be 19 percent, while the richest would receive less than 10 percent.
- *Efficient lighting.* The economic case for linking future rural electrification projects with an efficient lighting program using compact fluorescent lamps (CFLs) is compelling. Rural electrification costs per household are between US$445 and $600, so an additional $8 to $9 for three CFLs per household would have little impact on rural electrification project budgets.

Annex 1

Survey Design and Methodology

This annex has two main sections relevant to the design and methodology of the Peru National Survey of Rural Household Energy Use (henceforth known as the Survey). The first section discusses the survey sample, weighting and estimation procedures, questionnaire design, and implementation of the Survey. Annex 4 contains the complete questionnaire. The second section compares the Survey with the National Household Survey (*Encuesta Nacional de Hogares*, ENAHO).

Survey Design

It is essential to point out that the definition of rural population center used in the National Survey of Rural Household Energy Use is different from that used by INEI in the census. The definition used by INEI for the purpose of the census is that rural population centers are those with less than 100 dwellings grouped contiguously. The definition used in the National Survey of Rural Household Energy Use for rural population centers are those with less than 1000 dwellings grouped contiguously, a definition that better represents the target population for rural electrification programs. This difference in definition of rural population centers means that the data from this survey cannot be directly compared with data from the census of other surveys conducted by INEI.

The Survey covered 6,690 electrified and nonelectrified households in rural areas of Peru. This sample is large enough to allow for reliable estimations about the survey population. The fieldwork was conducted in seven regions: the Coastal North, Coastal Central, Coastal South, Andean North, Andean Central, Andean South, and Amazon regions. In each of these study regions, a stratum was assigned that was proportional to the number of houses. There are three stratifications: *peri-urban* aggregations of 401–1000 houses, *semi-rural* aggregations of fewer than 401 houses, and *dispersed rural* aggregations of population centers located in the interior of so-called *Areas de Empadronamiento Rural* (AER).[27] Once the stratifications were made for each study region, sample conglomerates were chosen. Each conglomerate is a geographic area with approximately 100 houses. The selection of the conglomerate sample in each stratum was random, and proportional to the number of houses in the stratum. Finally, in each conglomerate of the sample, 15 houses were randomly selected.[28] Table A.1.1 depicts the distribution of the sample size by region.[29]

Table A.1.1

Distribution of the Sample Size

Region	Sample Conglomerates	Sample Houses	Expected Standard Deviation (CV)
Coastal North	64	960	0.032
Coastal Central	64	960	0.050
Coastal South	48	720	0.038
Andean North	66	990	0.021
Andean Central	68	1,020	0.029
Andean South	68	1,020	0.024
Amazon	68	1,020	0.022
Total	446	6,690	

Source: INEI, 2005.

Consequently, the sample type is probabilistic, stratified by areas, two-staged, and independent in each region of the study. In light of the fact that the number of households selected in each study region is also proportional to the total population of that geographic

[27] This stratification is only utilized for sampling effects and not necessarily to obtain results for these levels. The AER is the geographic area conformed by a group of semidispersed houses that has, on average, 100 independent houses. These houses are grouped in one or more than one population center.

[28] These conglomerates can be made up of one or several communities, depending on the size of the population.

[29] The final database contains 6,476 records, 214 records having been found nonresponsive or otherwise unusable.

area, the Survey data are representative at the regional and national level.

The questionnaire and survey methodology were designed to obtain information on the demand and use of electricity in rural areas of Peru and collect detailed data for an analysis of the economic and financial aspects of rural electrification in Peru (see Annex 4) Data Weighting Procedures.

The estimation methodology to process the Survey data involved the usage of a weight or expansion factor that is multiplied by all the data of each register in the database. The final factor for each register has two components: the Basic Expansion Factor and the Adjusted Factors for no response.

The Basic Expansion Factor (*Wi*) for each sample home is determined by the sample design and equivalent to the inverse of the probability of final selection:

$$Wi = 1/f$$

In order for the estimations derived from the Survey to be representative of the population, it is necessary to multiply data from each sample home contained in the database by the weight or expansion factor calculated according to the sample design. Likewise, it is important to adjust the expansion factors keeping in mind the magnitude of the nonresponse. Given that the expansion factors are calculated at the level of each conglomerate, it is advantageous to adjust the expansion factors to this level.

Table A.1.2 shows a comparison of weighted versus unweighted data for total kilowatt-hour (kWh) consumption. An obvious question is why (with one exception) the weighted estimates are lower not just for the national average, but even *within* each region.

Table A.1.2

Weighted versus Unweighted Estimates of kWh/HH/Month

Region	Unweighted [1]	Weighted [2]	Difference [3]
Coastal North	38.4	38.3	–0%
Coastal Central	60.8	61.7	2%
Coastal South	59.6	59.1	–1%
Andean North	23.0	21.7	–6%
Andean Central	27.4	26.9	–2%
Andean South	18.9	16.7	–13%
Amazon	34.2	31.6	–8%
All Households	38.9	27.2	–35%

Source: INEI, 2005.

The difference between weighted and unweighted data at the regional level is very small for the three Coastal regions (2 percent or less), but much higher for the others (2–13 percent). The difference in the national average, however, is 35 percent. The explanation for the large difference in the *national* average is simple: The Andean regions (with low consumption) are underrepresented in the sample, while the Coastal regions (with high consumption) are overrepresented. Hence, the lower national average reflects the dominance of the Andean regions in the total population, giving them greater weight in the overall average.

Estimation of Standard Errors and Confidence Interval

For the current Survey, the sample errors of the estimations of the principal survey variables were calculated using the Variation Calculation System (CENVAR), which provided the estimators for sample variation for population parameters for the different regions of the estimation. The precision of the estimation was measured through the sampling error, calculated statistically from the sample data, and determined by the standard deviation:

$$C = \frac{T}{Q_1 + Q_2}$$

A simple manner to interpret the sample error of an estimation performed from the Survey is presented in terms of the *confidence interval*. The confidence interval of the Survey is 95 percent and it was calculated in the following manner:

$$p \pm 1.96 * s$$

The standard error was also used to obtain the *variation coefficient (CV)*, also known as standard relative error. The CV allows the user to evaluate the precision of the estimator in relative terms (see Table A.1.1 for the estimated variance of the sample by region).

Confidence limits are calculated from the standard form:

$$x \pm 1.96\left[\frac{\sigma}{\sqrt{n}}\right]$$

where n is the sample size, x is the estimated sample mean, and s is the sample standard deviation.

Questionnaire Design and Conduct of the Survey

The questionnaire was developed with input from the National Institute of Statistics and Information Technology

(INEI). The Technical Directorate of Demographics and Social Indicators of INEI was responsible for executing the fieldwork from April through July 2005 in the 24 *departamentos* of Peru. The Technical Directorate was also in charge of the data processing.

The questionnaire was drafted and revised by both the World Bank team and the MEM. Adjustments were made to the health, energy use, time use, and income sections of the initial survey, which was then tested in the field. In April 2005, the questionnaire was piloted in rural villages in three different geographic regions of Peru: Ica (Coastal), Huancayo (Andean), and Chanchamayo (Amazon). Discussions were held with the surveyors during the pilot survey implementation to identify problematic questions and difficulties that arose in the field and to eliminate any confusion. The questionnaire was then revised based on feedback from the surveyors and lessons learned in the field. The final survey questionnaire was designed to collect very detailed information on energy use and consumption.

In May 2005, the World Bank held a training session with the survey supervision team at INEI, which was followed by a six-day workshop held in Lima by INEI for the surveyors hired to execute the final Survey. A total of 75 surveyors and 24 supervisors (one for each *departamento* of Peru) were selected to implement the survey. Generally, teams included surveyors who were native to the area or who had prior work experience in the area to which they were assigned. Regional INEI offices and the regional supervisors provided additional support to the survey teams. The central INEI office in Lima was responsible for providing the statistic and cartographic information, providing technical and logistical support, and delivering the final survey results.

Completed survey forms were sent to the regional INEI office in Arequipa, where the data entry was performed. Once completed, the survey results were sent back to Lima, where INEI took additional steps to check the accuracy of data entry. The final data editing and preparation for data analysis was performed and completed in Washington, DC.

Household Energy Questionnaire Outline

The following is an outline of the survey questionnaire. The full survey questionnaire is included in Annex 3.

- 100. Characteristics of the House and Household
- 200. Characteristics of the Household Members
- 300. Sources of Energy
    - *Section 1: Use of Electricity from Interconnected Grid and Isolated System*
    - *Section 2: Use of Kerosene*
    - *Section 3: Use of Candles*
    - *Section 4: Use of Dry Cell Batteries*
    - *Section 5: Use of Car Batteries*
    - *Section 5: Use of LPG*
    - *Section 7: Use of Solar PV Home System*
    - *Section 8: Electric Generator Set*
    - *Section 9: Use of Firewood*
    - *Section 10: Use of Agriculture Residue*
    - *Section 11: Animal Dung*
    - *Section 12: Use of Cooking Stove and Cooking*
- 400. Productive Equipment
    - *Section 1: Electric Pumps*
    - *Section 2: Diesel Pumps*
- 500. Time Use
- 600. Household Income
    - *Section 1: Income from Work*
    - *Section 2: Income from Agricultural Activities*
    - *Section 3: Income from Livestock Activities*
    - *Section 4: Income from Fisheries*
    - *Section 5: Other Income*
    - *Section 6: Household Expenditures*
- 700. Attitude
- 800. Business Module
    - *Section 1: Basic Characteristics of the Business or Establishment*
    - *Section 2: Financing Sources for Business*
    - *Section 3: Uses of Motors (Motive Power) in Business*
    - *Section 4: Income from Business*
- 900. Opinion and Attitude on Energy and Business

Comparison between the National Survey of Rural Household Energy Use and the National Household Survey

This section compares the estimates of energy expenditures and total household expenditures obtained by the National Survey of Rural Household Energy Use (the Survey) described in the main text of this report with those from the ENAHO, a national household survey done by INEI every year to estimate socioeconomic characteristics and poverty conditions in Peru.

This exercise is performed even though it is clear that the Survey and the ENAHO are not strictly comparable. First, the ENAHO is carried out continuously throughout the year, while the Survey was implemented during June and July of 2005, which creates seasonality issues that are beyond the scope of this study. In addition, the ENAHO data used here are from 2004. Second, the sampling design and sample size are different. In particular, as noted under the Survey Design section, the definition of rural populations is different. Although the ENAHO accumulates information from 8,240 households throughout the year, the Survey interviewed 6,776 households. Third, and perhaps most importantly, the questionnaire designs differ because each survey pursues a different objective. The Survey contains much more detail on energy use, expenditures, and demand. As a result, the Survey estimates of energy consumption are more accurate. Due to these differences, the two studies are compared to identify similar trends, rather than to prove or disprove actual values.

Income information from the Survey was not included in the analysis because the Survey did not collect as detailed information as the ENAHO, meaning that the Survey income figures are lower than the ENAHO ones. The ENAHO collects both monetary and nonmonetary income data and imputes many values that are not collected in the Survey. For example, a significant component of ENAHO's income estimation comes from the opportunity cost of house rental for families who own a house. For these reasons, it was decided that the income figures in the ENAHO and the Survey are not strictly comparable. A more reliable estimate of household socioeconomic well being in both surveys is total household expenditure. The aggregate estimates for energy expenditure in the Survey—that is, considering all types of energy used by the household—results in 34.3 soles per month, while the ENAHO estimate is 14.6 soles per month. This difference of approximately 20 soles between the two surveys is mainly explained because the Survey captured almost 4 soles more of electricity expenditure, 6 soles more of LPG expenditure (three times than ENAHO estimates), and 2.2 soles more of fuelwood expenditures. In addition, almost 5 soles of difference comes from energy expenditures that only the Survey collects—that is, dry cell batteries, car batteries, and electric generators (small generators).

The details of the estimates are summarized in Table A.1.3 As seen in this table, when looking at each of the total energy expenditure components, there are

Table A.1.3

Comparison of Monthly Energy Expenditure and Total Cash Expenditure between the ENAHO and the Survey

	ENAHO					Survey				
		Expenditure Users		Expenditure All			Expenditure Users		Expenditure All	
Type of Energy Expenditure (EE)(1)	% Users	*N*	Mean	*N*	Mean	% Users	*N*	Mean	*N*	Mean
Electricity	31.6	2,607	13.8	8,240	4.4	45.6	2,954	18.27	6,476	8.33
Kerosene	52.6	4,338	7.7	8,240	4.1	50.5	3,271	11.9	6,476	6.00
LPG	10.5	862	28.0	8,240	2.9	26.9	1,745	34.4	6,476	9.26
Candle	23.3	1,923	4.9	8,240	1.1	56.6	3,666	3.6	6,476	2.02
Coal	0.7	61	20.3	8,240	0.2					
Fuelwood	9.3	765	17.1	8,240	1.6	13.1	849	29.6	6,476	3.88
Diesel	2.5	205	9.0	8,240	0.2					
Gasoline	0.2	15	41.5	8,240	0.1					
Dry cell battery						68.4	4,432	5.2	6,476	3.58
Car battery						13.8	894	7.9	6,476	1.1
Small generator						0.4	26	36.4	6,476	0.15
EE whole sample including zeros or missings(1)				8,240	14.6				6,476	34.3
Other Cash Expenditures(2)				8,240	375.1				6,476	375.6
Total Cash Expenditures(3)				8,240	389.6				6,476	409.9

Source: ENAHO 2004, four quarterly rounds, INEI, 2005.

(1) Households with missing values in any of the variables of the Energy Expenditure variables were recoded with zero.

(2) Includes cash expenditure from food, dress, clothing, investment in HH, furniture and equipment, house, conservation, health care and medical services, transportation and communication, leisure and entertainment, and others. Does not include self-consumption, self-supply, expenditure in agriculture activities, and livestock.

(3) Result of adding EE and Other Cash Expenditures.

similar tendencies in the average values and in the proportion of users from both surveys. Perhaps the most intriguing difference is the share of LPG and candle users. In ENAHO, only 10.5 percent of the households mention LPG expenditures, while in Survey, almost 30 percent of the households mention LPG expenditures. By contrast, in ENAHO, 23 percent of households reported spending money on candles versus 56.6 percent of households in Survey. These facts contribute to the higher Survey estimates of total energy expenditures.

One way to verify that the energy expenditure estimates in the Survey are accurate is to discount the energy expenditure estimates from the total cash expenditure in both surveys and compare the results. The resultant variable is called "Other Cash Expenditures." As shown in Table A.1.3, the average estimate of this variable in both surveys is almost the same: 375.1 soles in ENAHO and 375.6 soles in the Survey. In short, it is possible to confirm that the Survey has collected valuable and accurate information concerning energy consumption and also reliable information about total household expenditures when excluding energy expenditures. At the same time, these results provide support for the construction of the indicator: share of energy expenditures to total household expenditures, which is commonly used to perform country comparisons.

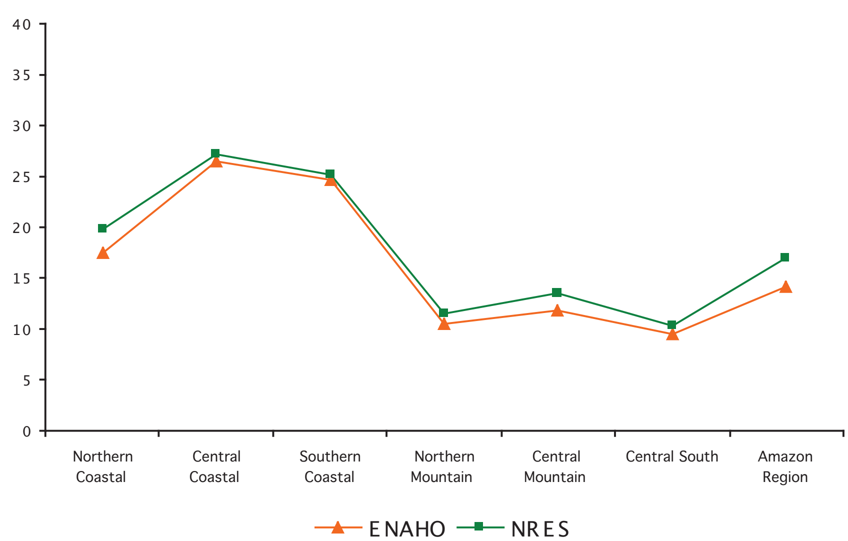
Energy Expenditures (Electricity, Kerosene) by Region

Electricity and kerosene are two of the most commonly used energy sources for rural households, so it is important for policy makers to analyze their consumption in detail. However, the question arises about whether similar trends in electricity and kerosene expenditures as those observed at the national rural level between the two surveys maintain when desegregating the data at the regional level. This section performs these comparisons. Results confirm similar regional behavior for electricity and kerosene expenditures. In addition, the average difference in the absolute values of the variables is only 4.4 soles lower for electricity expenditure and 4.1 soles lower for kerosene expenditure in ENAHO. This variation is expected since the Survey has more detailed questions to collect information about energy expenditures. In addition, part of the difference could be explained by issues such as seasonality and distinct sampling design objectives.

Electricity. Figure A.1.1 helps to visualize the electricity expenditure trends between the two surveys. In general, it is possible to confirm that estimates move in the same direction when data are desegregated by region. In respect to the absolute values, two regions, Central Coastal and Southern Coastal, have the smallest difference, 0.6 soles and 0.5 soles, respectively, whereas ENAHO has the lower

Figure A.1.1

Monthly Household Electricity Expenditure by Region (Users Only)



Source: ENAHO 2004, four quarterly rounds, INEI, 2005.
Note: The NRES refers to the Survey.

monthly electricity expenditure figures. This difference can be visualized in Figure A.1.1 as the gap between the two lines.

The Amazon region has the highest disparities between the electricity estimates. The monthly expenditure for the ENAHO survey is 2.8 soles lower than the Survey. One possible explanation is that the Survey may have surveyed more semirural households—those who use electricity more intensively—due to the geographic difficulties involved for surveyors to reach the most isolated households in the Amazon region.[30]

Table A.1.4 shows detailed information for estimated values and percentage differences from the two surveys. It is important to note that in the ENAHO survey, there is a higher frequency of households in regions with low levels of electricity expenditure, while the inverse is true for the Survey. These different frequencies arise due to the distinct sampling design of each survey. Consequently,

Table A.1.4

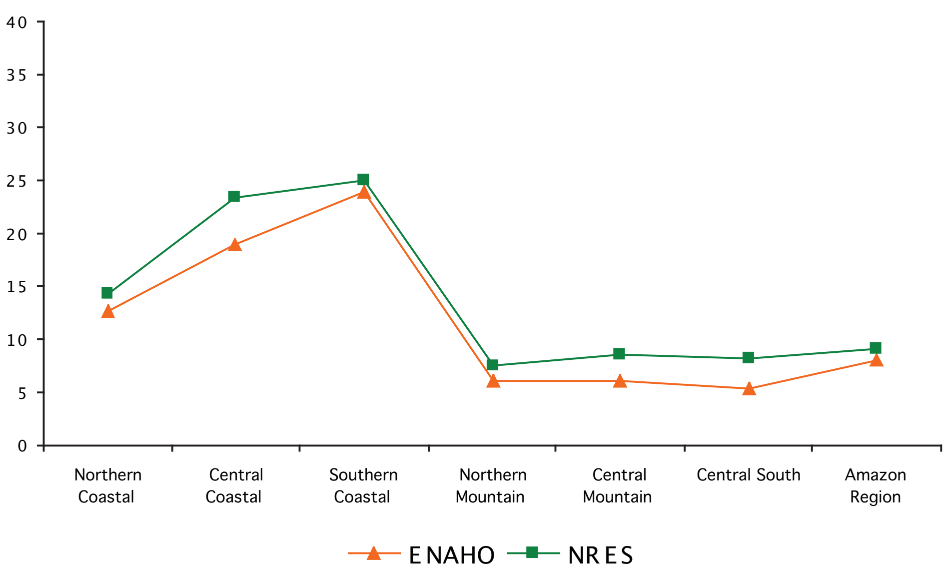
Monthly Household Electricity Expenditure by Region (Users Only)

	ENAHO		Survey		
Region	Mean (soles)	N	Mean (soles)	N	Difference (soles)
Coastal North	17.5	259	19.9	371	2.3
Coastal Central	26.5	192	27.1	565	0.6
Coastal South	24.6	117	25.1	445	0.5
Andean North	10.5	123	11.4	311	0.9
Andean Central	11.8	764	13.6	540	1.8
Andean South	9.5	669	10.3	453	0.8
Amazon	14.2	483	17.0	269	2.8
Total Rural Peru	13.8	2,607	18.3	2954	4.4

Source: ENAHO 2004, four quarterly rounds, INEI, 2005.

Figure A.1.2

Monthly Kerosene Expenditure by Region (Users Only)



Source: ENAHO 2004, four quarterly rounds, INEI, 2005.

Note: The NRES refers to the Survey.

[30] Isolated Amazon areas are also very dangerous not only because of drug trafficking, but also because the communities themselves are reluctant to have contact with people outside their communities. A few months prior to the Survey implementation, four health professionals from the Ministry of Health were assassinated by native people from Tagkijap community (El Comercio, 05/21/2005).

there is a difference in the total rural electricity expenditure estimates of 4.4 soles.

Kerosene. Results of the kerosene expenditure comparison are very similar to electricity expenditures. The average variation in the absolute values is a lower kerosene expenditure of 4.1 soles in the ENAHO. Differences at the regional level can be observed in Figure A.1.2. The estimates for this variable are especially close in the Coastal North and South regions as well as in the Amazon and Andean North regions. Disparities for these regions are less than 1.5 soles. In contrast, the Central Coastal and the Andean South regions present the highest disparities. Despite these differences, it is clear that similar tendencies exist among the regions for kerosene expenditure estimates.

Table A.1.5 shows detailed information for estimated values and percentage disparities from the two surveys. As in the case of electricity, the same patterns can be observed here: the total average kerosene expenditure is 4.1 soles lower in ENAHO mainly because the households from this survey are concentrated in regions with lower expenditures as a result of the survey's distinct sampling design. Indeed, when looking at the regional level, only the Coastal Central region presents a difference that is close to the total rural expenditure (4.5 soles).

Total Household Cash Expenditure

At the beginning of this section, it was mentioned that when excluding energy expenditures, the total household expenditures are similar in both surveys at 375 soles per month. However, the mean is only a summary measure of one variable, which could hide great differences, especially when comparing two variables—in this case, total expenditure in ENAHO versus the Survey. It is important to look with more detail and make a comparison throughout the distribution of values from both variables. This section attempts to address this issue. Results confirm that total cash expenditure excluding energy expenditure in both surveys is very similar, not only as an average, but also throughout the entire distribution of values.

In order to do the comparison, a nonparametric estimation was performed to construct densities for each of the two variables. Put simply, these densities, generally known as kernel densities, show the concentration or the frequency that the given variable takes on a certain numerical value.[31]

Table A.1.6 summarizes the numerical values of the variables analyzed in this report. Logarithm values were used in the estimation in order to smooth the distribution of the values and also avoid distortions that would originate from outliers.

Table A.1.5

Monthly Household Kerosene Expenditure by Region (Users Only)

	ENAHO		Survey		
Region	**Mean (soles)**	***N***	**Mean (soles)**	***N***	**Difference (soles)**
Coastal North	12.7	448	14.3	642	1.5
Coastal Central	18.9	87	23.4	294	4.5
Coastal South	23.9	68	25.0	205	1.1
Andean North	6.0	664	7.5	611	1.5
Andean Central	6.1	902	8.6	428	2.5
Andean South	5.3	814	8.2	459	2.9
Amazon	8.0	1,355	9.0	632	1.0
Total Rural Peru	7.7	4,338	11.9	3,271	4.1

Source: ENAHO 2004, four quarterly rounds, INEI, 2005.

[31] Following Chapman and Hall (1995), the kernel density estimator for given a random sample $X_1,\ldots,X_n$ with a continuous univariate density f is: $\hat{f}(x,h)=\frac{1}{nh}\sum_{j=1}^{n}K\left(\frac{x-X_j}{h}\right)$ with kernel K and bandwidth h. In this case it was performed a Epanechnikov kernel function, which is $K(x,p)$ when p = 1, where $K(x,p)=\frac{(1-x^2)^p}{2^{2p+1}B(p+1,p+1)}1\{|x|<1\}$, with $B(a,b)=\frac{\Gamma(a)\Gamma(b)}{\Gamma(a+b)}$.

Table A.1.6

Monthly Household Kerosene Expenditure by Region

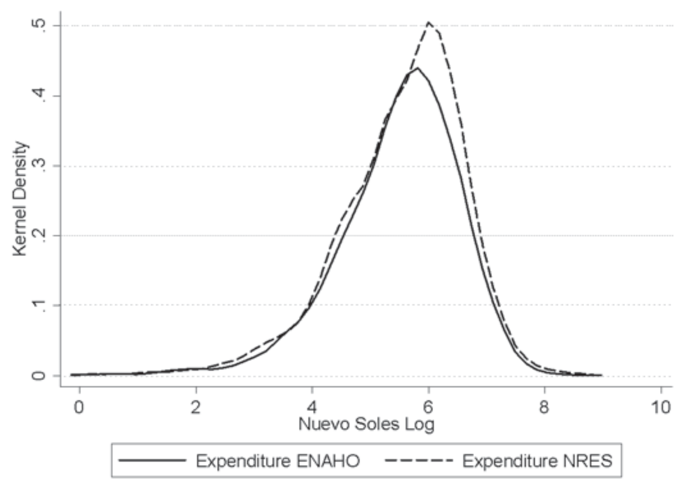
Variables	N	Mean	Std. Dev	Min	Max
Absolute values					
ENAHO	8,208	376.55	366.46	1	6,837.67
Survey	6,452	377.02	331.31	2	4,688.00
Logarithm					
ENAHO log	8208	5.50	1.04	0.00	8.83
Survey log	6452	5.57	0.94	0.69	8.45

Source: ENAHO 2004, four quarterly rounds, INEI, 2005.

Note: There are fewer observations because only positives values were kept due to the fact that logarithms exist only in this domain.

Figure A.1.3

Kernel Density Estimation of Total Monthly Household Cash Expenditure without Energy Expenditures (*Logarithm*)



Source: ENAHO 2004, four quarterly rounds, INEI, 2005.

Note: NRES refers to the Survey.

The resulting densities can be observed in Figure A.1.3. The main conclusion from this exercise is that both distributions are close: in other words, for each log value of total expenditure, both the ENAHO and the Survey show values whose concentration levels are very similar. Perhaps the most important difference between the two surveys occurs to the right of the average, in which the Survey estimate is slightly higher than that of ENAHO.

Survey Comparison Conclusions

The comparison of the National Rural Energy Survey with the ENAHO survey has generated three important findings.

First, energy expenditures are higher in the Survey. Reasons behind this difference are due mainly to the fact that the Survey is more detailed for questions that collect information about energy expenditures. Other reasons could be the seasonality involved in the different surveys' implementation and the different objectives of the sampling designs of each survey. Specifically, the Survey was implemented one year after the ENAHO survey and most importantly, this former Survey was implemented specifically in rural areas with an inference level for each rural region.

Second, when excluding energy expenditures from total household expenditures, the average expenditure is almost the same for both surveys. Moreover, the similarities maintain not only on average, but also throughout the entire distribution of values.

Third, when desegregating electricity and kerosene expenditures at the regional level, despite some variations, there is a clear similarity in the tendencies of the estimates from both surveys.

Annex 2

Survey Results

All the tables shown in Annex 2 summarize the results of the National Survey of Rural Household Energy Use (INEI, 2005). The results reported in this annex are after applying the weighting factors discussed in Annex 1, Section 4, unless otherwise specified.

Table A.2.1

Percentage of Households that Use Each Type of Energy, by Region

	Coastal Region			Andean Region				
	North	Central	South	North	Central	South	Amazon	All Regions
Candle	47%	53%	60%	56%	69%	66%	46%	60%
Kerosene	71%	32%	31%	71%	44%	52%	73%	57%
Small generator	0.9%	1.3%	—	—	1.0%	0.2%	0.9%	0.6%
Dry cell battery	71%	51%	55%	78%	66%	74%	91%	74%
Car battery	31%	23%	13%	9%	8%	7%	15%	11%
Grid electricity	35%	60%	71%	22%	52%	44%	18%	39%
LPG	28%	63%	53%	5%	17%	10%	7%	14%
Fuelwood	85%	74%	68%	94%	92%	64%	95%	84%
Solar PV	0.3%	0.1%	0.1%	0.4%	—	0.9%	1.1%	0.5%
Ag. residue	8%	7%	5%	5%	18%	13%	3%	11%
Dung	0.4%	0.5%	15%	3.6%	26%	65%	0.1%	25%
All Households	156,419	75,314	27,787	362,029	634,240	565,024	383,403	2,204,216
	100%	100%	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

[32] Source for Annex 2 is: Peru National Survey of Rural Household Energy Use, INEI, 2005.

Table A.2.2

Percentage of Households that Use Each Type of Energy, by Expenditure Quintiles

	1. Poorest	2	3	4	5. Richest	
Expenditure Quintile>	**<113 S/month**	**113–201 S/month**	**201–321 S/month**	**321–533 S/month**	**>533 S/month**	**All**
Candle	54%	60%	60%	62%	63%	60%
Kerosene	61%	61%	57%	54%	51%	57%
Small generator	1.1%	0.1%	0.3%	0.5%	1.1%	0.6%
Dry cell battery	64%	80%	77%	74%	76%	74%
Car battery	4%	7%	10%	16%	19%	11%
Grid electricity	27%	34%	38%	45%	50%	39%
LPG	1%	5%	8%	21%	37%	14%
Fuelwood	87%	86%	84%	83%	81%	84%
Solar PV	0.3%	0.1%	0.5%	0.2%	1.5%	0.5%
Ag. residue	16%	12%	10%	9%	8%	11%
Dung	31%	34%	26%	19%	15%	25%
All Households	441,398	441,612	440,132	440,247	440,827	2,204,216
	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

Table A.2.3

Total Household Monthly Cash Spending on Energy by Region, in Soles (Users Only)

	Coastal Region			Andean Region				
	North	Central	South	North	Central	South	Amazon	All Regions
Candle	2.74	5.34	4.43	2.97	3.41	3.49	3.67	3.43
Number of households	73,657	39,680	16,723	201,768	434,878	372,737	177,456	1,316,898
Kerosene	14.57	22.80	26.06	7.51	8.39	8.02	9.39	9.30
Number of households	111,037	24,201	8,721	258,658	277,913	290,873	281,155	1,252,557
Small generator	41.37	37.20	—	—	—	20.28	33.57	33.20
Number of households	1,431	887	—	—	—	1,278	3,353	6,949
Dry cell battery	4.48	6.26	5.29	4.34	5.42	4.40	7.45	5.36
Number of households	110,934	38,683	15,200	282,821	417,450	417,082	349,836	1,632,008
Car battery	6.18	12.57	8.65	5.53	5.76	5.95	6.76	6.60
Number of households	47,704	16,956	3,719	33,871	50,252	36,970	56,522	245,994
Grid electricity	19.82	27.04	24.66	10.87	13.36	9.44	16.03	13.63
Number of households	51,328	43,751	18,739	78,070	327,738	229,695	63,624	812,945
LPG	30.90	36.87	36.48	32.70	32.70	28.40	33.68	32.60
Number of households	43,299	47,376	14,734	18,567	109,233	54,359	26,274	313,843
Fuelwood	35.60	38.71	48.48	27.13	21.62	29.06	30.18	26.58
Number of households	22,355	5,884	2,407	50,898	113,628	62,483	15,286	272,941
All Energy Spending	37.22	58.55	55.06	18.76	26.42	19.89	22.83	25.09
% of Total Expd	7.6%	9.5%	9.6%	9.9%	11.9%	9.3%	7.4%	9.7%
Number of Households	156,419	75,315	27,787	362,029	634,240	565,023	383,403	2,204,215

Source: Authors' calculations, 2005.

Note: Expenditure on car battery only includes recharging fee.

Table A.2.4

Total Household Monthly Cash Spending on Energy by Expenditure Quintiles, in Soles (Users Only)

	1. Poorest	2	3	4	5. Richest	
Expenditure Quintile>	**<113 S/month**	**113–201 S/month**	**201–321 S/month**	**321–533 S/month**	**>533 S/month**	**All**
Candle	2.71	2.95	3.62	3.64	4.13	3.43
Valid *N*	235,931	265,881	265,618	270,536	278,933	1,316,898
Kerosene	4.89	6.61	8.80	11.36	16.19	9.30
Valid *N*	270,397	269,364	249,869	238,264	224,663	1,252,557
Small generator	–	–	13.00	28.97	38.14	33.20
Valid *N*	–	–	775	1,623	4,550	6,949
Dry cell battery	3.39	4.50	5.34	6.00	7.30	5.36
Valid *N*	280,933	352,093	339,003	324,723	335,256	1,632,008
Car battery	5.19	5.10	5.83	6.73	7.39	6.48
Valid *N*	18,351	31,570	42,297	70,281	83,495	245,994
Grid Electricity	7.36	8.54	10.38	14.20	22.52	13.63
Valid *N*	113,534	143,193	160,146	187,719	208,353	812,945
LPG	20.42	20.64	26.20	30.08	37.07	32.60
Valid *N*	3,649	19,861	33,750	93,032	163,550	313,843
Fuelwood	13.63	17.87	22.94	27.73	35.98	26.58
Valid *N*	17,184	46,243	56,207	74,155	79,153	272,941
All Energy Spending	9.41	15.33	20.59	31.08	49.06	25.09
% of Total Spending	17.1%	9.9%	8.2%	7.4%	5.8%	9.7%
Valid *N*	441,398	441,612	440,132	440,248	440,826	2,204,215

Source: Authors' calculations, 2005.

Table A.2.5

Total Household Monthly Cash Spending on Energy by Region, in Soles (All Households)

	Coastal Region			Andean Region				
	North	Central	South	North	Central	South	Amazon	All Regions
Candle	1.29	2.81	2.66	1.65	2.34	2.30	1.70	2.05
Kerosene	10.34	7.33	8.18	5.37	3.67	4.13	6.89	5.28
Small generator	0.38	0.44	—	—	—	0.05	0.29	0.10
Dry cell battery	3.18	3.22	2.90	3.39	3.57	3.24	6.79	3.97
Car battery	1.89	2.83	1.14	0.51	0.43	0.39	0.99	0.72
Grid electricity	6.50	15.71	16.63	2.34	6.91	3.84	2.66	5.03
LPG	8.55	23.19	19.34	1.68	5.63	2.73	2.31	4.64
Fuelwood	5.09	3.02	4.20	3.81	3.87	3.21	1.20	3.29
All Energy Spending	37.22	58.55	55.06	18.76	26.42	19.89	22.83	25.09
As % of Total Expenditure	7.6%	9.5%	9.6%	9.9%	11.9%	9.3%	7.4%	9.7%
Number of Households	156,419	75,315	27,787	362,029	634,240	565,023	383,403	2,204,215

Source: Authors' calculations, 2005.

Table A.2.6

Total Household Monthly Cash Spending on Energy by Expenditure Quintiles, in Soles (All Households)

	1. Poorest	2	3	4	5. Richest	
Expenditure Quintile>	**<113 S/month**	**113–201 S/month**	**201–321 S/month**	**321–533 S/month**	**>533 S/month**	**All**
Candle	1.45	1.78	2.19	2.24	2.61	2.05
Kerosene	3.00	4.03	5.00	6.15	8.25	5.28
Small generator	—	—	0.02	0.11	0.39	0.10
Dry cell battery	2.16	3.59	4.11	4.43	5.55	3.97
Car battery	0.22	0.36	0.56	1.07	1.40	0.72
Grid electricity	1.89	2.77	3.78	6.06	10.64	5.03
LPG	0.17	0.93	2.01	6.36	13.75	4.64
Fuelwood	0.53	1.87	2.93	4.67	6.46	3.29
All Energy Spending	9.41	15.33	20.59	31.08	49.06	25.09
% of Total Spending	17.1%	9.9%	8.2%	7.4	5.8	9.7
Valid *N*	441,398	441,612	440,132	440,248	440,826	2,204,215

Source: Authors' calculations, 2005.

Table A.2.7

Percentage of Households that Use Each Type of Energy by Electrification Status and Region

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
With Access to Grid Electricity								
Candle	50%	31%	49%	41%	57%	52%	48%	51%
Kerosene	31%	15%	21%	12%	19%	20%	26%	20%
Small generator	—	—	—	—	—	—	0.2%	0.0%
Dry cell battery	46%	34%	42%	50%	52%	61%	77%	55%
Car battery	0.3%	0.2%	3.5%	1.0%	0.4%	0.8%	1.5%	0.7%
Grid electricity	100%	100%	100%	100%	100%	100%	100%	100%
LPG	58%	74%	65%	18%	27%	14%	29%	28%
Fuelwood	70%	66%	60%	89%	89%	74%	87%	81%
Solar PV	—	—	—	—	—	—	0.2%	0.0%
Ag. residue	4%	4%	4%	1.6%	17%	14%	5%	12%
Dung	0.1%	0.4%	12%	1.7%	25%	54%	0.7%	26.2%
All Households	54,585	45,378	19,651	80,260	332,084	250,561	68,990	851,509
	100%	100%	100%	100%	100%	100%	100%	100%
Without Access to Grid Electricity								
Candle	46%	85%	88%	60%	81%	77%	46%	65%
Kerosene	93%	58%	57%	89%	71%	76%	84%	80%
Small generator	1.4%	3.2%	—	—	2.0%	0.4%	1.0%	1.0%
Dry cell battery	85%	77%	85%	86%	81%	84%	95%	86%
Car battery	47%	56%	37%	12%	16%	11%	18%	18%
Grid electricity	—	—	—	—	—	—	—	—
LPG	11%	46%	24%	2%	6%	6%	2%	6%
Fuelwood	93%	85%	86%	95%	95%	57%	97%	86%
Solar PV	0.4%	0.3%	0.5%	0.5%	—	1.6%	1.3%	0.8%
Ag. residue	10%	12%	8%	6%	19%	13%	3%	10%
Animal dung	0.5%	0.5%	21%	4%	28%	73%	—	24%
All Households	101,835	29,936	8,136	281,769	302,156	314,462	314,413	1,352,707

Source: Authors' calculations, 2005.

Table A.2.8

Percentage of Households that Use Each Type of Energy by Electrification Status and Expenditure Quintile

	<113.25 S/month	113.26–201.00 S/month	201.01–321.13 S/month	321.14–533.22 S/month	>533.22 S/month	All Expenditure Quintiles
With Access to Grid Electricity						
Candle	45%	49%	55%	52%	53%	51%
Kerosene	18%	21%	18%	20%	21%	20%
Small generator	—	—	—	—	—	—
Dry cell battery	48%	58%	57%	52%	58%	55%
Car battery	0.6%	0.3%	0.3%	0.7%	1.3%	0.7%
Grid electricity	100%	100%	100%	100%	100%	100%
LPG	2%	9%	16%	36%	58%	28%
Fuelwood	85%	85%	84%	81%	75%	81%
Solar PV	—	—	—	—	0.1%	0.1%
Ag. residue	17%	18%	13%	10%	7%	12%
Animal dung	38%	39%	31%	20%	13%	26%
All Households	118,912	149,335	168,910	195,931	218,422	851,510
	100%	100%	100%	100%	100%	100%
Without Access to Grid Electricity						
Candle	57%	66%	64%	69%	74%	65%
Kerosene	77%	81%	81%	82%	80%	80%
Small generator	1.5%	0.2%	0.5%	0.8%	2.1%	1.0%
Dry cell battery	70%	91%	90%	92%	94%	86%
Car battery	6%	11%	15%	28%	36%	18%
Grid electricity	—	—	—	—	—	—
LPG	0.5%	2.4%	2.7%	9%	16%	6%
Fuelwood	88%	86%	85%	84%	88%	86%
Solar PV	0.3%	0.1%	0.8%	0.4%	2.9%	0.8%
Ag. residue	15%	10%	7%	8%	8%	10%
Animal dung	28%	32%	24%	19%	16%	24%
All Households	322,486	292,276	271,222	244,317	222,404	1,352,705
	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

Table A.2.9

Comparison of Total Household Monthly Cash Spending on Energy between Households with and without Access to Grid Electricity by Region, in Soles (Users Only)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
With Access to Grid Electricity								
Candle	0.91	1.62	1.66	1.18	1.37	1.26	1.49	1.32
Valid *N*	27,247	14,220	9,587	33,055	189,623	129,969	33,149	436,850
Kerosene	7.22	26.16	29.63	5.81	10.78	7.96	5.86	9.88
Valid *N*	16,640	6,995	4,065	9,358	63,941	50,803	17,744	169,545
Small generator	—	—	—	—	—	—	28.50	28.50
Valid *N*							158	158
Dry cell battery	2.94	4.62	4.03	3.47	3.88	3.34	4.11	3.67
Valid *N*	24,898	15,530	8,272	39,849	172,192	153,789	52,795	467,324
Car battery	3.52	12.00	9.94	3.24	2.57	3.93	6.46	4.81
Valid *N*	149	81	692	807	1,205	1,910	1,021	5,863
Grid electricity	19.82	27.04	24.66	10.87	13.36	9.44	16.03	13.63
Valid *N*	51,328	43,751	18,739	78,070	327,738	229,695	63,624	812,945
LPG	30.39	37.24	36.37	32.91	32.61	27.61	34.84	32.63
Valid *N*	31,659	33,738	12,791	14,158	90,735	35,634	20,083	238,799
Fuelwood	33.44	44.11	47.44	29.05	21.12	31.61	28.45	27.00
Valid *N*	12,559	4,133	1,630	24,124	77,460	44,747	10,247	174,899
All Energy Spending	47.97	63.92	60.11	28.03	31.90	22.58	34.68	32.41
As % of Total Expenditure	7.8%	10.5%	10.0%	10.4%	10.9%	9.1%	9.2%	9.9%
Valid *N*	54,584	45,378	19,651	80,261	332,084	250,561	68,990	851,510
Without Access to Grid Electricity								
Candle	3.81	7.42	8.14	3.32	4.99	4.68	4.17	4.49
Valid *N*	46,411	25,460	7,136	168,713	245,255	242,767	144,307	880,048
Kerosene	15.87	21.43	22.94	7.58	7.67	8.04	9.63	9.20
Valid *N*	94,397	17,206	4,655	249,300	213,971	240,070	263,411	1,083,012
Small generator	41.37	37.20	—	—	—	20.28	33.82	33.31
Valid *N*	1,431	887				1,278	3,195	6,791
Dry cell battery	4.93	7.37	6.80	4.48	6.50	5.00	8.04	6.03
Valid *N*	86,036	23,153	6,929	242,973	245,259	263,293	297,041	1,164,684
Car battery	6.19	12.57	8.24	5.53	5.43	6.06	6.70	6.52
Valid *N*	47,556	16,875	3,027	33,064	49,048	35,060	55,501	240,131
Grid electricity	—	—	—	—	—	—	—	—
Valid *N*								
LPG	32.28	35.95	37.19	32.02	33.17	29.89	29.91	32.49
Valid *N*	11,640	13,638	1,943	4,409	18,498	18,724	6,191	75,044
Fuelwood	38.38	25.98	50.66	25.40	22.68	22.65	33.70	25.83
Valid *N*	9,796	1,751	778	26,774	36,168	17,736	5,039	98,042
All Energy Spending	31.46	50.41	42.85	16.12	20.39	17.75	20.23	20.48
As % of Total Expenditure	7.5%	8.2%	8.6%	9.7%	12.9%	9.4%	7.0%	9.5%
Valid *N*	101,834	29,937	8,135	281,768	302,156	314,462	314,413	1,352,705

Source: Authors' calculations, 2005.

Table A.2.10

Comparison of Total Household Monthly Cash Spending on Energy between Households with and without Access to Grid Electricity by Expenditure Quintiles (Users Only)

	<113.25 S/month	113.26–201.00 S/month	201.01–321.13 S/month	321.14–533.22 S/month	>533.22 S/month	All Expenditure Quintiles
			With Access to Grid Electricity			
Candle	1.18	1.10	1.31	1.28	1.56	1.32
Valid *N*	53,630	73,649	92,432	101,956	115,184	436,850
Kerosene	3.94	4.57	7.07	11.94	16.51	9.88
Valid *N*	21,863	31,729	30,902	38,947	46,105	169,545
Small generator	—	—	—	28.50	—	28.50
Valid *N*				158		158
Dry cell battery	2.66	3.12	3.66	3.85	4.39	3.68
Valid *N*	55,887	87,221	96,118	100,864	126,562	466,652
Car battery	3.00	6.00	8.00	4.46	6.89	5.72
Valid *N*	672	516	504	1,329	1,904	4,925
Grid electricity	7.36	8.54	10.38	14.20	22.52	13.63
Valid *N*	113,534	143,193	160,146	187,719	208,353	812,945
LPG	25.71	19.40	24.62	30.43	36.96	32.63
Valid *N*	2,044	12,878	26,410	70,133	127,334	238,799
Fuelwood	14.50	19.32	22.23	27.37	34.17	27.00
Valid *N*	7,337	24,440	30,518	56,273	56,331	174,899
All Energy	10.89	16.38	21.82	37.43	58.75	32.41
Valid *N*	118,912	149,336	168,909	195,931	218,422	851,510
			Without Access to Grid Electricity			
Candle	3.15	3.66	4.86	5.08	5.93	4.49
Valid *N*	182,301	192,231	173,186	168,581	163,749	880,048
Kerosene	4.97	6.88	9.04	11.25	16.10	9.20
Valid *N*	248,535	237,635	218,967	199,317	178,558	1,083,012
Small generator	—	—	13.00	29.02	38.14	33.31
Valid *N*			775	1,466	4,550	6,791
Dry cell battery	3.58	4.95	6.02	6.97	9.06	6.04
Valid *N*	224,374	264,873	242,381	223,858	208,694	1,164,180
Car battery	5.28	5.20	6.13	6.83	7.49	6.61
Valid *N*	17,679	30,359	39,556	68,436	80,653	236,683
Grid electricity	—	—	—	—	—	—
Valid *N*						
LPG	13.69	22.93	31.88	29.02	37.48	32.49
Valid *N*	1,606	6,983	7,340	22,899	36,216	75,044
Fuelwood	12.99	16.25	23.79	28.85	40.46	25.83
Valid *N*	9,847	21,803	25,689	17,881	22,821	98,042
All Energy	8.86	14.79	19.83	25.99	39.55	20.48
Valid *N*	322,486	292,276	271,223	244,316	222,405	1,352,705

Source: Authors' calculations, 2005.

Table A.2.11

Number and Percentage of Households Using Kerosene for Lighting and Cooking by Electrification Status and by Region (All Households)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
With Access to Grid Electricity								
Cooking	1,188	3,743	3,335	334	14,520	12,901	551	36,572
(%)	2.2%	8.2%	17.0%	0.4%	4.4%	5.1%	0.8%	4.3%
Lighting	7,125	972	233	4,070	24,447	27,915	12,714	77,476
(%)	13%	2%	1%	5%	7%	11%	18%	9%
Lighting and cooking	580.0	1,203.0	263.0	139.0	2,181.0	672.0	—	5,038.0
(%)	1.1%	2.7%	1.3%	0.2%	0.7%	0.3%	0.0%	0.6%
Other purposes	7,746	1,077	235	4,815	22,794	9,315	4,479	50,461
(%)	14.2%	2.4%	1.2%	6.0%	6.9%	3.7%	6.5%	5.9%
Not used	37,944	38,383	15,586	70,903	268,143	199,758	51,246	681,963
(%)	70%	85%	79%	88%	81%	80%	74%	80%
Total	54,583	45,378	19,652	80,261	332,085	250,561	68,990	851,510
(%)	100%	100%	100%	100%	100%	100%	100%	100%
Without Access to Grid Electricity								
Cooking	278	1,580	1,456	—	1,715	6,086	—	11,115
(%)	0.3%	5.3%	17.9%	0.0%	0.6%	1.9%	0.0%	0.8%
Lighting	92,906	12,093	2,505	233,750	193,485	191,304	231,423	957,466
(%)	91%	40%	31%	83%	64%	61%	74%	71%
Lighting and cooking	325.0	2,740.0	380.0	1,454.0	8,850.0	11,749.0	6,993.0	32,491.0
(%)	0.3%	9.2%	4.7%	0.5%	2.9%	3.7%	2.2%	2.4%
Other purposes	889	793	314	14,096	9,921	30,931	24,995	81,939
(%)	0.9%	2.6%	3.9%	5.0%	3.3%	9.8%	7.9%	6.1%
Not used	7,437	12,731	3,480	32,468	88,184	74,393	51,001	269,694
(%)	7%	43%	43%	12%	29%	24%	16%	20%
Total	101,835	29,937	8,135	281,768	302,155	314,463	314,412	1,352,705
(%)	100%	100%	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

Table A.2.12

Number and Percentage of Households Using Kerosene for Lighting and Cooking by Region (All Households)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
	All Areas *(Electrified and Unelectrified)*							
Cooking	1,467	5,323	4,790	334	16,235	18,986	551	47,686
(%)	0.9%	7.1%	17.2%	0.1%	2.6%	3.4%	0.1%	2%
Lighting	100,031	13,066	2,738	237,820	217,932	219,219	244,137	1,034,943
(%)	64%	17%	10%	66%	34%	39%	64%	47%
Lighting and cooking	905	3,943	643	1,593	11,031	12,420	6,993	37,528
(%)	0.6%	5.2%	2.3%	0.4%	1.7%	2.2%	1.8%	1.7%
Other purposes	8,634	1,869	549	18,911	32,715	40,247	29,474	132,399
(%)	5.5%	2.5%	2.0%	5.2%	5.2%	7.1%	7.7%	6.00%
Not used	45,382	51,114	19,066	103,371	356,327	274,151	102,248	951,659
(%)	29%	68%	69%	29%	56%	49%	27%	43%
Total	156,419	75,315	27,786	362,029	634,240	565,023	383,403	2,204,215
(%)	100%	100%	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

Table A.2.13

Number and Percentage of Households Using Kerosene for Lighting and Cooking by Electrification Status and Expenditure Quintiles (All Households)

	<113.25 S/month	113.26–201.00 S/month	201.01–321.13 S/month	321.14–533.22 S/month	>533.22 S/month	All
With Access to Grid Electricity						
Cooking	1,361	2,374	6,336	11,131	15,370	36,572
(%)	1.1%	1.6%	3.8%	5.7%	7.0%	4.3%
Lighting	15,430	20,478	13,440	13,480	14,648	77,476
(%)	13%	14%	8%	7%	7%	9%
Lighting and cooking	—	47	1,401	1,068	2,523	5,039
(%)	0.0%	0.0%	0.8%	0.5%	1.2%	0.6%
Other purposes	5,071	8,831	9,725	13,268	13,565	50,460
(%)	4%	6%	6%	7%	6%	6%
Not used	97,049	117,606	138,007	156,984	172,317	681,963
(%)	82%	79%	82%	80%	79%	80%
Total	118,911	149,336	168,909	195,931	218,423	851,510
(%)	100%	100%	100%	100%	100%	100%
Without Access to Grid Electricity						
Cooking	252	813	4,341	2,737	2,972	11,115
(%)	0.1%	0.3%	1.6%	1.1%	1.3%	0.8%
Lighting	232,222	211,492	187,956	170,400	155,397	957,467
(%)	72%	72%	69%	70%	70%	71%
Lighting and cooking	2,111	8,144	4,635	8,291	9,310	32,491
(%)	0.7%	2.8%	1.7%	3.4%	4.2%	2.4%
Other purposes	13,950	17,185	22,035	17,889	10,879	81,938
(%)	4%	6%	8%	7%	5%	6%
Not used	73,951	54,641	52,255	44,999	43,846	269,692
(%)	23%	19%	19%	18%	20%	20%
Total	322,486	292,275	271,222	244,316	222,404	1,352,703
(%)	100%	100%	100%	100%	100%	100%
All Households (With and Without Access to Grid Electricity)						
Cooking	1,613	3,187	10,677	13,868	18,342	47,687
(%)	0.4%	0.7%	2.4%	3.2%	4.2%	2.2%
Lighting	247,652	231,970	201,396	183,880	170,045	1,034,943
(%)	56%	53%	46%	42%	39%	47%
Lighting and cooking	2,111	8,191	6,036	9,359	11,832	37,529
(%)	0.5%	1.9%	1.4%	2.1%	2.7%	1.7%
Other purposes	19,021	26,016	31,760	31,157	24,444	132,398
(%)	4%	6%	7%	7%	6%	6%
Not used	171,000	172,248	190,263	201,984	216,163	951,658
(%)	39%	39%	43%	46%	49%	43%
Total	441,397	441,612	440,132	440,248	440,826	2,204,215
(%)	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

Table A.2.14

Number and Percentage of Households Using Kerosene and Candles for Lighting by Electrification Status and Region (All Households)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
Without Access to Grid Electricity								
Do not use candles/kero	22,822	30,226	9,850	44,838	133,034	105,537	26,993	373,300
(%)	42%	67%	50%	56%	40%	42%	39%	44%
Kerosene only	4,516	932	214	2,367	9,427	15,055	8,849	41,360
(%)	8%	2%	1%	3%	3%	6%	13%	5%
Candles only	24,056	12,976	9,306	31,214	172,423	116,437	29,284	395,696
(%)	44%	29%	47%	39%	52%	47%	42%	47%
Candles and kerosene	3,190	1,244	281	1,842	17,200	13,532	3,865	41,154
(%)	6%	3%	1%	2%	5%	5%	6%	5%
Total	54,584	45,378	19,651	80,261	332,084	250,561	68,991	851,510
(%)	100%	100%	100%	100%	100%	100%	100%	100%
Without Access to Grid Electricity								
Do not use candles/kero	3,173	812	266	5,101	2,576	10,263	36,576	58,767
(%)	3%	3%	3%	2%	1%	3%	12%	4%
Kerosene only	52,251	3,664	734	107,954	54,325	61,432	133,530	413,890
(%)	51%	12%	9%	38%	18%	20%	43%	31%
Candles only	5,431	14,291	4,984	41,462	97,245	101,146	39,421	303,980
(%)	5%	48%	61%	15%	32%	32%	13%	23%
Candles and kerosene	40,979	11,169	2,152	127,250	148,010	141,621	104,886	576,067
(%)	40%	37%	27%	45%	49%	45%	33%	43%
Total	101,834	29,936	8,136	281,767	302,156	314,462	314,413	1,352,704
(%)	100%	100%	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

Table A.2.15

Number and Percentage of Household Using Kerosene and Candles for Lighting by Electrification Status and Expenditure Quintiles (All Households)

	<113.25 S/month	113.26–201.00 S/month	201.01–321.13 S/month	321.14–533.22 S/month	>533.22 S/month	All
With Access to Grid Electricity						
Do not use candles/kero	58,073	65,549	69,816	85,281	94,580	373,299
(%)	49%	44%	41%	44%	43%	44%
Kerosene only	7,209	10,137	6,661	8,695	8,658	41,360
(%)	6%	7%	4%	4%	4%	5%
Candles only	45,408	63,262	84,252	96,103	106,670	395,695
(%)	38%	42%	50%	49%	49%	47%
Candles and kerosene	8,221	10,387	8,180	5,853	8,513	41,154
(%)	7%	7%	5%	3%	4%	5%
Total	118,911	149,335	168,909	195,932	218,421	851,508
(%)	100%	100%	100%	100%	100%	100%
Without Access to Grid Electricity						
Do not use candles/kero	15,071	12,417	12,885	10,775	7,620	58,768
(%)	5%	4%	5%	4%	3%	4%
Kerosene only	125,113	87,628	85,152	64,961	51,035	413,889
(%)	39%	30%	31%	27%	23%	31%
Candles only	73,081	60,223	65,746	54,851	50,077	303,978
(%)	23%	21%	24%	23%	23%	23%
Candles and kerosene	109,220	132,008	107,440	113,730	113,672	576,070
(%)	34%	45%	40%	47%	51%	43%
Total	322,485	292,276	271,223	244,317	222,404	1,352,705
(%)	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

Table A.2.16

Household Monthly Expenditure on Kerosene for Lighting and Cooking by Electrification Status and Region (Users Only)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
With Access to Grid Electricity								
Cooking	27.19	33.69	32.70	25.20	23.54	19.21	3.45	23.72
Valid *N*	1,188	3,743	3,335	334	14,520	12,901	551	36,571
Lighting	5.50	8.27	4.79	4.54	5.11	4.33	5.75	4.98
Valid *N*	7,125	972	233	4,070	24,447	27,915	12,714	77,476
Lighting and cooking	8.26	30.00	33.50	30.00	14.83	12.00	—	18.71
Valid *N*	580	1,203	263	139	2,181	672		5,038
Other purposes	5.67	11.86	6.31	4.85	8.35	2.94	6.46	6.50
Valid *N*	7,746	1,077	235	4,815	22,794	9,315	4,479	50,460
Total Exp.	7.22	26.16	29.63	5.81	10.78	7.96	5.86	9.88
Valid *N*	16,640	6,995	4,065	9,358	63,941	50,803	17,744	169,545
Without Access to Grid Electricity								
Cooking	16.00	30.96	34.27	—	33.94	13.09	—	21.70
Valid *N*	278	1,580	1,456		1,715	6,086		11,115
Lighting	15.60	18.24	16.40	7.55	7.16	6.53	9.66	8.72
Valid *N*	92,906	12,093	2,505	233,750	193,485	191,304	231,423	957,467
Lighting and cooking	90.00	32.88	25.07	3.30	12.77	27.07	13.43	20.27
Valid *N*	325	2,740	380	1,454	8,850	11,749	6,993	32,491
Other purposes	16.64	11.50	19.98	8.41	8.62	9.14	8.29	8.84
Valid *N*	889	793	314	14,096	9,921	30,931	24,995	81,938
Total Exp.	15.87	21.43	22.94	7.58	7.67	8.04	9.63	9.20
Valid *N*	94,397	17,206	4,655	249,300	213,971	240,070	263,411	1,083,012

Source: Authors' calculations, 2005.

Table A.2.17

Household Monthly Expenditure on Kerosene for Lighting and Cooking by Region (Weighted—Users Only)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
	All Areas *(Electrified and Unelectrified)*							
Cooking	25.07	32.88	33.18	25.20	24.64	17.25	3.45	23.25
Valid *N*	1,467	5,323	4,790	334	16,235	18,986	551	47,686
Lighting	14.88	17.50	15.41	7.50	6.93	6.25	9.46	8.44
Valid *N*	100,031	13,066	2,738	237,820	217,932	219,219	244,137	1,034,943
Lighting and cooking	37.58	32.00	28.52	5.63	13.18	26.25	13.43	20.06
Valid *N*	905	3,943	643	1,593	11,031	12,420	6,993	37,529
Other purposes	6.80	11.71	14.13	7.51	8.43	7.71	8.01	7.95
Valid *N*	8,634	1,869	549	18,911	32,715	40,247	29,474	132,398
Total Exp.	14.57	22.80	26.06	7.51	8.39	8.02	9.39	9.30
Valid *N*	111,037	24,201	8,721.00	258,658	277,913	290,873	281,155	1,252,557

Source: Authors' calculations, 2005.

Table A.2.18

Household Monthly Expenditures on Candles for Lighting by Electrification Status and Region (Users Only)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
	With Access to Grid Electricity							
Candle	0.91	1.62	1.66	1.18	1.37	1.26	1.49	1.32
Valid *N*	27,247	14,220	9,587	33,055	189,623	129,969	33,149	436,850
	Without Access to Grid Electricity							
Candle	3.81	7.42	8.14	3.32	4.99	4.68	4.17	4.49
Valid *N*	46,411	25,460	7,136	168,713	245,255	242,767	144,307	880,048

Source: Authors' calculations, 2005.

Table A.2.19

Household Monthly Expenditures on Kerosene for Lighting and Cooking by Electrification Status and Expenditure Quintiles (Users Only)

	<113.25 S/month	113.26–201.00 S/month	201.01–321.13 S/month	321.14–533.22 S/month	>533.22 S/month	All
With Access to Grid Electricity						
Cooking	10.37	16.19	11.83	23.19	31.34	23.72
Population	1,361	2,374	6,336	11,131	15,370	36,571
Lighting	3.66	3.55	6.08	5.77	6.64	4.98
Population	15,430	20,478	13,440	13,480	14,648	77,476
Lighting and cooking	—	7.50	16.35	14.54	22.00	18.71
Population		47	1,401	1,068	2,523	5,038
Other purposes	3.08	3.80	3.99	8.55	9.35	6.50
Population	5,071	8,831	9,725	13,268	13,565	50,460
Total	3.94	4.57	7.07	11.94	16.51	9.88
Population	21,863	31,729	30,902	38,947	46,105	169,545
Without Access to Grid Electricity						
Cooking	12.00	12.75	15.96	18.47	36.33	21.70
Population	252	813	4,341	2,737	2,972	11,115
Lighting	4.93	6.67	8.68	11.17	14.51	8.72
Population	232,222	211,492	187,956	170,400	155,397	957,467
Lighting and cooking	12.21	8.82	18.31	14.28	38.43	20.27
Population	2,111	8,144	4,635	8,291	9,310	32,491
Other purposes	4.50	8.21	8.86	9.54	14.23	8.84
Population	13,950	17,185	22,035	17,889	10,879	81,938
Total	4.97	6.88	9.04	11.25	16.10	9.20
Population	248,535	237,635	218,967	199,317	178,558	1,083,012

Source: Authors' calculations, 2005.

Table A.2.20

Household Monthly Expenditures on Kerosene for Lighting and Cooking by Expenditure Quintiles, in Soles (Users Only)

	<113.25 S/month	113.26–201.00 S/month	201.01–321.13 S/month	321.14–533.22 S/month	>533.22 S/month	All
All Areas (Electrified and Unelectrified)						
Cooking	10.62	15.31	13.51	22.26	32.15	23.25
Population	1,613	3,187	10,677	13,868	18,342	47,686
Lighting	4.85	6.40	8.51	10.77	13.83	8.44
Population	247,652	231,970	201,396	183,880	170,045	1,034,943
Lighting & Cooking	12.21	8.81	17.86	14.31	34.92	20.06
Population	2,111	8,191	6,036	9,359	11,832	37,529
Other Purposes	4.12	6.71	7.37	9.12	11.52	7.95
Population	19,021	26,016	31,760	31,157	24,444	132,398
Total	4.89	6.61	8.80	11.36	16.19	9.30
Population	270,397	269,364	249,869	238,264	224,663	1,252,557

Source: Authors' calculations, 2005.

Table A.2.21

Household Monthly Expenditures on Candles for Lighting by Electrification Status and Expenditure Quintiles, in Soles (Users Only)

	<113.25 S/month	113.26–201.00 S/month	201.01–321.13 S/month	321.14–533.22 S/month	>533.22 S/month	All
With Access to Grid Electricity						
Candle	1.18	1.10	1.31	1.28	1.56	1.32
Valid *N*	53,630	73,649	92,432	101,956	115,184	436,850
Without Access to Grid Electricity						
Candle	3.15	3.66	4.86	5.08	5.93	4.49
Valid N	182,301	192,231	173,186	168,581	163,749	880,048

Source: Authors' calculations, 2005.

Table A.2.22

Household Monthly Expenditures on Kerosene and Candles for Lighting by Electrification Status and Region, in Soles (Users Only)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
With Access to Grid Electricity								
Kerosene only	2.56	3.86	8.36	3.74	5.45	2.73	4.65	3.86
Valid *N*	4,516	932	214	2,367	9,427	15,055	8,849	41,360
Candles only	0.94	1.57	1.54	1.17	1.41	1.26	1.19	1.31
Valid *N*	24,056	12,976	9,306	31,214	172,423	116,437	29,284	395,696
Both candles and kerosene	5.87	8.19	14.44	6.55	4.79	4.64	8.10	5.38
Valid *N*	3,190	1,244	281	1,842	17,200	13,532	3,865	41,154
Total (All)	1.66	2.25	2.06	1.62	1.89	1.73	2.56	1.88
Valid *N*	31,762	15,152	9,801	35,423	199,050	145,024	41,998	478,210
Without Access to Grid Electricity								
Kerosene only	11.16	13.55	22.25	6.55	5.74	5.65	7.60	7.32
Valid *N*	52,251	3,664	734	107,954	54,325	61,432	133,530	413,889
Candles only	6.26	8.21	9.13	4.68	6.74	6.42	8.21	6.64
Valid *N*	5,431	14,291	4,984	41,462	97,245	101,146	39,421	303,980
Both candles and kerosene	21.75	24.39	17.78	10.49	10.82	9.94	11.93	11.80
Valid *N*	40,979	11,169	2,152	127,250	148,010	141,621	104,886	576,069
Total (All)	15.29	15.08	12.72	8.08	8.57	7.90	9.32	9.15
Valid *N*	98,662	29,124	7,869	276,667	299,580	304,199	277,836	1,293,938

Source: Authors' calculations, 2005.

Table A.2.23

Household Monthly Expenditures on Kerosene and Candles for Lighting by Region (Users Only)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
All Areas (Electrified and Unelectrified)								
Kerosene only	10.48	11.58	19.11	6.49	5.70	5.07	7.41	7.00
Valid *N*	56,767	4,596	948	110,322	63,752	76,487	142,378	455,249
Candles only	1.92	5.05	4.19	3.17	3.33	3.66	5.22	3.63
Valid *N*	29,488	27,267	14,289	72,676	269,668	217,583	68,704	699,676
Both candles and kerosene	20.60	22.77	17.40	10.43	10.19	9.48	11.79	11.37
Valid *N*	44,169	12,413	2,433	129,092	165,210	155,153	108,751	617,223
Total (All)	11.97	10.69	6.81	7.35	5.91	5.91	8.43	7.19
Valid *N*	130,424	44,276	17,671	312,090	498,630	449,223	319,834	1,772,148

Source: Authors' calculations, 2005.

Table A.2.24

Household Monthly Expenditures on Kerosene and Candles for Lighting by Electrification Status and Expenditure Quintiles (Users Only)

	<113.25 S/month	113.26–201.00 S/month	201.01–321.13 S/month	321.14–533.22 S/month	>533.22 S/month	All
With Access to Grid Electricity						
Kerosene only	4.55	6.10	8.04	10.20	11.33	7.32
Valid *N*	125,113	87,628	85,152	64,961	51,035	413,889
Candles only	3.95	5.81	6.85	8.07	9.74	6.64
Valid *N*	73,081	60,223	65,746	54,851	50,077	303,980
Both candles and kerosene	7.57	8.85	11.49	13.51	17.86	11.80
Valid *N*	109,220	132,008	107,440	113,730	113,672	576,069
Total (All)	5.48	7.34	9.17	11.31	14.42	9.15
Valid *N*	307,414	279,859	258,338	233,542	214,784	1,293,938
Without Access to Grid Electricity						
Kerosene only	3.64	2.54	3.75	5.34	4.16	3.86
Valid *N*	7,209	10,137	6,661	8,695	8,658	41,360
Candles only	1.24	1.12	1.20	1.26	1.58	1.31
Valid *N*	45,408	63,262	84,252	96,103	106,670	395,696
Both candles and kerosene	3.87	4.42	6.10	5.06	7.53	5.38
Valid *N*	8,221	10,387	8,180	5,853	8,513	41,154
Total (All)	1.88	1.70	1.78	1.78	2.17	1.88
Valid *N*	60,839	83,787	99,093	110,651	123,841	478,210

Source: Authors' calculations, 2005.

Table A.2.25

Household Monthly Expenditures on Kerosene and Candles for Lighting by Expenditure Quintiles

	<113.25 S/month	113.26–201.00 S/month	201.01–321.13 S/month	321.14–533.22 S/month	>533.22 S/month	All
All Areas (Electrified and Unelectrified)						
Kerosene only	4.50	5.73	7.73	9.63	10.29	7.00
Valid *N*	132,323	97,765	91,813	73,656	59,693	455,249
Candles only	2.91	3.41	3.68	3.74	4.19	3.63
Valid *N*	118,490	123,486	149,998	150,954	156,748	699,676
Both candles and kerosene	7.31	8.53	11.11	13.09	17.14	11.37
Valid *N*	117,441	142,395	115,620	119,582	122,185	617,223
Total (All)	4.89	6.04	7.12	8.25	9.94	7.19
Valid *N*	368,253	363,646	357,431	344,192	338,625	1,772,148

Source: Authors' calculations, 2005.

Table A.2.26

Household Monthly Expenditures on Lighting and Electricity by Electrification Status and Region (Weighted—Users Only)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
With Access to Grid Electricity								
Candles	0.91	1.62	1.66	1.18	1.37	1.26	1.49	1.32
Valid *N*	27,247	14,220	9,587	33,055	189,623	129,969	33,149	436,850
Kerosene (Light only)	3.62	5.12	8.52	4.39	4.40	3.04	4.55	3.92
Valid *N*	7,706	2,175	496	4,209	26,628	28,587	12,714	82,514
LPG (Light only)	—	1.05	2.00	—	20.67	—	—	18.26
Valid *N*		100	47		1,032			1,180
Small generator	—	—	—	—	—	—	28.50	28.50
Valid *N*							158	158
Dry cell battery	2.94	4.62	4.03	3.47	3.88	3.36	4.11	3.68
Valid *N*	24,898	15,530	8,272	39,849	172,192	153,117	52,795	466,652
Car battery	3.52	12.00	10.56	3.24	6.00	3.93	8.13	5.72
Valid *N*	149	81	651	807	516	1,910	812	4,925
Electricity (Grid)	19.82	27.04	24.66	10.87	13.36	9.44	16.03	13.63
Valid *N*	51,328	43,751	18,739	78,070	327,738	229,695	63,624	812,945
All Expend								
(Lighting and electricity)	21.40	28.59	26.95	13.25	16.46	11.83	19.70	16.26
Valid *N*	53,461	45,118	19,390	79,041	331,055	248,678	68,781	845,522
Without Access to Grid Electricity								
Candles	3.81	7.42	8.14	3.32	4.99	4.68	4.17	4.49
Valid *N*	46,411	25,460	7,136	168,713	245,255	242,767	144,307	880,048
Kerosene (Light only)	14.28	16.89	14.56	7.12	6.64	6.24	8.33	7.98
Valid *N*	93,230	14,833	2,886	235,205	202,335	203,053	238,416	989,958
LPG (Light only)	12.67	13.07	—	—	—	18.00	—	16.24
Valid *N*	437	154				1,162		1,753
Small generator	41.37	37.20	—	—	—	20.28	33.82	33.31
Valid *N*	1,431	887				1,278	3,195	6,791
Dry cell battery	4.93	7.37	6.80	4.48	6.50	5.01	8.04	6.04
Valid *N*	86,036	23,153	6,929	242,973	245,259	262,790	297,041	1,164,180
Car battery	6.19	12.57	8.24	5.59	5.76	6.06	6.74	6.61
Valid *N*	47,556	16,875	3,027	32,730	46,295	35,060	55,140	236,683
Electricity (Grid)	—	—	—	—	—	—	—	—
Valid *N*								
All Expend								
(Lighting and electricity)	22.65	28.76	21.16	12.50	14.74	12.85	17.57	15.44
Valid *N*	101,149	29,804	8,135	280,593	300,612	309,684	310,512	1,340,491

Source: Authors' calculations, 2005.

Table A.2.27

Household Monthly Expenditures on Lighting and Electricity by Region, in Soles (Users Only)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
All Areas (Electrified and Unelectrified)								
Candles	2.74	5.34	4.43	2.97	3.41	3.49	3.67	3.43
Valid *N*	73,657	39,680	16,723	201,768	434,878	372,737	177,456	1,316,898
Kerosene (Light only)	13.47	15.38	13.68	7.08	6.38	5.85	8.14	7.67
Valid *N*	100,936	17,009	3,381	239,414	228,963	231,640	251,130	1,072,472
LPG (Light only)	12.67	8.32	2.00	—	20.67	18.00	—	17.05
Valid *N*	437	254	47		1,032	1,162		2,933
Small generator	41.37	37.20	—	—	—	20.28	33.57	33.20
Valid *N*	1,431	887				1,278	3,353	6,949
Dry cell battery	4.48	6.26	5.29	4.34	5.42	4.40	7.45	5.36
Valid *N*	110,934	38,683	15,200	282,821	417,450	415,907	349,836	1,630,832
Car battery	6.18	12.57	8.65	5.53	5.76	5.95	6.76	6.60
Valid *N*	47,704	16,956	3,678	33,537	46,811	36,970	55,952	241,608
Electricity (Grid)	19.82	27.04	24.66	10.87	13.36	9.44	16.03	13.63
Valid *N*	51,328	43,751	18,739	78,070	327,738	229,695	63,624	812,945
All Expend								
(Lighting and electricity)	22.22	28.66	25.24	12.66	15.64	12.39	17.96	15.76
Valid *N*	154,610	74,922	27,525	359,633	631,667	558,362	379,293	2,186,013

Source: Authors' calculations, 2005.

Table A.2.28

Household Monthly Expenditures on Lighting and Electricity by Electrification Status and Expenditure Quintiles, in Soles

	<113.25 S/month	113.26–201.00 S/month	201.01–321.13 S/month	321.14–533.22 S/month	>533.22 S/month	All
			With Access to Grid Electricity			
Candles	1.18	1.10	1.31	1.28	1.56	1.32
Valid *N*	53,630	73,649	92,432	101,956	115,184	436,850
Kerosene (Light only)	3.31	3.01	3.70	4.61	5.17	3.92
Valid *N*	15,430	20,525	14,841	14,547	17,171	82,514
LPG (Light only)	—	—	35.00	5.97	1.05	18.26
Valid *N*			516	563	100	1,180
Small generator	—	—	—	28.50	—	28.50
Valid *N*				158		158
Dry cell battery	2.66	3.12	3.66	3.85	4.39	3.68
Valid *N*	55,887	87,221	96,118	100,864	126,562	466,652
Car battery	3.00	6.00	8.00	4.46	6.89	5.72
Valid *N*	672	516	504	1,329	1,904	4,925
Electricity (Grid)	7.36	8.54	10.38	14.20	22.52	13.63
Valid *N*	113,534	143,193	160,146	187,719	208,353	812,945
All Expend						
(Lighting and electricity)	9.38	11.03	13.11	16.82	25.55	16.26
Valid *N*	117,418	148,819	168,760	194,164	216,360	845,522
			Without Access to Grid Electricity			
Candles	3.15	3.66	4.86	5.08	5.93	4.49
Valid *N*	182,301	192,231	173,186	168,581	163,749	880,048
Kerosene (Light only)	4.74	6.14	7.93	9.99	12.90	7.98
Valid *N*	234,333	219,636	192,592	178,691	164,707	989,958
LPG (Light only)	—	—	12.75	—	16.95	16.24
Valid *N*			298		1,455	1,753
Small generator	—	—	13.00	29.02	38.14	33.31
Valid *N*			775	1,466	4,550	6,791
Dry cell battery	3.58	4.95	6.02	6.97	9.06	6.04
Valid *N*	224,374	264,873	242,381	223,858	208,694	1,164,180
Car battery	5.28	5.20	6.13	6.83	7.49	6.61
Valid *N*	17,679	30,359	39,556	68,436	80,653	236,683
Electricity (Grid)	—	—	—	—	—	—
Valid *N*						
All Expend						
(Lighting and electricity)	8.15	12.14	15.17	19.40	26.14	15.44
Valid *N*	316,738	290,086	269,230	242,956	221,481	1,340,491

Source: Authors' calculations, 2005.

Table A.2.29

Household Monthly Expenditures on Lighting and Electricity by Expenditure Quintiles

Expenditure Quintile>	1. Poorest <113 S/month	2 113–201 S/month	3 201–321 S/month	4 321–533 S/month	5. Richest >533 S/month	All
			All Areas (Electrified and Unelectrified)			
Candles	2.71	2.95	3.62	3.64	4.13	3.43
Valid *N*	235,931	265,881	265,618	270,536	278,933	1,316,898
Kerosene (Light only)	4.65	5.88	7.63	9.59	12.17	7.67
Valid *N*	249,763	240,160	207,433	193,238	181,877	1,072,472
LPG (Light only)	—	—	26.85	5.97	15.93	17.05
Valid *N*			814	563	1,556	2,933
Small generator	—	—	13.00	28.97	38.14	33.20
Valid *N*			775	1,623	4,550	6,949
Dry cell battery	3.40	4.50	5.35	6.00	7.30	5.36
Valid *N*	280,261	352,093	338,499	324,723	335,256	1,630,832
Car battery	5.19	5.22	6.16	6.78	7.48	6.60
Valid *N*	18,351	30,875	40,060	69,765	82,557	241,608
Electricity (Grid)	7.36	8.54	10.38	14.20	22.52	13.63
Valid *N*	113,534	143,193	160,146	187,719	208,353	812,945
All Expend						
(Lighting and electricity)	8.48	11.76	14.38	18.25	25.85	15.76
Valid *N*	434,156	438,905	437,990	437,120	437,841	2,186,013

Source: Authors' calculations, 2005.

Table A.2.30

Percentage of Households with and without Access to Grid Electricity by Region

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
With access to grid electricity	35%	60%	71%	22%	52%	44%	18%	39%
Without access to grid electricity	65%	40%	29%	78%	48%	56%	82%	61%
All Households	156,418	75,315	27,786	362,029	634,240	565,023	383,403	2,204,214
	100%	100%	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

Table A.2.31

Percentage of Households with and without Access to Grid Electricity by Expenditure Quintiles

	1. Poorest	2	3	4	5. Richest	
Expenditure Quintile>	**<113 S/month**	**113–201 S/month**	**201–321 S/month**	**321–533 S/month**	**>533 S/month**	**All**
With access to grid electricity	27%	34%	38%	45%	50%	39%
Without access to grid electricity	73%	66%	62%	56%	51%	61%
All Households	441,398	441,612	440,132	440,247	440,827	2,204,216
	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

Table A.2.32

Household Electricity Consumption, Expenditure in Soles, Effective Price per kWh, and Electricity Used for Lighting by Region

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	**Central**	**South**	**North**	**Central**	**South**		
kWh used/month	38.30	61.73	59.06	21.68	26.87	16.66	31.56	27.19
Valid *N*	51,328	43,751	18,699	78,070	327,738	229,695	63,624	812,904
Spend per month	19.82	27.04	24.66	10.87	13.36	9.44	16.03	13.63
Valid *N*	51,328	43,751	18,739	78,070	327,738	229,695	63,624	812,945
Effective price per kWh	0.57	0.49	0.47	0.60	0.62	0.83	0.71	0.67
Valid *N*	51,328	43,751	18,699	78,070	327,738	229,695	63,624	812,904
% of electricity used for lighting	28.00	24.01	24.16	43.71	41.07	54.61	38.55	42.87
Valid *N*	50,109	42,503	17,731	74,548	316,196	224,429	57,883	783,398
kWh for lighting per month	6.99	10.38	9.32	6.44	7.70	5.82	6.92	7.10
	51,328	43,751	18,498	76,739	319,949	229,695	61,330	812,904

Source: Authors' calculations, 2005.

Table A.2.33

Household Electricity Consumption, Expenditure Effective Price per kWh and Electricity Used for Lighting by Expenditure Quintiles

Expenditure Quintile>	1. Poorest <113 S/month	2 113–201 S/month	3 201–321 S/month	4 321–533 S/month	5. Richest >533 S/month	All
kWh used/month	11.70	14.64	19.96	28.66	48.51	27.19
Valid *N*	113,534	143,193	160,146	187,719	208,353	812,945
Spend per month	7.36	8.54	10.38	14.20	22.52	13.63
Valid *N*	113,534	143,193	160,146	187,719	208,353	812,945
Effective price per kWh	0.83	0.76	0.69	0.62	0.55	0.67
Valid *N*	113,534	143,193	160,146	187,719	208,353	812,945
kWh for lighting per month	4.37	5.28	6.46	7.51	10.06	7.10
Valid *N*	117,146	145,477	160,872	189,011	206,128	818,633

Source: Authors' calculations, 2005.

Table A.2.34

Type and Number of Electric Lights Owned by Household by Expenditure Quintiles (All Households with Grid Connection)

Expenditure Quintile>	1. Poorest <113 S/month	2 113–201 S/month	3 201–321 S/month	4 321–533 S/month	5. Richest >533 S/month	All
Incandescent lamp	2.1	2.0	2.2	2.0	1.9	2.0
Valid *N*	118,912	149,336	168,909	195,931	218,422	851,510
Fluorescent tube	0.4	0.5	0.5	0.9	1.4	0.8
Valid *N*	118,912	149,336	168,909	195,931	218,422	851,510
Compact fluorescent lamp	0.3	0.4	0.5	0.6	1.1	0.6
Valid *N*	118,912	149,336	168,909	195,931	218,422	851,510
All electric lights	2.7	2.9	3.2	3.5	4.5	3.5
Valid *N*	118,912	149,336	168,909	195,931	218,422	851,510

Source: Authors' calculations, 2005.

Table A.2.35

Type and Number of Electric Lights Owned by Region (Users Only)

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
Incandescent lamp	2.64	2.61	2.90	2.50	2.74	2.60	2.25	2.64
Valid *N*	37,351	25,755	13,885	56,807	259,160	227,446	36,180	656,584
Fluorescent tube	2.21	2.73	2.61	2.24	2.26	1.86	2.34	2.24
Valid *N*	29,100	25,266	6,838	31,099	135,123	50,698	30,182	308,307
Compact fluorescent lamp	2.31	2.74	2.88	2.38	2.05	2.03	2.21	2.22
Valid *N*	23,354	22,686	6,911	28,868	99,824	31,433	34,989	248,065
All electric lights	3.97	4.38	3.97	3.49	3.67	3.00	3.35	3.50
Valid *N*	54,584	45,293	19,651	80,261	332,084	250,167	68,351	850,393

Source: Authors' calculations, 2005.

Table A.2.36

Type and Number of Electric Lights Owned by Expenditure Quintiles (Users Only)

	1. Poorest	2	3	4	5. Richest	
Expenditure Quintile>	<113 S/month	113–201 S/month	201–321 S/month	321–533 S/month	>533 S/month	All
Incandescent lamp	2.5	2.5	2.7	2.6	2.9	2.6
Valid *N*	100,145	118,748	141,047	149,687	146,958	656,584
Fluorescent tube	1.8	1.8	1.9	2.2	2.7	2.2
Valid *N*	24,438	40,263	46,540	79,254	117,813	308,307
Compact fluorescent lamp	1.5	2.0	2.1	2.0	2.6	2.2
Valid *N*	21,762	29,711	39,314	61,583	95,695	248,065
All Electric Lights	2.7	2.9	3.3	3.5	4.5	3.5
Valid *N*	118,912	149,336	167,877	195,931	218,337	850,393

Source: Authors' calculations, 2005.

Table A.2.37

Electricity Usage for Lighting by Lifeline Rate

Usage per Month	kWh Used/mo for Lamp Lighting	% of Electricity Used for Lighting	Average Effective Price per kWh (in S/month)
<=30 kWh/mo	5.9	53%	0.76
Valid *N*	555,784	555,784	578,065
> 30 kWh/mo	10.3	19%	0.46
Valid *N*	227,613	227,613	234,840
All Levels of Usage	7.2	43%	0.67
Valid *N*	783,398	783,398	812,904

Source: Authors' calculations, 2005.

Table A.2.38

Type and Number of Electric Lights Owned by Lifeline Rate

Usage per Month	Incandescent	Fluorescent	Compact Fluorescent	All Electric Lamp Lighting
<=30 kWh/mo	2.6	1.9	2.0	3.1
Valid *N*	469,108	163,054	145,713	577,587
> 30 kWh/mo	2.9	2.6	2.6	4.6
Valid *N*	160,244	137,738	92,618	234,840
All Levels of Usage	2.7	2.2	2.2	3.5
Valid *N*	629,352	300,792	238,331	812,427

Source: Authors' calculations, 2005.

Table A.2.39

Television Ownership by Region

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
No TV	13%	7%	8%	40%	38%	42%	36%	35%
B&W TV only	28%	25%	29%	34%	32%	38%	21%	32%
Color TV only	55%	63%	54%	22%	26%	16%	38%	28%
Color and B&W TV	4%	5%	9%	4%	5%	5%	5%	5%
All Households	54,585	45,377	19,652	80,261	332,084	250,561	68,990	851,510

Note: Television refers to plug-in television.

Table A.2.40

Television Ownership by Expenditure Quintiles

	1. Poorest	2	3	4	5. Richest	
Expenditure Quintile>	<113 S/month	113–201 S/month	201–321 S/month	321–533 S/month	>533 S/month	All
No TV	75%	50%	37%	22%	13%	35%
B&W TV only	17%	38%	42%	38%	23%	32%
Color TV only	7%	9%	17%	33%	57%	28%
Color and B&W TV	1%	3%	4%	7%	8%	5%
All Households	118,911	149,335	168,910	195,931	218,420	851,507
	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

Note: Television refers to plug-in television.

Table A.2.41

Plug-in Radio and Television Ownership by Region

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
No Radio/TV	8%	4%	2%	24%	11%	21%	21%	15%
Radio only	5%	4%	6%	17%	27%	21%	15%	20%
TV only	46%	28%	19%	23%	14%	15%	27%	19%
Radio and TV	42%	65%	73%	37%	49%	43%	37%	46%
All Households	54,583	45,377	19,651	80,260	332,085	250,561	68,990	851,507

Source: Authors' calculations, 2005.

Note: Television refers to plug-in television.

Table A.2.42

Plug-in Radio and Television Ownership by Expenditure Quintiles

	1. Poorest	2	3	4	5. Richest	
Expenditure Quintile>	<113 S/month	113–201 S/month	201–321 S/month	321–533 S/month	>533 S/month	All
No Radio/TV	39%	21%	13%	8%	5%	15%
Radio only	36%	29%	25%	14%	8%	20%
TV only	10%	13%	16%	22%	28%	19%
Radio and TV	15%	37%	47%	56%	59%	46%
All Households	118,911	149,336	168,909	195,931	218,422	851,509
	100%	100%	100%	100%	100%	100%

Source: Authors' calculations, 2005.

Note: Television refers to plug-in television.

Table A.2.43

Electric Appliance Ownership by Region

	Coastal Region			Andean Region			Amazon Region	All Regions
	North	Central	South	North	Central	South		
Iron	52%	60%	46%	21%	22%	14%	33%	25%
Fan	12%	11%	5%	0.8%	1.2%	0.1%	8%	3%
Refrigerator	29%	41%	33%	6%	7%	4%	19%	11%
Video/DVD	22%	21%	23%	5%	9%	8%	15%	11%
Microwave	2.4%	2.6%	1.9%	1.1%	0.9%	0.1%	0.6%	0.9%
Stove	0.5%	1.0%	0.8%	0.2%	—	—	0.3%	0.1%
Washing machine	1.9%	1.8%	1.4%	0.2%	0.5%	—	1.3%	0.6%
Dom water pump	1.9%	2.1%	1.7%	—	—	—	0.3%	0.3%
Electric motor	0.8%	1.0%	0.2%	1.7%	0.8%	0.4%	0.7%	0.8%
Sewing machine	2.0%	1.0%	0.9%	—	0.7%	0.4%	0.7%	0.6%
Electric drill	1.1%	0.2%	0.9%	0.4%	0.1%	0.4%	0.5%	0.4%
Electric saw	—	0.2%	0.3%	0.2%	—	0.2%	—	0.1%
Irrigation pump	0.4%	0.4%	0.7%	—	0.3%	0.1%	0.3%	0.2%
All Households	54,584	45,377	19,652	80,260	332,084	250,561	68,990	851,508

Source: Authors' calculations, 2005.

Table A.2.44

Electric Appliance Ownership by Expenditure Quintiles

	1. Poorest	2	3	4	5. Richest	
Expenditure Quintile>	<113 S/month	113–201 S/month	201–321 S/month	321–533 S/month	>533 S/month	All
Iron	5%	12%	23%	39%	58%	25%
Fan	0%	0%	1%	3%	10%	3%
Refrigerator	0.9%	3%	5%	17%	37%	11%
Video/DVD	3%	6%	8%	14%	28%	11%
Microwave	—	0.1%	0.4%	0.4%	4.3%	0.9%
Stove	—	—	0.1%	0.3%	0.4%	0.1%
Washing machine	—	0.0%	0.3%	0.0%	3.1%	0.6%
Dom water pump	—	—	0.1%	0.3%	1.5%	0.3%
Electric motor	0.5%	0.6%	0.7%	0.5%	1.8%	0.8%
Sewing machine	—	0.9%	0.0%	0.8%	1.7%	0.6%
Electric drill	—	0.1%	0.1%	0.3%	1.7%	0.4%
Electric saw	—	0.1%	0.0%	—	0.4%	0.1%
Irrigation pump	0.1%	0.1%	0.0%	0.9%	0.2%	0.2%
All Households	193,117	204,630	164,044	150,843	138,876	851,510

Source: Authors' calculations, 2005.

Table A.2.45

Households with Photovoltaic (PV) Systems

Departamento	Grid Access	Panel Used Last Month	Panel is: [1]	Monthly Rental [Soles]	System Cost [Soles]	Year Installed	Annual Maint. Cost [Soles]	Size [Watts]
Lambayeque	Yes							
Tumbes	Yes							
Tumbes	Yes							
Piura								
Lambayeque		Yes	owned		2500	2001		
La Libertad								
La Libertad		Yes	owned		1400	2003		
Ica	Yes							
Lima		Yes	given			2004		
Arequipa	Yes							
Arequipa	Yes							
Arequipa	Yes							
Arequipa		Yes	owned		550	1986		34
Arequipa	Yes							
Arequipa								
Cajamarca		Yes	owned		5000	2004		
Cajamarca		Yes	owned		900	2004		85
Cajamarca		Yes	rented	18		2005	500	12
Ayacucho	Yes							
Huanuco								
Pasco	Yes							
Ayacucho	Yes							
Ayacucho	Yes							
Cusco		Yes	owned		2500	2002		
Puno		Yes	owned		650	2002		75
Puno		Yes	owned		1200	2000		
Puno		Yes	owned		1500	2004		100
Puno		Yes	owned		2800	1982		
Puno		Yes	owned		1800	1992		12
San Martin	Yes							
Loreto	Yes	Yes	owned		704	2004		77
Loreto	Yes							
Cajamarca								
Amazonas		Yes	owned		1300	2000		
Amazonas		Yes	owned		8000	1998		70
Amazonas		Yes	owned		500	2005		75
Amazonas								
Loreto		Yes	owned		120	1999	145	600[2]
Loreto		Yes	owned		85	2001	135	600[2]
Loreto		Yes	given			2002	60	600[2]
Loreto		Yes	owned		230	2004	10	600[2]
Ayacucho		Yes	owned		600	2005		75

Source: Authors' calculations, 2005.

Notes: (1) No systems were reported as leased. Only two systems are reported as given. Whether the inference is that systems reported as owned were in fact bought (by the reporting householders) is not clear. (2) It seems likely that there is a data entry error for those households reporting 600 Watt systems, given cost estimates of 85 to 230 soles. The question was asked as "panel cost." Whether this was interpreted by the enumerators as total system cost is not clear.

Table A.2.46

Small Generator Users, Cost Data

	Owned Small Generator Cost	Diesel Fuel Cost	Gasoline Fuel Cost	Maintenance and Repair Cost
	Soles	Soles/Month	Soles/Month	Soles/Month
Coastal North	2,375	17	78	12
Coastal Central	1,716	44	59	
Coastal South	—	—	—	—
Andean North	—	—	—	—
Andean Central	—	—	—	—
Andean South	928		18	3
Amazon	2,140	25	60	
All	**1,919**	**29**	**53**	**7**
	Number of Households Actually Sampled			
Coastal North	7	2	5	4
Coastal Central	7	7	2	0
Coastal South	0	0	0	0
Andean North	0	0	0	0
Andean Central	0	0	0	0
Andean South	3	0	3	1
Amazon	6	3	3	0
All	**23**	**12**	**13**	**5**

Source: Authors' calculations, 2005.

(1) Average cost of gasoline generators = 1703 soles.

Annex 3

Estimating the Benefits of Rural Electrification

Many issues arise in the estimation of demand curves, and in the use of changes in consumer surplus to measure benefits. These are discussed in this Annex, and the methodology and results are compared with other studies.

The Demand Curve

Assumptions about the shape of the demand curve are critical when only few points are available. Many of the early studies of the benefits of rural electrification recognized that demand curves were likely concave (as drawn in Figure A.3.1), but then used a linear curve anyway.[33]

Unfortunately such an assumption will lead to an overestimation of the area *C*, and of the net benefits of electrification, because the empirical evidence is that the demand curve is much more likely to have a concave shape of the type shown in Figure A.3.1. Recognizing this problem, some studies (e.g., the World Bank's Solar Homes project in Bolivia) take the area *C* as one third of the area determined by a linear demand curve.

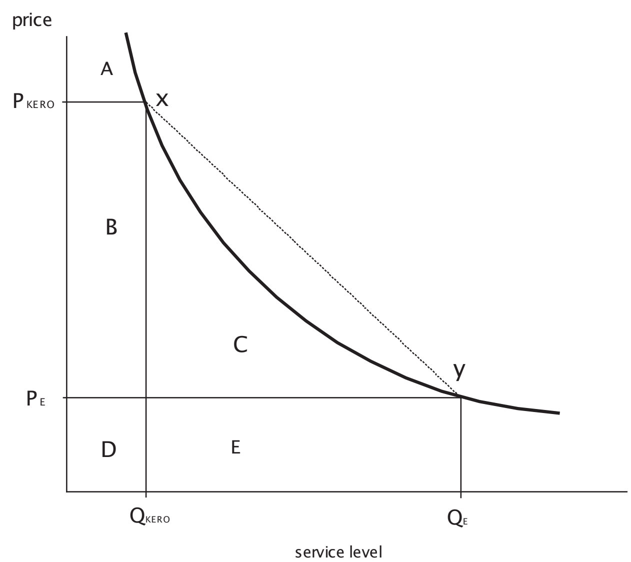
Others have made the assumption of some particular functional form, which has the advantage of calculation of the area under the demand curve by definite integrals. One commonly used approach is to use a curve of constant elasticity β:

$$Q = Q_0 \left[\frac{P}{P_0} \right]^{\beta} \qquad \textbf{Equation A.3.1}$$

For which the corresponding area *C* (i.e., between Q_{KERO} and Q_E) can be calculated from the corresponding definite integral.[34]

Figure A.3.1

Demand for Lighting



Source: INEI, 2005.

This has the merit of simplicity, but some shortcomings remain. The implication of such a curve is that at zero price, the quantity consumed would be infinitely large. Yet, in the face of very dramatic electricity price decreases (as are achieved for example by grid-connection vis-à-vis car battery use), in the short run, consumption will be constrained by the stock of appliances required to actually use larger quantities of electricity.[35]

This approach of estimating changes in welfare by consumer surplus has a number of issues and limitations

[33] For example, a linear demand curve was used in the Philippines study of rural electrification benefits (Barnes, D. F., A. Domdom, V. Peskin, and H. Peskin, *Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits.* ESMAP formal Report 255/02. Washington, DC: World Bank, 2002).

[34] For details, see P. Meier, *Economic Analysis of Solar Home Systems: A Case Study for the Philippines,* World Bank, 2003.

[35] P. Choynowksi (*Measuring Willingness to Pay for Electricity,* Asian Development Bank, Economics Research Department Technical Note Series #3, July 2002) has therefore proposed an alternative functional form of the general specification $\ln q = a + \beta p$. This has the advantage that the upper bound of electricity demand (when the price is zero) is given by e^a, which captures the fact that consumption is bounded by the stock of electrical appliances. The price elasticity is given by βp, which varies with price: the greater the price, the greater the elasticity of demand. The implication is that at very high prices (typical of the equivalent price of kerosene), demand is more elastic than at low prices (typical of the price of grid-electricity).

that are rarely acknowledged in many studies of rural electrification benefits. Therefore, this approach needs to be applied with some caution.[36] One must recognize that the demand curve shifts outward with increases in income (for a so-called *normal* good for a given price, higher income implies a greater demand). However in the case of an *inferior* good—of which radio listening is a good example—consumption *decreases* with increase of income.

Data Issues

Estimating the points required to establish a demand curve for some service such as lighting is not straightforward. In the Peru survey, respondents were asked to estimate the proportion of kerosene used for the various uses (such as lighting, and cooking), which was cross-checked against estimates derived from information collected about the *hours* of use and *type* of kerosene lamps. As shown in Figure A.3.2, these estimates show very different results.

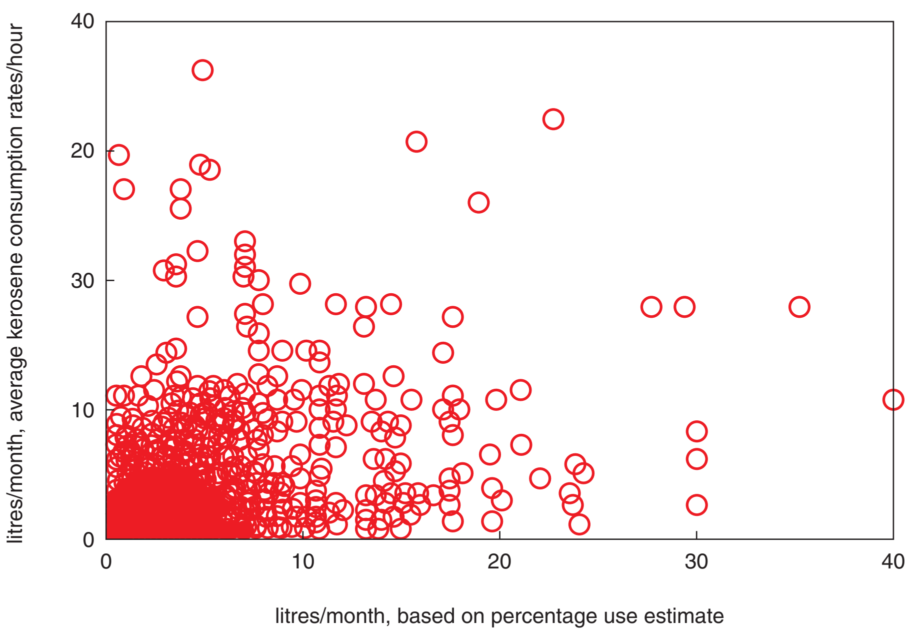
Because it is likely that user estimates of the fraction of kerosene devoted to lighting are unreliable (except for those who state 100 percent of household kerosene consumption is for lighting), the calculations presented in this box use the typical average consumption rates cited in Jones *et al* (2005) (0.01 liter per hour for a simple wick lamp, 0.03 liters per hour for a hurricane lamp, and 0.07 liters per hour for a petromax lamp). This approach also provides an estimate of kerosene consumption that is intrinsically consistent with estimates of lumen-hours, which is vital for the willingness-to-pay calculations. Indeed, as shown in Table A.3.1, estimates of cost/kLmh based on average consumption of lamp-types have much lower variance than based on user estimates.

Estimates of Willingness to Pay

Table A.3.2 shows the benefit calculations for each expenditure quintile. As described in Section 5 of this report, Q_{KERO} refers to quantity of kerosene consumed by unelectrified households, P_{KERO} is the price of kerosene, Q_E is the quantity of electricity consumed (by electrified households), and P_E is the price of electricity. The table

Figure A.3.2

Comparison of Estimates Used for Kerosene Lighting



Source: INEI, 2005.

[36] The idea of measuring changes in consumer surplus by the area under the (uncompensated) demand curve is attributed to Marshall in 1890. Thus, changes in utility are measured by a monetary amount. But the impact of electrification is to dramatically decrease prices for lighting, TV viewing, and other services previously provided at high cost by electricity substitutes—in some cases, by an order of magnitude. Hence, as price falls, the consumer's *real* income (though not monetary income) rises. In other words, one should measure the area under a *constant real income* demand curve, not a constant monetary income demand curve.

displays the values (i.e., B, C, D, and E) that correspond to the different areas under the lighting demand curve shown in Figure A.3.1. The table then sums these values to obtain the estimated willingness to pay for each quintile.

The calculations show that the willingness of unelectrified households to pay for grid electricity ranges from 24 to 38 soles per month ($B + C + D + E$), depending on the expenditure quintile. The net benefit (after subtracting existing benefits from kerosene lamps) ranges from 17 to 30 soles per month. Average willingness to pay per kilowatt-hour ranges from 3.9 to 5.0 soles/kWh (or US$1.23 to 1.54/kWh). The WTP/kWh *decreases* with increasing expenditure because the poor pay a much higher price for kerosene lighting, and therefore benefit from electrification proportionately more than the upper quintiles. However, the total value of benefits *increases* with increasing expenditure.

The willingness-to-pay results for Peru are consistent with those obtained in other countries (Table A.3.3). Average WTP in Peru is US$8 per household per month, compared with US$11 in Bolivia and US$12 in Laos, but significantly lower than the Philippines (US$38/household/month). This is due to the use of a linear demand curve in the Philippines calculations. When a constant elasticity demand curve is used, WTP in the Philippines falls to US$7/household/month.

Table A.3.1

Statistical Comparison of User Estimates of Kerosene Consumption versus Average Lamp Consumption

	Based on User Estimates of Proportion of Kerosene Used for Lighting, (Soles/kLmh)	Based on Average Hourly Consumption of Lamp-Types (Soles/kLmh)
Mean	0.93	0.73
Standard deviation	4.39	1.72
Coefficient of variation	4.69	2.35

Source: INEI, 2005.

Table A.3.2

Assumptions and Results, Willingness to Pay for Lighting per Month, by Quintile

	Unit	1 (Poorest)	2	3	4	5 (Richest)
Assumptions						
Q_{KERO} [wick-lamp]	kLmh	0.8	1.1	1.1	1.2	1.7
Q_E	kLmh	111.9	129.5	141.9	205.6	323.5
P_{KERO} [wick-lamp]	S/kLmh	3.0	2.9	2.8	2.8	2.7
P_E	S/kLmh	0.061	0.053	0.048	0.034	0.026
Results						
Elasticity	[ ]	–1.3	–1.2	–1.2	–1.2	–1.1
Areas: B	S	2.5	3.1	3.2	3.3	4.7
C	S	14.5	16.2	16.4	18.6	25.0
D	S	0.1	0.1	0.1	0.0	0.0
E	S	6.8	6.9	6.8	7.1	8.3
Total WTP	S	23.9	26.2	26.4	29.0	38.0
Net Benefit	**S**	**17.1**	**19.3**	**19.6**	**21.9**	**29.7**
Average kWh	kWh	4.8	5.6	6.5	7.4	9.6
Average WTP/kWh	S/kWh	5.0	4.7	4.1	3.9	4.0
	US$/kWh	1.54	1.46	1.26	1.21	1.23

Source: INEI, 2005.

Table A.3.3

Cross-Country Comparisons of WTP Calculations

	Unit	Peru	Bolivia	Philippines	Laos
Assumptions					
Q_{KERO}	kLmh/month	1.13	7	4.1	20
Q_E	kLmh/month	142	90	204	435
P_{KERO}	$ per kLmh	0.89	0.48	0.36	0.195
P_E	$ per kLmh	0.015	0.04	0.0075	0.003
Results					
Elasticity	[ ]	–1.18	–1.03	*	–0.74
Total WTP (per $U.S. household/month)		**8.17**	**12.24**	**38.18**	**11.20**

Source: Peru results for Q_{KERO} are for wick-lamp kLmh/only. Bolivia data from Annex 9, *ERTIC Project PAD,* 2003. Philippines data from ESMAP, *Rural Electrification and Development in the Philippines: Measuring The Social and Economic Benefits,* Formal Report 255/02, May 2002. Laos data from PAD, *2nd Southern Provinces Rural Electrification Project, 2004*

kLmh = kiloLumen-hour.

* Based on linear demand curve.

Annex 4

Survey Questionnaire: Consumption of Energy Households in Rural Areas

Survey Consumption of Energy Households in Rural Areas

Household Module

Confidential Questionnaire

Amparado por el Decreto Legislativo N° 604

ECEHAR.01

Contains: Characteristics of the house, household and the household members. Household energy sources. Opinions about the use of electric energy use. Time used. Household income.

Conglomerate N°	N° of selected houses	Type of selection	Is this house a replacement?	N° of selected house being replaced	Questionnaire 1. N°	Questionnaire 2. N°	Additional questionnaire
			Yes . . . . . 1 No 2				

Geografic Location → Sample Location

1. Department		5. Zone N°		9. Total households that occupy the house	
2. Province		6. Block N°			
3. District		7. Area N°		10. Household N°	
4. Population center		8. House N°			

11. House address

Name of street, Av., Jr., freeway, etc.	N°	Int.	Floor	Block	Lot	Km.	Telephon.

12. Names & last names of household head	

13. Interview & Supervision

Visit	7. Encuestador						Local supervisor			
		Hour		Next visit				Hour		
2.1.1.1.1.1.1	Date	From	To	Date	Hour	Result of the visit (*)	Date	From	To	Result of the visit (*)

14. Final Result of the Survey

Date	
Result	

(*)Results Codes

1. Complete	4. Absent	7. Other ________________ (Specify)
2. Incomplete	5. Vacant house	
3. Rejected	6. Did not begin interview	

15. Functionaries of the Interview		
Office	Cod.	9. Names & last names
Interviewer:		
Local supervisor:		
National supervisor:		

16. Total # people registered in chapter 200		Observations	

100. Characteristics of House & Household

House Data

101. Tipo de vivienda:

1	Independent house
2	Apartment in building
3	House in villa
4	House in vicinity house (Alley, or yard)
5	Hut or cabin
6	Improvised house
7	Local not fit for human habitation
8	Other______________________(specify)

102. The predominant material in the outer walls is:

1	Brick or cement block
2	Stone or sillar with lime or cement
3	Adobe (sun-dried brick)
4	Quincha (cane with mud)
5	Stone with mud
6	Wood
7	Rustic mat
8	Other material__________(specify)

103. The predominant material in the floor is:

1	Parquet, polished wood
2	Vinyl or asphalt strips
3	Ceramic tiles
4	Bare wood planks
5	Cement
6	Earth, sand
7	Other material____________(specify)

104. The predominant material in the roof is:

1	Concrete
2	Wood
3	Tiles
4	Calamine/fiber of cement
5	Bamboo or rustic mat with mud
6	Rudimentary mats
7	Palm leaf/thatched
8	Other material_____________(specify)

105. How many rooms does your house have:

Excluding kitchen, bathroom, garage and storage.

N° o

106. Do you use a space in the house to perform an activity that provides income to the home:

Yes	1
No	2

Interviewer:

If code 1 (Yes) is circled in question 106, fill out chapter 800 **"Business".**

9.1.1.1.1.1.1.1 Household Data

107. The house that your household occupies is:

		What is the monthly amount?
Rented?	1	} S/
Own, totally paid?	2	
Own, by invasion?	3	
Own, buying it on credit?	4	
Yielded by the work center?	5	
Yielded by another home or institution?	6	
Other way?______________	7	(Specify)

108. The sanitation system of this household is connected to:

1 Public network within the house
2 Public network outside the house but within building
3 Pit toilet (treated)
4 Pit toilet/latrine (untreated)
5 River, stream or canal
6 None

109. The water supply to drink and to prepare food in your home comes from:

	Yes	No	Distance to the water source (meters)
1. Public network, within the house?	1	2	
2. Public network, outside the house but inside the building?	1	2	
3. Pylon of public use?	1	2	
4. Tanker or another similar?	1	2	
5. Well?	1	2	
6. Rivers, builds drains, springs or similar?	1	2	
7. Other____________ (Specify)	1	2	

Interviewee N° 200. Characteristics of Household Members

201.	202.		203.	204.		205.		206.		207.	
N° of Ord.	What is the full name of each one of the people that lives permanently in this home and those who are lodged here? (Dont forget to register the absent home members and new born)		What is the relationship with the head of home?	Is a household member?		Are they absent from home 30 days or more?		Are they present in home 30 days or more?		Over the last 12 months how many months did .... (person) sleep & eat in this house?	
			Boss M/F 1 Wife/Husband 2 Son/Daughter 3 Son-in-law/ Daughter-in-law 4 Grandson 5 Parents/Parents-in-law 6 Other relatives 7 Housekeeper 8 Pensioner 9 Others. Non-relatives 10			Pass to ↓ ↓					
	Name	Last names	Code	Yes	No	Yes	No	Yes	No	N°	
1			1	1	2	1	2	1	2		
2				1	2	1	2	1	2		
3				1	2	1	2	1	2		
4				1	2	1	2	1	2		
5				1	2	1	2	1	2		
6				1	2	1	2	1	2		
7				1	2	1	2	1	2		
8				1	2	1	2	1	2		
9				1	2	1	2	1	2		
10				1	2	1	2	1	2		
11				1	2	1	2	1	2		
12				1	2	1	2	1	2		

208.		209.		210.	211.		212.		213.	
					For 3 years or older					
Sex		How old are you?		.... (Name) Considers themself:	Which is the last year or degree of studies and level that approved?		Do you attend some center or program of regular education?		How many hours do you read or study during the night at home? Frequency:	
				Native quechua? 1 Native aymara? 2 Native amazonico? 3 African-peruvian or black? 4 Oriental or of asian origin? 5 White or of european origin (caucasian)? 6 Mestizo? 7	Without level 1 Initial education 2 Primary incomplete 3 Primary complete 4 Secondary incomplete 5 Secondary complete 6 Superior. Nonuniversity. Incomplete. 7 Superior. Nonuniversity. Complete. 8 Superior. University. Incomplete. 9 Superior. University. Complete. 10 Postgrado 11				Daily 1 Every other day 2 Weekly 3 Monthly 4	
Male	Female	12	Months	Code	Level	Year/Grade	Yes	No	Hrs.	Frecuencia
1	2						1	2		
1	2						1	2		
1	2						1	2		
1	2						1	2		
1	2						1	2		
1	2						1	2		
1	2						1	2		
1	2						1	2		
1	2						1	2		
1	2						1	2		
1	2						1	2		
1	2						1	2		

Interviewee N° 200. Characteristics of Household Members

201.	214.	215.	216.	217.	
	Para 14 años y mas edad				
N° of Ord.	Last week, from .... to	What is the principal occupation that you perform?	What is your business, organization or enterprise dedicated to for your principal occupation?	You work in your principal occupation or business as:	
	Perform some type of work? 1 Perform some task for money? 2 Did not work but has job? 3 Helping on the farm, store or family business without being paid? 4 Was looking for work before? 5 Was looking for work, first time? 6 Was taking care of home, without work? 7 Was studying & without work? 8 Living off pension or retired & without work? 9 (6–9: go to Chapt. 300 & apply Section 1 Chapt. 600) Living off rents and without work? 10 Other? ___________ (Specify) 11			Employer or patron? 1 Independent worker? 2 Employee? 3 Blue collar worker? 4 Unpaid family worker? 5 Household worker? 6 Other? ___________ (Specify) 7 **(go to Chapt. 300 & apply Chapt. 600 Section 1)**	
	Code	Specify	Specify	Code	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

218.	219.	220.	221.	222.
The type of pay or income your receive from your principal occupation is: (Choose an alternative)	**Monetary income section**	**Agricultural income section**	**Livestock income section**	**Fishing income section**
Paycheck? 1 Salary? 2 Commision? 3 Pay for unit (piecework)? 4 Tip 5 Grant? 6 Professional Honoraria (with R.U.C)? 7 Income for business or service? 8 Income (earnings) for Agricultural Act? 9 Income (earnings) for Livestock Act? 10 Income (earnings) for Fishing Act? 11 Others? ______________________ 12				
Code	**N° ord**	**N° ord**	**N° ord**	**N° ord**
	1	1	1	1
	2	2	2	2
	3	3	3	3
	4	4	4	4
	5	5	5	5
	6	6	6	6
	7	7	7	7
	8	8	8	8
	9	9	9	9
	10	10	10	10
	11	11	11	11
	12	12	12	12

100. Characteristics of House & Household

106. Under this question, there should be an instruction for interviewer to make sure that he/she fill in small business questionnaire module as well as complete the rest of household questionnaire.

200. Characteristics of Household Members

Please delete questions 212, 214 and 215. Please also include codes for question 213 (principal occupation) that include codes appropriate for rural and marginal urban areas.

300. Sources of Energy (Only for the Head of Home or the Spouse)

301.	Are the following energy sources used in your home?	Yes	No
1	Electricity from interconnected grid or isolated system	1	2
2	Kerosene	1	2
3	Candle	1	2
4	Dry cell batteries	1	2
5	Car batteries	1	2
6	LPG	1	2
7	Solar PV home system	1	2
8	Firewood	1	2
9	Animal dung	1	2
10	Crop residue	1	2
11	Electric generator set	1	2
12	Charcoal	1	2
13	Coal	1	2
14	Other, specify	1	2

SECTION 1: USE OF ELECTRICITY FROM INTERCONNECTED GRID AND ISOLATED SYSTEM

302. Does your home have an electricity connection?

Yes	1	Go to 304
No	2	Go to 303A

303A. If your home has no electricity, please indicate whether the following statements are major, minor or not a reason to explain why the household is not connected to the grid?

Code: Major Reason = 1
Minor Reason = 2
Not a Reason = 3
Not Applicable = –7

	No Reason	Minor Reason	Major Reason
1. Electricity is not available in my area	1	2	3
2. Our household can't pay the connection fee	1	2	3
3. Our household can't pay the cost of house wiring	1	2	3
4. Our household can't afford the monthly payment	1	2	3
5. Our household can't afford to buy electrical equipment	1	2	3
6. We are satisfied with present energy source	1	2	3
7. We do not see any application of electricity	1	2	3
8. Other reason______________________	1	2	3

303B. If your home has no electricity, would you like to have access to grid electricity?

21.1.1.1.1.1.1.1.1	Yes	1	Go to 326
	No	2	Go to 326

304. What is the name of the distribution company that provides electricity service in your home?
Code: Write down name of the company
____

305. In what year was the electrical connection first made to your home?	
Code: Year of connection of home (ie. 1958)	
Does not know	–8
____________________	

306. Does your home have an electric meter?			
21.1.1.1.1.1.1.2	Yes	1	
21.1.1.1.1.1.1.3	No	2	Go to 308

307. How many households are connected to the same electric meter including yours?
Code: Number of homes or "1" if the responding household is the only home that connect to electric meter

308. How many hours per day does your home typically have electricity service?	**309. How many days per month does your household typically have electricity service in your home?**	**310. During the last 12 months, how many months has your home had electricity service?**
Code: Hours per day of service	Code: Days per month of service	Code: Months with service for the last 12 months
Don't know –8	Don't know –8	Don't know –8
____________________	____________________	____________________

311. To whom does your household pay for the electricity service that you receive at home?		
Directly to the distributing company	1	
Pay to the neighbor or relative	2	
The electricity is included in the rent	3	Go to 315A
Others____________________ (Specify)	4	
Do not pay	5	Go to 315A

312. How does your household pay for the electrical service that you receive in your home?

Per KWH used (amount of units consumed shown in the meter)	1		
		How much does HH pay for each billing?	No. of days per billing period
By the number of bulbs, fluorescent tubes or electrical apparatuses	2		
Fixed charge or flat rate	3		
Others ________________________ (Specify)	4	Go to 315A	

313. If household pays the distributing company directly, request to see the last 3 bills.
Enumerator: Fill in the information below by reading from the bill. Enter "–7" for not applicable. Only record KWH usage and cost of electricity excluding installation fee. Do not include installation fee that may be included in the bill.

	Date of the previous reading			Date of the last reading			G. KWH Usage	H. Cost (S/.)
	A. Day	B. Month	C. Year	D. Day	E. Month	F. Year		
Bill #1								
Bill #2								
Bill #3								

314A. If respondent cannot show previous electricity bill, what is the average payment for one month (30 days) of electric service?

Code: Enter payment in S/per month.

Does not know –8

314B. Does the amount of payment mentioned in 314A include installation fee?

Code:

Does not know	–8		
Yes	1	Enter amount in S/.	
			(monthly)
No	2		
Does not know	–8		

315A. Does your household use any of the following incandescent light bulbs?				**315B. How many light bulbs of this class does the household use?**	**315C. What is the sum of all hours for all bulbs used during the last 24 hour period?** Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
N	Type and size of light bulb	Yes	No	No. of incandescent	No. of hours	No. of minutes
1	25 Watts	1	2			
3	50 Watts	1	2			
4	75 Watts	1	2			
5	100 Watts	1	2			

316A. Does your household use any of the following fluorescent tubes?				316B. How many tubes this class does the household use?	316C. What is the sum of all hours for all bulbs used during the last 24 hour period? Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
N	Type and size of light fluorescent	Yes	No	No. of fluorescent	No. of hours	No. of minutes
1	10 W (Straight)	1	2			
2	20 W (Straight)	1	2			
3	40 W (Straight)	1	2			
4	22 W (Circular)	1	2			
4	32 W (Circular)	1	2			

317A. Does your household use any of the following energy saving light bulbs?				317B. How many tubes of this class does the household use?	317C. What is the sum of all hours for all bulbs used during the last 24 hour period? Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
				Code: Enter the number, or "–7" for do not use.	Code: Enter "–7" for do not use.	
N	Type and size of energy saving light bulb	Yes	No	No. of energy saving light bulbs	No. of hours	No. of minutes
1	< 12 Watts	1	2			
2	12 Watts	1	2			
3	18 Watts	1	2			
4	20 Watts	1	2			
5	25 Watts	1	2			

318A. Does your household use electricity for the following purposes?			318B. In general, what percentage of spending on electricity each month is for the following purposes?	
Code: "0" if none and percentage if applicable Does not know –8 Not applicable –7				
Use type	Yes	No	Percentage	Does not know
1. Lighting	1	2		–8
2. Cooking	1	2		–8
3. Electric appliances	1	2		–8
4. Family business	1	2		–8
5. Farm irrigation	1	2		–8
6. Other	1	2		–8
Total			**100%**	

	319A. Does your household use the following plug-in electric appliances?			**319B. How many of each appliance does the household use?**	**319C. What is the average wattage rating of the appliance?** Note: Estimate the average wattage if more than one appliance in use.	**319D. What is the sum of all hours for all appliances used during the last 24 hour period?** Note to enumerators: If the household has more than one appliance of this type, ask the respondent about the use of each appliance in the household and sum the total hours that the appliances are used in the last 24 hours.	
				Code: Enter the number or "–7" for do not use.	Code: Enter the average number of watts of appliances or "–7" for do not use.	Code: Enter hours of use with fraction., or "–7" for do not use.	
	Appliance Type	Y	N			No. of hours	No. of minutes
1	Radio	1	2				
2	Sound equipment	1	2				
3	TV black and white	1	2				
4	TV color	1	2				
5	Recording video/DVD	1	2				
6	Electric motors	1	2				
7	Refrigerator	1	2				
8	Microwave oven	1	2				
9	Electric stove	1	2				
10	Electric iron	1	2				
11	Fan	1	2				
12	Washing machine	1	2				
13	Domestic water pump	1	2				
14	Electrical sewer machine	1	2				
15	Electric drill	1	2				
16	Electric saw	1	2				
17	Electric pump for irrigation	1	2				
18	Others?___________(Specify)	1	2				
19	Others?___________(Specify)	1	2				
20	Others?___________(Specify)	1	2				

320A. In your opinion, your household electricity supply during the dry season is:		**320B. In your opinion, your household electricity supply during the rainy season is:**	
Normal	1	Normal	1
Irregular	2	Irregular	2
Not applicable	–7	Not applicable	–7

321. Over the past month, how many times has the household's electricity services failed for more than 30 minutes?

Code: Number of times		
Never	0	Go to 323
Does not know	–8	

322. Over the past one month, could you please estimate the amount of hours (in total) electricity service has not been available to your home due to electricity cuts or blackouts?

Code: Enter hours with fraction	
Does not know	–8
____________________	

323. Over the past one month, how often did the household experience dimming of the light?

Often	1
Rarely	2
Never	3

324. In case of power failure, what backup equipment does the household use, if any?

	Yes	No
A. Candles	1	2
B. Kerosene wick lamp	1	2
C. Petromax	1	2
D. Gas lamp	1	2
E. Car/Motorcycle battery	1	2
F. Generator	1	2

325. Please indicate whether the following are major, minor, or not reasons for your household connecting to grid electricity.

Code: Major Reason = 1 Minor Reason = 2 No Reason = 3

	Major Reason	Minor Reason	No Reason
1. For entertainment	1	2	3
2. For information and/or the news	1	2	3
3. For better lighting within the home	1	2	3
4. For better safety outside the home	1	2	3
5. To improve income	1	2	3
6. Because electricity is cheaper than other fuels	1	2	3
7. For education of your children	1	2	3
8. Other reason______________________	1	2	3

SECTION 2: USE OF KEROSENE

326. In the past month did your household use kerosene?

Yes	1	
No	2	Go to 330

327A. How does your household usually purchase kerosene?	**327B. How many units of kerosene do you use per month?** Note: Unit refers to type of measurement answered in A. Use decimal point for less than one gallon or liter.	**327D. What is the price of each unit of kerosene?**	**327E. What is the average monthly expenditure on kerosene?**
Code: 1 = Gallons 2 = Liters 3 = Other _______ (Specify)	Code: Enter number of units of kerosene used in a month.	Code: Enter price in S/. per unit answered in A.	Code: Amount in S/. of monthly spending.
Code Number	Quantity	S/.per unit	S/.per month
_____________	_____________	_____________	_____________

328A. Does your household use kerosene for the following purposes?

Code: "0" if none and percentage if applicable
Does not know –8
Not applicable –7

328B. In general, what percentage of kerosene does the household use each month for the following purposes?

	Yes	No	Percent	Does not know
1. To start firewood	1	2		–8
2. Lamp lighting	1	2		–8
3. Cooking	1	2		–8
4. Appliances	1	2		–8
5. Home Business	1	2		–8
6. Other (specify) ________	1	2		–8
Total			**100%**	

329A. Does your household use any of the following lamp or appliance?			329B. How many of each of these appliances does your household use?	329C. What is the sum of all hours for all . . . used during the last 24 hour period Note: Ask the respondent about the use of each . . . in the household and sum the total hours that the . . . are used in the last 24 hours.	329D. What is the sum of all days for all . . . used during the last month? Note: Ask the respondent about the use of each . . . in the household and sum the total days that the . . . are used in the last month.
	Yes	No	Quantity	No. of hours	Code: Enter number of days
1. Simple wick lamp	1	2			
2. Hurricane lantern	1	2			
3. Petromax lamp	1	2			
4. Wick stove	1	2			
5. Pressurized stove	1	2			
6. Refrigerator	1	2			
7. Freezer	1	2			
8. Other, specify	1	2			

SECTION 3: USE OF CANDLES

330. In the past month, did your household use candles for illumination?		
Yes	1	
No	2	Go to 333

331A. How many candles did your household use in the past month?	331B. What is the price of each candle?	331C. What is the average monthly expenditure of the household on candles?	331D. What is the sum of all hours for all candles used during the last 24 hour period? Note: Ask the respondent about the use of each candle in the household and sum the total hours that the candles are used in the last 24 hours.
Code: Enter number of candles.	Code: Enter price in S/.	Code: Enter monthly expenditure in S/.	Code: Enter number of hours/min.
			Hours ____ Minutes ____

332A. Does your household use candles for following purposes?			332B. In general, what percentage of candles does the household use each month for the following purposes?	
Code: "0" if none and percentage if applicable Does not know –8 Not applicable –7				
	Yes	No	Percent	Does not know
1. Home use	1	2		–8
2. Family business use	1	2		–8
3. Other	1	2		–8
Total			**100%**	

SECTION 4: USE OF DRY CELL BATTERIES

333. In the past month did your household use dry cell batteries at home?

Yes	1	
No	2	Go to 336

334A. Does your household use batteries of the following sizes?			334B. In a typical month, how many dry batteries of . . . did your household use in the past month?	334C. What was the price of each battery of size . . .?	334D. In the last month, how much did the household spend on batteries for each size . . .?
	Yes	No	Code: Enter number of dry cell batteries.	Code: Enter price in S/. of battery.	Code: Enter monthly expenditure in S/.
1. Large (Size D & C)	1	2			
2. Small (size AA & AAA)	1	2			

335A. Does your household use dry cell batteries for the following purposes?			335B. How many hours per day does your household use the . . .?	
			Code: Enter number of hours used per day; do not use any enter "0"	
	Yes	No	Hours	Minutes
1. Radio	1	2		
2. Clock	1	2	XXXXXXXXXXXXXXXXXXXXXXXXX	
3. Flashlight	1	2	XXXXXXXXXXXXXXXXXXXXXXXXX	
4. Others? ____________ (Specify)	1	2		

SECTION 5: USE OF CAR BATTERIES

336. In the past month, did your household use a car battery to provide electricity at home?

Yes	1	
No	2	Go to 344

337. How many car batteries does your household use at home at the same time?

Code: Enter number of car batteries.		

338A. What is the cost of the car battery?		**338B. What is the voltage of the battery?** Enumerator: Ask to see the batteries.							**338C. What is the amperage of the battery?**
Code: Enter cost in S/. of car battery		Code: Enter voltage of car battery, if no battery enter –7, if do not know enter –8							Code: Enter ampere of car battery
Batt No.		6 V	8 V	12 V	24 V	Other	Do not know	Not applicable	
1		6	8	12	24		–8	–7	
2		6	8	12	24		–8	–7	
3		6	8	12	24		–8	–7	

338D. If your household used a battery previous to this one, how many months did the previous battery last?

Code: Enter number of months previous battery lasted.
Does not apply –7

____

338E. What is the cost per recharge for the first battery listed?	**338F. How many recharges for all car batteries does your household have each month?**	**338G. How many days does each recharge last?**	**338H. What is the average monthly expenditure for recharging car batteries?**	**338I. What is the cost of the round trip transportation per recharge?**
Code: Amount in S/ Does not know –8	Code: Enter number of recharges	Code: Enter number of days each recharge last	Code: Enter monthly expenditure in S/.	Code: Enter roundtrip transportation cost in S/.
__________	__________	__________	__________	__________

339A. Does your household use any of the following incandescent light bulbs, which are energized by car batteries?				**339B. How many light bulbs of this class does the household use?**	**339C. What is the sum of all hours for all bulbs used during the last 24 hour period?** Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
	Type and size of light bulb	Yes	No	Code: Enter the number, or "–7" for do not use	Code: Enter hours of use with fraction., or "–7" for do not use	
					Hours	Minutes
1	< 10 Watts	1	2			
2	15 Watts	1	2			
3	25 Watts	1	2			

	340A. Does your household use any of the following fluorescent tubes, which are energized by car batteries?			**340B. How many tubes this class does the household use?**	**340C. What is the sum of all hours for all bulbs used during the last 24 hour period?** Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
				Code: Enter the number, or "–7" for do not use	Code: Enter hours of use with fraction., or "–7" for do not use	
	Type and size of fluorescent tube	Y	N		Hours	Minutes
1	10 W (Straight)	1	2			
2	20 W (Straight)	1	2			
3	22 W (Circular)	1	2			

	341A. Does your household use any of the following energy saving light bulbs, which are energized by car batteries?			**341B. How many light bulbs of this class does the household use?**	**341C. What is the sum of all hours for all bulbs used during the last 24 hour period?** Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
				Code: Enter the number, or "–7" for do not use	Code: Enter hours of use with fraction., or "–7" for do not use	
	Type and size of light bulb	Y	N		Hours	Minutes
1	7 W or less	1	2			
2	9 Watts	1	2			
3	12 Watts	1	2			
4	18 Watts	1	2			
5	20 Watts	1	2			

342A. Does your household use a car battery for the following purposes?			**342B. In general, what percentage of spending on car battery each month is for the following purposes?**	
Code: "0" if none and percentage if applicable Does not know –8 Not applicable –7				
	Yes	No	Percent	Does not know
A. Lighting	1	2		–8
B. Cooking	1	2		–8
C. Electric appliances	1	2		–8
D. Home business use	1	2		–8
E. Other	1	2		–8
Total	**1**	**2**	**100%**	

343A. Does the household use the following electric appliances, which are powered by electricity from car battery?				343B. How many of each appliance does your household have?	343C. What is the average wattage rating of the appliance? Note: Estimate the average wattage if more than one appliance in use.	343D. What is the sum of all hours for all appliances used during the last 24 hour period? Note to enumerators: If the household has more than one appliance of this type, ask the respondent about the use of each appliance in the household and sum the total hours that the appliances are used in the last 24 hours.	
				Code: Enter number of appliances or if do not use enter "–7"	Code: Enter the average number of watts of appliances or if do not use enter "–7"	Code: Enter the number of hours of use with fraction or if do not use enter "–7"	
		Yes	No			Hours	Minutes
1	Radio	1	2				
2	Sound equipment	1	2				
3	TV black and white	1	2				
4	TV color	1	2				
5	Video recorder	1	2				
6	DVD	1	2				
7	Others _______ (Specify)	1	2				

SECTION 6: USE OF LPG

344. In the past month did your household use LPG at home?		
Yes	1	
No	2	Go to 348

345A. What size of gas cylinder/tank does your household use at home?			345B. How many cylinders does your household use in a month?	345C. What is the price per cylinder or tank of LPG?	345D. On an average how much does your household spend per month on LPG?	345E. How many days does one cylinder of LPG last?
	Yes	No	Code: Enter number of cylinders used in a month	Code: Enter price in S/. per cylinder	Code: Enter monthly expenditure in S/.	Code: Enter number of days one cylinder
1. 10 Kg Cylinder	1	2				
2. 45 Kg Cylinder	1	2				
3. Other specify size in Kg of cylinder_________	1	2			_________	

346A. Does your household use LPG following purposes?			346B. In general, what percentage of LPG does your household use each month for the following purposes?	
Code: "0" if none and percentage if applicable Does not know –8 Not applicable –7				
	Yes	No	Percent	Does not know
1. Lamp lighting	1	2		–8
2. Cooking	1	2		–8
3. Appliances	1	2		–8
4. Home business	1	2		–8
5. Other ___________ (Specify)	1	2		–8
Total			**100%**	

347A. Does the household use the following gas appliance?			347B. How many of each appliance does your household have?	347C. What is the sum of all hours for all . . . used during the last 24 hour period? Note: Ask the respondent about the use of each . . . in the household and sum the total hours that the . . . are used in the last 24 hours.		347D. What is the sum of all days for all . . . used during the last month? Note: Ask the respondent about the use of each . . . in the household and sum the total days that the . . . are used in the last month.
			Code: Enter number of appliances	Code: Enter number of hours, or if do not use any enter "–7".		Code: Enter number of days, or if do not use any enter "–7".
Type of Appliance	Yes	No		Hours	Minutes	
1. Gas lamp	1	2				
2. LPG stove	1	2				
3. LPG stove & oven	1	2				
4. Refrigerator	1	2				
5. Freezer	1	2				
6. Other __________ (Specify)	1	2				

SECTION 7: USE OF SOLAR PV HOME SYSTEM

348. In the past month did your household use a solar PV home system (SHS) to provide electricity at home?		
Yes	1	
No	2	Go to 360

349. The solar PV home system that you use is:			
Owned?	1		
Leased?	2	Go to 351	
Rented?	3	→ Monthly rent S/.	
Given to the hh?	4	Go to 352	
Not applicable.	–7		

350. If owned, what was total cost paid in cash for the solar PV home system (include all the components)?

Code: Total cost in S/.
Not applicable –7

S/. ____________________ Go to 352

351A. If leased, how much is the monthly payment?	351B. If leased, what was the initial payment? (S/.)	351C. If leased, how many monthly payments are required?
Code: Enter the amount of monthly payment. Not applicable –7	Code: Enter the number of initial payments in S/., or if initial payment is not required enter "0" Not applicable –7	Code: Enter the number of payments. Not applicable –7
S/.	S/.	S/.

352. In which year did the household obtain the solar PV home system?

Code: Enter year the household obtained it (i.e. 1990)
Not applicable –7
Does not know –8

____

353. How much did your household spend on repairs or maintenance of the solar PV home system in the last 12 months?

Enumerator: Do not include light bulbs.

Code: Enter repair cost in S/., or "0" for no spending on repair

S/. ____________________

354. What is the size in watt peak (Wp) of the solar PV system?

Code: Enter size of solar PV in Wp.
Does not know –8

Wp ____________________

355A. Does your household use any of the following incandescent light bulbs, which are energized by solar PV system?				355B. How many light bulbs in this class does the household use?	355C. What is the sum of all hours for all bulbs used during the last 24 hour period? Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
				Code: Enter the number, or "–7" for do not use	Code: Enter hours of use with fraction., or "–7" for do not use	
N	Type and size of light bulb	Y	N		Hours	Minutes
1	10 Watts or less	1	2			
2	15 Watts	1	2			
3	25 Watts	1	2			

356A. Does your household use any of the following fluorescent tubes, which are energized by solar PV system?				**356B. How many tubes in this class does the household use?**	**356C. What is the sum of all hours for all tubes used during the last 24 hour period?** Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
				Code: Enter the number, or "–7" for do not use	Code: Enter hours of use with fraction., or "–7" for do not use	
	Type and size of fluorescent tube	Y	N		Hours	Minutes
1	10 W (Straight)	1	2			
2	20 W (Straight)	1	2			
3	22 W (Circular)	1	2			

357A. Does your household use any of the following energy saving light bulbs, which are energized by solar PV system?				**357B. How many light bulbs in this class does the household use?**	**357C. What is the sum of all hours for all bulbs used during the last 24 hour period?** Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
				Code: Enter the number, or "–7" for do not use	Code: Enter hours of use with fraction., or "–7" for do not use	
	Type and size of light bulb	Y	N		Hours	Minutes
1	7 Watts or less	1	2			
2	9 Watts	1	2			
3	12 Watts	1	2			
4	18 Watts	1	2			
5	20 Watts	1	2			

358A. Does your household use PV system for the following purposes?			**358B. In general, what percentage of solar energy does your household use each month for the following purposes?**	
Code: "0" if none and percentage if applicable Does not know –8 Not applicable –7				
	Yes	No	Percent	Does not know
1. Lamp lighting	1	2		–8
2. Cooking	1	2		–8
3. Appliances	1	2		–8
4. Home business	1	2		–8
5. Other ___________ (Specify)	1	2		–8
Total			**100%**	

359A. Does the household use the following electric appliances, which are powered by electricity from solar PV system?				**359B. How many of each appliance does your household have?**	**359C. What is the average wattage rating of the appliance?** Note: Estimate the average wattage if more than one appliance in use.	**359D. What is the sum of all hours for all appliances used during the last 24 hour period?** Note to enumerators: If the household has more than one appliance of this type, ask the respondent about the use of each appliance in the household and sum the total hours that the appliances are used in the last 24 hours.	
				Code: Enter number of appliances or if do not use enter "–7"	Code: Enter the average number of watts of appliances or if do not use enter "0"	Code: Enter the number of hours of use with fraction or if do not use enter "–7"	
		Yes	No			Hours	Minutes
1	Radio	1	2				
2	Sound equipment	1	2				
3	TV black and white	1	2				
4	TV color	1	2				
5	Video recorder	1	2				
6	DVD	1	2				
7	Others _______ (Specify)	1	2				
8	Others _______ (Specify)	1	2				

SECTION 8: ELECTRIC GENERATOR SET

360. In the past month did your household use an electric generator set to provide electricity at home?		
Yes	1	
No	2	Go to 372

361. The electric generator set that you use is:			
Owned?	1		
Leased?	2	Go to 363	
Rented?	3	⟶ What is the monthly rent? S/.	
Allowed to use by another home or company?	4	Go to 364	

362. If own, what was total cost paid in cash for the electric generator set (include all the components)?
Code: Total cost in S/.
S/.

363A. If leased, how much is the monthly payment?	**363B. If leased, what was the initial payment? (S/.)**	**363C. If leased, how many monthly payments are required?**
Code: Enter the amount of monthly payment in S/.	Code: Enter the amount of initial payment in S/., or if initial payment is not required enter "0"	Code: Enter the number of monthly payments/.
S/.	S/.	S/.

364. In which year did the household obtain an electric generator set?
Code: Enter year the household obtained it (i.e. 1990)
____

365A. What type of fuel does the electric generator set use?				**365B. How many units of fuel mentioned in 369A did your household use for gen-set last month?**		**365C. What is the price per unit?**	**365D. What is the average monthly expenditure on diesel or gasoline for electric generator set?**
		Yes	No	No. of units	Type of unit	S/. per unit	S/. per month
1	Diesel	1	2				S/.
2	Gasoline	1	2				

Type of Unit
Gallon .....1 Liter 2

366. On an average, how much did your household spend per month on repairs and/or maintenance of electric generator set?
Code: Enter repair cost per month in S/., or "0" for no spending on repair.
S/.

367A. Does your household use any of the following incandescent light bulbs, which are energized by an electric generator set?				**367B. How many light bulbs in this class does the household use?**	**367C. What is the sum of all hours for all bulbs used during the last 24 hour period?** Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
	Type of light bulb	Y	N	Code: Enter the number, or "–7" for do not use	Code: Enter hours of use with fraction., or "–7" for do not use	
					Hours	Minutes
1	25 Watts	1	2			
2	50 Watts	1	2			
3	75 Watts	1	2			
4	100 Watts	1	2			

	368A. Does your household use any of the following fluorescent tubes, which are energized by an electric generator set?			**368B. How many light bulbs in this class does the household use?**	**368C. What is the sum of all hours for all bulbs used during the last 24 hour period?** Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
	Type and size of fluorescent	Y	N	Code: Enter the number, or "–7" for do not use	Code: Enter hours of use with fraction., or "–7" for do not use	
					Hours	Minutes
1	10 W (Straight)	1	2			
2	20 W (Straight)	1	2			
3	40 W (Straight)					
4	22 W (Circular)	1	2			
5	32 W (Circular)					

	369A. Does your household use any of the following energy saving light bulbs, which are energized by an electric generator set?			**369B. How many light bulbs in this class does the household use?**	**369C. What is the sum of all hours for all bulbs used during the last 24 hour period?** Note to enumerators: Ask the respondent about the use of each bulb in watt classes of bulbs in the household and sum the total hours that the bulbs are used in the last 24 hours.	
	Type and size of light bulb	Y	N	Code: Enter the number, or "–7" for do not use	Code: Enter hours of use with fraction., or "–7" for do not use	
					Hours	Minutes
1	Less than 12 W	1	2			
2	12 Watts	1	2			
3	18 Watts	1	2			
4	20 Watts	1	2			
5	25 Watts	1	2			

370A. Does your household use electric generator set for the following purposes?

370B. In general, what percentage of your household monthly spending on electric generator set is for the following purposes?

Code: "0" if none and percentage if applicable
Does not know –8
Not applicable –7

	Yes	No	Percent	Does not know
1. Lamp lighting	1	2		–8
2. Cooking	1	2		–8
3. Appliances	1	2		–8
4. Home business	1	2		–8
5. Other ____________ (Specify)	1	2		–8
Total			**100%**	

				371B. How many of each appliance does your household have?	371C. What is the average wattage rating of the appliance? Note: Estimate the average wattage if more than one appliance in use.	371D. What is the sum of all hours for all appliances used during the last 24 hour period? Note to enumerators: If the household has more than one appliance of this type, ask the respondent about the use of each appliance in the household and sum the total hours that the appliances are used in the last 24 hours.	
371A. Does the household use the following electric appliances, which are powered by electricity from generator set?				Code: Enter number of appliances or if do not use enter "–7"	Code: Enter the average number of watts of appliances or if do not use enter "–7"	Code: Enter the number of hours of use with fraction or if do not use enter "–7"	
		Yes	No			Hours	Minutes
1	Radio	1	2				
2	Sound equipment	1	2				
3	TV black and white	1	2				
4	TV color	1	2				
5	Video recorder	1	2				
6	DVD	1	2				
7	Others ______ (Specify)	1	2				

SECTION 9: USE OF FIREWOOD

372. In the past month did your household use firewood at home?		
Yes	1	
No	2	Go to 376

373. How does your household obtain firewood?		
Purchase only	1	
Collect/received only	2	Go to 375A
Purchase and collect	3	
Other ___________ (Specify)	4	

THE FOLLOWING ARE QUESTIONS FOR PURCHASED FIREWOOD

374A. How much did you spend during the last purchase?		374B. How many total days will this purchase last?	374C. What was the one-way distance traveled (in meters) to make this purchase?	374D. How long did it take to travel one-way to make this purchase of firewood?		
Code: Enter amount of money (in S/.) spent last time. *Don't include transportation cost*		Code: Enter number of days firewood lasted.	Code: Enter distance in km traveled, use fraction for less than one km. Does not know –8	Code: Enter time in hours and minutes.		
Total S/.	Decimal				Hours	Minutes
				Adult Male		
				Adult Female		
				Child		

THE FOLLOWING ARE QUESTIONS FOR COLLECTED FIREWOOD		
375A. How many times did your household collect firewood last month?	**375B. How many total days did the previous collected firewood last?**	**375C. What was the one-way distance traveled in the previous collection of firewood?**
Code: Number of collection	Code: Enter number of days firewood lasted.	Code: Enter distance in meters traveled, use fraction for less than one meter Does not know . . . –8

375D. In the last week, how much time (hours per week) was used in collecting firewood by the following members?		
Code: Enter number of hours or "0" for not spending any time Not applicable –7	Code: Enter hours of use with fraction., or "–7" for do not use	
Use Type	Hours	Minutes
Adult Male		
Adult Female		
Children		

SECTION 10: USE OF AGRICULTURE RESIDUE		
376. In the past month did your household use agriculture residue at home?		
Yes	1	
No	2	Go to 378

377A. How many times did your household collect agriculture residue last month?	**377B. How many total days did this collected agriculture residue last?**	**377C. What was the one-way distance traveled in the previous collection of agriculture residue?** (Distance in meters)
Code: Number of collection	Code: Enter number of days agriculture residue lasts.	Code: Enter distance in meters traveled, use fraction for less than one meter Does not know –8

377D. In the last week, how much time (hours per week) was used in collecting crop residues by the following members?		
Code: Enter number of hours or "0" for not spending any time		
Use Type	Hours	
Adult Male		
Adult Female		
Children		

SECTION 11: ANIMAL DUNG		
378. In the past month did your household use dung at home?		
Yes	1	
No	2	Go to 380A

379A. How many times did your household collect dung last month?	379B. How many total days did this collected dung last?	379C. What was the one-way distance traveled in the previous collection of dung? Distance in meters
Number of collection	Code: Enter number of days dung lasted.	Code: Enter distance in meters traveled, use fraction for less than one meter.

379D. In the last week, how much time (hours per week) was used in collecting dung by the following members?

Code: Enter number of hours or "0" for not spending any time
Not applicable –7

Use Type	Hours	
Adult Male		
Adult Female		
Children		

SECTION 12: USE OF COOKING STOVE AND COOKING

We would like to ask about cooking fuels and all the stoves and fires that the household uses during a usual week.

380A. What is the principle type of stove that your household uses to cook meals? Enumerator: Ask respondent if it is possible to see the stove.	**380B. Where is this stove located?** Enumerator: Ask respondent if it is possible to see the stove and area where the stove is located	**380C. Is there a window or vent in the cooking area?** Enumerator: Ask respondent if it is possible to see the stove and area where the stove is located.	**380D. What type of fuel does your household usually use with this stove?** Enter type of fuels that is used most often with this stove.	**380E. Does your household use any other kind of fuel with this stove?** Enter the second most often used fuel	**380F. Who usually starts and tends this stove?** Check the household member ID in Section 200 HH Member ID (See code nunber in Section 200)
Code: 1 =Open fire e.g. three stones 2 =Traditional stove no chimney 3 =Traditional stove with chimney 4 =Gas/kerosene stove –7=Not applicable	Code: 1= Outdoors 2= Semi-enclosed 3= Separate kitchen 4= In living area	Code: 0= None 1= One only 2= Two or more	Code: 0=. None 1= Firewood 2= Crop residue or wood chips 3= Dung 4= Charcoal 5= Coal 6= Kerosene 7= LPG 8= Electricity	Code: 1= Firewood 2= Crop residue or wood chips 3= Dung cakes 4= Charcoal 5= Coal 6= Kerosene 7= LPG 8= Electricity	
Code Number	Code Number	Code Number	Code Number	Code Number	Code Number
1.					
2.					
3.					

400. Productive Equipment

SECTION 1: ELECTRIC PUMPS

401. How many electric pumps are used by your household?

Code: Number of pumps

Enter 0 if none and go to Section 405

402. Does your household use an electric pump set for any of the following activities?

Yes 1

No 2

	Yes	No
Agricultural activities	1	2
Livestock (including poultry farm)	1	2
Other, specify	1	2

403A. What is the number of the electricity meter on each pump?		403B. What is the kw size of each pump?	403C. Last year, what is the total yearly cost of electricity for each pump?
Enumerator: Request responding household to show previous electric bills for irrigation pump set, and record meter number from the bill in the space below. If electric bill is not available, look for the meter number at the electricity meter.			
Code: Enter number. 0 Do not use –7 Not applicable –8 No meter		Code: Enter size of pump (KW) ______________________	Code: Enter electricity charges S/ per year ______________________
21.1.1.1.1.1.1.4			
21.1.1.1.1.1.1.5 21.1.1.1.1.1.1.6	Pump # 1		
21.1.1.1.1.1.1.7 21.1.1.1.1.1.1.8	Pump # 2	21.1.1.1.1.1.1.9	
21.1.1.1.1.1.1.10 21.1.1.1.1.1.1.11	Pump # 3	21.1.1.1.1.1.1.12	

404A.	404B.		404C.	
Electric pump set number	Last year, how many hours per day and days per month, pump set number . . . . was operated during the 6 month period between		Last year, how many hours per day and days permonth, pump set number . . . . was operated during the 6 month period between	
	6 months period April – September		6 months period October – March	
21.1.1.1.1.1.1.14	No. of hours	No.of days	No. of hours	No.of days
21.1.1.1.1.1.1.15 Pump # 1				
21.1.1.1.1.1.1.16 Pump # 2	21.1.1.1.1.1.1.17	21.1.1.1.1.1.1.18	21.1.1.1.1.1.1.19	21.1.1.1.1.1.1.20
21.1.1.1.1.1.1.21 Pump # 3	21.1.1.1.1.1.1.22	21.1.1.1.1.1.1.23	21.1.1.1.1.1.1.24	21.1.1.1.1.1.1.25

SECTION 2: DIESEL PUMPS

405. How many diesel pumps are used by your household?

Code: Number of pumps
Enter 0 if none and go to Chapter 500

406. Does your household use a diesel pump set for any of the following activities?

Yes 1

No 2

	Yes	No	
Agricultural activities	1	2	
Livestock (including poultry farm)	1	2	
Other, specify	1	2	

407A.		407B.	407C.
Diesel pump number:		What is the size in horse power (HP) of each pump?	What is the total yearly cost of diesel fuel for each pump?
Code: 0 Do not use –7 Not applicable –8 No meter 21.1.1.1.1.1.1.26		______________________	Code: Enter cost of diesel in S/ per year ______________________
21.1.1.1.1.1.1.27 21.1.1.1.1.1.1.28	Pump # 1		
21.1.1.1.1.1.1.29 21.1.1.1.1.1.1.30	Pump # 2	21.1.1.1.1.1.1.31	
21.1.1.1.1.1.1.32 21.1.1.1.1.1.1.33	Pump # 3	21.1.1.1.1.1.1.34	

408A.	408B.		408C.	
Diesel pump set number	Last year, how many hours per day and days per month, pump set number . . . . was operated during the 6 month period between		Last year, how many hours per day and days permonth, pump set number . . . . was operated during the 6 month period between	
	6 months period April – September		6 months period October – March	
21.1.1.1.1.1.1.36	No. of hours	No.of days	No. of hours	No.of days
21.1.1.1.1.1.1.37 Bomba # 1				
21.1.1.1.1.1.1.38 Bomba # 2	21.1.1.1.1.1.1.39	21.1.1.1.1.1.1.40	21.1.1.1.1.1.1.41	21.1.1.1.1.1.1.42
21.1.1.1.1.1.1.43 Bomba # 3	21.1.1.1.1.1.1.44	21.1.1.1.1.1.1.45	21.1.1.1.1.1.1.46	21.1.1.1.1.1.1.47

500. Time Use

Please indicate the numbers of hour spent on various activities by male and female household member and children in the household yesterday in hours and fractions. All answers should be for a 24-hour period.

Note: The total number of hours for all activities must add up to 24 hours.

Code: Enter number of hours, or fraction for less than one hour or "0" for do not spend time on that activity category. –7 for not applicable (i.e., no children in the family, or no spouse of head of the household.

	Woman (Head or Spouse of Head)	Man (Head or Spouse of Head)	(Enter 1st Person ID number, see ID number in Section 200)	(Enter 2nd Person ID number, see ID number in Section 200)
21.1.1.1.1.2 Activities for last 24 hours	Hrs	Hrs		
1. Sleeping (night sleep)				
2. Bathing and beautifying yourself				
3. Preparing meal/cooking				
4. Farming, gardening, animal husbandry, fishing				
5. Income earning activities such as, doing handicraft, tending shop				
6. Taking meals				
7. Processing food and/or preparing cheese & butter.				
8. Water fetching and collecting fuels				
9. Other household chores such as, washing clothes & house cleaning				
10. Repairing clothes, basket, machineries, equipment, tools, and etc.				
11. Religious practices such as, praying, reading bible, and etc.				
12. Reading/studying				
13. Watching TV/listening to radio/resting				
14. Visiting neighbors/socializing/entertaining guests				
15. Other leisure activities				
16. Shopping				
17. Other, specify				
Total (24 hours per person)				

600. Household Income

SECTION 1: INCOME FROM WORK

Exclude income from agricultural, livestock, and fisheries activities.

During the past 12 month please indicate the total amount of income household members received from the following sources.

Enumerator:

(1) Ask for income earned from each income category by key income earners in the household.
(2) If there are more than 4 income earners in the household, enter only the top 4 income earners.
(3) If there are only 2 income earners, fill in the first two column, and enter "–7" for not applicable for column 3–4
(4) Enter "0" for no income earned in that category.
(5) To add up all the income, first add all income earned by all income earners in each income category and enter result in the last column "Total (S/.)"
(6) Second, sum up the total income in the last column "Total (S/.)".

Code: Enter income in S/. No income earned 0 Not applicable –7	Person Number	Person Number	Person Number	Person ID Number	
601. During the last 12 months, what is your household total cash income from wages, salaries, and overtime?	**1st Income Earner**	**2nd Income Earner**	**3rd Income Earner**	**4th Income Earner**	**Total (S./)**
(include wages and salaries from government, private company and selling labor)					
Total					
602. During the last 12 months, what is the income your household received from the following sources:	**1st Income Earner**	**2nd Income Earner**	**3rd Income Earner**	**4th Income Earner**	**Total (S./)**
1. Christmas and independent day holiday bonus					
2. Vacation bonus					
3. Profit sharing					
4. Compensation for service time					
5. Other bonus income (specify)					
6. Other bonus income (specify)					
Total					
603. During the last 12 months, did your household receive income from the following sources:	**1st Income Earner**	**2nd Income Earner**	**3rd Income Earner**	**4th Income Earner**	**Total (S./)**
1. Income from divorce, separation and alimony					
2. Pension from being widow or surviving family member					
3. Retirement pension					
4. Remittance					
Total					

SECTION 2: INCOME FROM AGRICULTURAL ACTIVITIES

604. During the past 12 months, please indicate the total amount of income your household received from the following agricultural activities.

Enumerator:
(1) Ask for the gross income earned from sales of each agricultural product.
(2) Enter "0" for no income earned in that category.
(3) To add up income from agriculture, first sum up all of the gross income from each agricultural activity in the last column and enter result in row 8.
(4) Enter total expenditure for agricultural activities in row 9 last column. Be sure to include all types of expenditure.
(5) Deduct expenditure in row 9 and enter net income from agriculture in row 10.

Code: Enter income in S/.
Enter land use for cultivation in Hectares, use fraction for less than one Ha
No income earned 0
Not applicable –7

Income From Agricultural Activities

Indicate name of crops that you grow during the past 12 months. For example, corn, yucca, wheat, coffee, cotton, sugar cane, fruits such as, orange, lime, apple, melon, grape mango, and etc.

604A. Type of crop	604B. Total production		604C. What is the equivalence in Kilos?		604D. Amount sold		604E. Price per unit (kilo)	604F. Total income (S./)
	Quantity (total)	Unit measure	Quantity (total)	Unit measure	Quantity (total)	Unit measure		
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
Total								

604. Indicate name of agricultural sub product and/or by-product that your household sold during the last 12 months. For example dried potato, (pap seca, hernia de papa farina, chuno, and etc.)

604G. Type of product	604H. Total production		604I. What is the equivalence in Kilos?		604J. Amount sold		604K. Price per unit (kilo)	604L. Total income (S./)
	Quantity (total)	Unit measure	Quantity (total)	Unit measure	Quantity (total)	Unit measure		
1.								
2.								
3.								
4.								
5.								
Total								

604M. Total Income From Agricultural Activities

604N. Expenditure

Indicate the total expenditure for agricultural activities including land rental fee, hired labor equipment and machineries, fertilizer, herbicide, pesticide, seedling, irrigation or water user fee.

604O. Total Net Income From Agricultural Activities

SECtION 3: INCOME FROM LIVESTOCK ACTIVITIES

605. Please indicate the total number of livestock and domestic fowls currently owned by your household, number sold during the past 12 months, price per animal, and revenue from each type of animal sold in the past 12 months.

Enumerator:

(1) Enter the total number of livestock currently owned by the household in the first column "Total # Owned Currently".

(2) Enter the number of animal sold during the last 12 month in the second column "Total # Sold"

(3) Enter"0" for no animal of that type sold during the last 12 months.

(4) Enter the sale price per animal, if the price varied use the average price per animal.

(5) Enter gross revenue from animal sold during the last 12 months.

(6) To add up income from livestock and other by-product, first sum up all of the revenue from animal sold and income from by-product during the last 12 months and enter result in row 15.

(7) Enter total expenditure for livestock activities in row 16 last column. Be sure to include all types of expenditure.

(8) Deduct expenditure in row 16 from row 15 and enter net income from agriculture in row 17.

Code: Enter income in S/.

No income earned 0

Not applicable –7

During Last 12 Months

605A. Indicate name of animal and fowls that you raised and sold over the past 12 months. Example of animal or livestock are llama, alpaca, goat, sheep, guinea pig, rabbit, cow, pig and etc. Example of fowls are hen, rooster, duck, and turkey	**605B. Total # sold**	**605C. Sale price per animal sold (S/.)**	**605D. Revenue fr. animal sold**	**605E. Quantity that currently own**
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
Total				

605. Income from by-product of livestock activities and product from animal. Indicate name of livestock by-product that were sold over the past 12 months. Example of by-products are wool, milk, cheese, butter, and etc.				
605F. Types of products	**605G. Total # produced**		**605H. Average sale price of each product (S/.)**	**605I. Total Revenue from sale of each product S/**
	Total quantity	Unit measure	Total amount S/	Total amount in S/
1.				
2.				
3.				
4.				
5.				
Total				
605J. Total income from livestock activities				
Expenditure				
605K. Please indicate the total expenditure for livestock activities including land rental fee, hired labor, fodders or feedstock, vaccination, medicines, water, and etc.				
605L. Total net income from livestock activities and their by-product				

21.1.1.1.1.2.1.1 SECTION 4: INCOME FROM FISHERIES

606A. During the past 12 months, please indicate the total amount of income your household earned from fisheries.	**Monto en S/.**
Income from fisheries	
606B. Please indicate the total expenditure for fisheries including boat repair and maintenance, fuels, fishing net, and related equipment.	
606C. Total net income from fishery activities	

SECTION 5: OTHER INCOME

607. During the past 12 months . . . to . . . did your household receive income from the following sources:	**TOTAL S/.**
1. House, apartment or room rental	
2. Income from renting agricultural land, or animal	
3. Income from renting machinery and vechicle	
4. Income from dividend stock and bond	
5. Interest from savings or lending	
6. Reward and prizes	
7. Other income (Specify)	
Total	

SECTION 6: HOUESHOLD EXPENDITURES

608A. Last month (May) . . . what was the total household spending for?	**TOTAL S/.**
1. Food for household members	
2. Household expenditure for water, telephone, and transportation	
3. Home maintenance and repair	
4. Household expenditure for personal hygine–soap, detergent, shampoo–and clothing	
5. Recreation activities, entertainment, cultural services	
Total	

608B. Over the last 3 months (March to May), what was the total household spending for?	TOTAL S/.
1. Expenditure for health care including medicine doctor fee and hospitalization.	
2. Education of household members	
3. Transfer expenditures (pensions, remittances to other family members, etc.)	
4. Clothing and shoes for household members	
Total	
608C. Over the last 12 months (June to May), what was the total household spending for?	**TOTAL S/.**
1. Furniture & cooking utensils (furniture repair, electro domestic appliances, etc.)	

700. Attitude

I am going to read to you a list of statements concerning energy use and other issues. I would like you to tell me if you agree or disagree with these statements and how strong your feelings are

Enumerator: Read the following statements one by one, and ask respondent whether he/she agrees or disagree and probe for how strong his/her feeling is.

Code: Strongly disagree 1; Disagree 2; Agree 3; Strongly agree 4; Does not know 5		Disagree	Agree	Does not know
1	Electricity is very important for the children's education.	1	2	–8
2	With electrical light the children can study at night	1	2	–8
3	At the moment, it is easy to read at night in the home.	1	2	–8
4	Reading with electrical light is better than with the light of candles or lamp.	1	2	–8
5	Our household is happy with with the lighting system that we have in our home.	1	2	–8
6	To use kerosene or oil is harmful for the health.	1	2	–8
7	A car battery is a good source of electricity.	1	2	–8
8	A solar PV home system is a good source of electricity.	1	2	–8
9	Electricity helps with domestic tasks and care of the children.	1	2	–8
10	Today, the quality of life of my household is better than it was 10 years ago.	1	2	–8
11	The monthly electric bill is or would be a financial burden for my family.	1	2	–8
12	Monthly spending for non-electric energy sources is/was a financial burden for my family.	1	2	–8
13	I feel safe in my house in the evening.	1	2	–8
14	I feel safe outside my house in the evening.	1	2	–8
15	The electricity makes it easy to have information and the news.	1	2	–8
16	Watching TV provides my household with great entertainment.	1	2	–8
17	News and information from radio and television provide good information relevant for conducting business.	1	2	–8
18	News and information from radio and television provide useful information about agricultural activities.	1	2	–8
19	News and information from radio and television provide good knowledge on family health issues.	1	2	–8

800. Business Module

SECTION 1: BASIC CHARACTERISTICS OF THE BUSINESS OR ESTABLISHMENT		
801. Who is the principal operator of this business/small enterprise?		
Owner	1	
Relative	2	
Employee	3	
802. What is the level of education of the principle operator of this business/small enterprise?		
No formal education	1	
Initial education	2	
Primary Incomplete	3	
Primary Complete	4	
Secondary Incomplete	5	
Secondary Complete	6	
Superior Non University Incomplete	7	
Superior Non University Complete	8	
Superior University Incomplete	9	
Superior University Complete	10	
Postgraduate	11	
Does not know	–8	

803. Principal operator is?		
Male	1	
Female	2	

804. What is the best description of your business is activity?		
Production/extraction (fishing, mining, etc.) of some possession		1
Commerce and sale of merchandise?	2	
Providing services?	3	
Other (Specify) ____________	4	

805. Please describe the type of business and/or the products.
Describe Activity

806. How long has this business been operating?

Code: Enter year and month in numeric

_______________ _______________

SECTION 2: FINANCING SOURCES FOR BUSINESS

807. Please indicate financing source when you started your business:	Financing Source Yes	No	808. At present, the financing source of your business comes from:	Financing Source Yes	No	What was the total amount financed?
1. Own resources?	1	2	1. Own resources?	1	2	
2. Personal loans from relative/family/friend?	1	2	2. Personal loans from relative/family/friend?	1	2	
3. Partnership?	1	2	3. Partnership?	1	2	
4. Commercial Banks?	1	2	4. Commercial Banks?	1	2	
5. Nongovernmental organization	1	2	5. Nongovernmental organization	1	2	
6. Money lenders?	1	2	6. Money lenders?	1	2	
7. Cajas Rurales? (Type of rural agricultural bank)	1	2	7. Cajas Rurales? (Type of rural agricultural bank)	1	2	
8. Others? (Specify)	1	2	8. Others? (Specify)	1	2	
	____________Total			____________Total		

SECTION 3: USES OF MOTOR (MOTIVE POWER) IN BUSINESS

The following questions refer to motor(s) used in the business.

Typically, motor is used for grinding, milling, shredding, cutting and/or drilling such as, timber, wood, and metal; motor is also used to drive fans, pumps, and compressors that move and compress air, water and other gases and liquids.

809. In your business do you use motors to drive machinery for any of the following applications?

Yes 1

No 2

	Yes	No
1. Grinding/milling/shredding?	1	2
2. Cutting/drilling	1	2
3. Fan (exclude fan that is typically used for cooling in the household)	1	2
4. Pump	1	2
5. Compressor	1	2
6. Other _______________ (Specify)	1	2
7. Other _______________ (Specify)	1	2

Note: If there are no motors used for any purpose in the household, go to section 4.

810. How many motors used for the applications mentioned above are electric motor and how many are diesel motor?

Code: Enter "0", if answer "No" for all of the questions above.

___________ Number of electric motors	___________ Number of diesel or gasoline motors

811A. What is the meter number of the motor?	811B. What type of energy does this motor use?	811C. What is the size of each motor in horsepower?	811D. What is the total monthly cost of energy for each motor?
	Code:	Code: Enter size of pump (hp)	Code: Enter S/ per year
Motor 1	Diesel 1	Not applicable –7	–7 Not applicable
Motor 2	Electricity 2	Don't know –8	–8 Don't know
Motor 3	Gasoline 3		
Motor 4	Does not use meter 0		
	Not applicable 7		
21.1.1.1.1.2			
21.1.1.1.1.2 21.1.1.1.1.2	21.1.1.1.1.2.1.6	21.1.1.1.1.2.1.7	
21.1.1.1.1.2 21.1.1.1.1.2	21.1.1.1.1.2.1.10	21.1.1.1.1.2.1.11	
21.1.1.1.1.2	21.1.1.1.1.2.1.13	21.1.1.1.1.2.1.14	

SECTION 4: INCOME FROM BUSINESS

812. During the last 3 months what is the total gross revenue of sales of goods and/or services from your business?

____

Amount in (S/.)

813. During the last 3 months what is the total gross expenses for your business?

____

Amount in (S/.)

814. During the last 3 months what is the total net income from your business?

____

Amount in (S/.)

900. OPINION AND ATTITUDE ON ENERGY AND BUSINESS

914. Opinion And Attitude On Energy And Business

I am going to read to you a list of statements concerning energy use and other issues. I would like you to tell me if you agree or disagree with these statements and how strong your feelings are

Enumerator: Read the following statements one by one, and ask respondent whether he/she agrees or disagree and probe for how strong his/her feeling is.

	Code: Disagree 1 Agree 2 Does not know 3	Disagree	Agree	Does not know
1	News and information from radio provide good knowledge for conducting business activities.	1	2	–8
2	The use of electricity has allowed or will allow me to keep my business open for longer hours.	1	2	–8
3	The low quality of the electrical service can be harmful for my business.	1	2	–8
4	The quality of the electrical service has gone down during the last 2 or 3 years.	1	2	–8
5	The cost of electricity at the prevailing rate is quite reasonable for my business.	1	2	–8
6	The purchase of diesel for my business is not a problem to me.	1	2	–8
7	With greater availability of credit (loan), I would buy more electric appliances.	1	2	–8
8	With electricity I could/can make more money from my business.	1	2	–8
9	Electricity would help me run my business efficiently.	1	2	–8
10	Lighting with Solar PV Home System is the next best thing to electric lighting from the grid.	1	2	–8

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The Energy Sector Management Assistance Program is a global knowledge and technical assistance program administered by the World Bank and assists low-income, emerging and transition economies to acquire know-how and increase institutional capability to secure clean, reliable, and affordable energy services for sustainable economic development.

ESMAP's work focuses on three global thematic energy challenges:

- Energy Security
- Poverty Reduction
- Climate Change

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ESMAP is governed and funded by a Consultative Group (CG) composed of representatives of Australia, Austria, Canada, Denmark, Finland, France, Germany, Iceland, Norway, Sweden, The Netherlands, United Kingdom, and The World Bank Group. The ESMAP CG is chaired by a World Bank Vice President and advised by a Technical Advisory Group of independent, international energy experts who provide informed opinions to the CG about the purpose, strategic direction, and priorities of ESMAP. The TAG also provides advice and suggestions to the CG on current and emerging global issues in the energy sector likely to impact ESMAP's client countries. ESMAP relies on a cadre of engineers, energy planners, and economists from the World Bank, and from the energy and development community at large, to conduct its activities.

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ENERGY AND POVERTY

Just less than one-half of the people in developing countries have no access to electricity and a similar number are reliant on biomass energy for cooking and heating. As a consequence, they are deprived of the means of moving out of poverty. Greater access to modern energy services can improve poor people's income through enhancement of productive use of energy and it can also increase their quality of life by providing quality lighting, communication, and other important services.

ESMAP has the goal of substantially improving energy use by poor people through addressing the widespread problems of the household energy. This is done through high quality analytical work on energy access, promoting an increase in the quality and number of projects dealing with energy and poverty issues by international donors, and by disseminating successful approaches to the international development community.

THE WORLD BANK

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