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Promoting Productive Uses of Electricity in Rural Areas of Peru: Experience & Lessons Learned



James Finucane
Susan V. Bogach
Luis E. Garcia



Energy Unit
Sustainable Development Department
Latin America and the Caribbean Region
The World Bank



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Energy Sector Management Assistance Program (ESMAP)

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c/o Energy, Transport, and Water Department

The World Bank Group

1818 H Street, NW

Washington, DC 20433, USA

Tel.: 202-473-4594; Fax: 202-522-3018

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FOREWARD

The Government of Peru is committed to improving rural electrification coverage, aiming to increase rural coverage from an estimated 55 percent at the end of 2010 to 88 percent by 2020. To achieve this goal, the Directorate General of Rural Electrification (DGER) of the Ministry of Energy and Mines (MEM) has been implementing and executing the National Plan for Rural Electrification, prepared annually, based on the 2006 Rural Electrification Law, to extend service and attract participation of the population, local governments and electricity distribution companies.

Within this program, the World Bank (WB) and Global Environmental Facility (GEF) are supporting the Directorate of Competitive Funds (DFC) of the DGER in the implementation and execution of the Rural Electrification (RE) Project, initiated in July 2006 and the Second Rural Electrification Project initiated in July 2011, to assist electricity distribution companies to implement rural electrification. Among the activities underway in the first RE Project is the implementation of a pilot program to develop the productive use of electricity, promoting opportunities for income generation in rural areas.

This report provides an early assessment of the productive uses of electricity in Peru under the RE Project. Among the key issues discussed are:

- Is it important to include provisions to encourage productive uses of electricity in rural electrification projects?
- How can such productive uses of electricity best be facilitated and enhanced?
- What are the constraints to increasing productive uses of electricity in rural communities?
- Who should be responsible for the execution of promotion activities?
- What is the role of the electricity distribution company in these activities?
- How successful were the efforts to date and what lessons can be learned that can be applied in other areas?

It is our hope that this document will help policy makers, NGOs and government institutions to create effective programs that maximize the benefits of bringing electricity to rural communities in Peru and other countries.

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

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ABBREVIATIONS AND ACRONYMS

ADINELSA	Administrative Office of Electric Infrastructure
BDS	Business Development Services
COES	Comite de Operacion Economica del Sistema Interconectado
DFC	Directorate of Competitive Funds
DGE	Directorate General of Electricity
DGH	Directorate General of Hydrocarbons
DGER	Directorate General of Rural Electrification
DGPM	Directorate General of Multi-annual Programming
DP	Directorate of Projects
EDC	Electricity Distribution Company
ECL	Electricity Concessions Law
ELSE	Electro Sur Este
ERR	Economic Rate of Return
ESMAP	Energy Sector Management Assistance Program
FONAFE	National Fund for the Financing of the Entrepreneurial Activity of the State
FOSE	Electricity Social Compensation Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographical Information System
GNI	Gross National Income
GoP	Government of Peru
IBRD	International Bank for Reconstruction and Development
JICA	Japan International Cooperation Agency
MEF	Ministry of Economy and Finance
MEM	Ministry of Energy and Mining
NGO	Non-governmental organization
NPRE	National Plan for Rural Electrification
OSINERGMIN	Organismo Supervisor de la Inversión en Energía y Minería
RE	Rural Electrification
SER	Rural Electric System
SME	Small and Medium Enterprise
SWER	Single Wire Earth Return
SNIP	National System of Public Investments
VAD	Value Added in Distribution
WB	World Bank

EXECUTIVE SUMMARY

Bringing electricity to rural communities can increase opportunities for local entrepreneurs to generate income by modernizing production methods and raising the value of production. Common examples in Peru are the installation of electric motors to grind grains and to process coffee in agricultural activities or the use of electric pumps to irrigate the land and improve growing conditions and yields.

Promotion of productive uses also contributes to the financial viability of the electricity infrastructure in rural areas. Promotion of productive uses, in advance of or together with rural electrification programs, can make rural electricity distribution investments more attractive and reduce the amounts of subsidies needed. In the absence of sufficient increases in economic activity and electricity demand, the financial sustainability of the infrastructure in isolated areas becomes uncertain and the contributions of the electrification investments to rural well-being are limited.

In general, contrary to the use of electricity for lighting and domestic appliances, its adoption for production does not happen on its own or rapidly. This reality makes it important to include activities in rural electrification projects that address barriers to and encourage the adoption of electricity for income generation activities.

This report tells the story of the early implementation of a pilot program to promote productive uses of electricity carried out by the Directorate General of Rural Electrification (DGER) in the Ministry of Energy and Mines (MEM) in Peru, through the World Bank and GEF-assisted Rural Energy Project.

Rural electrification in Peru. Peru, located in the west central portion of South America's Pacific coast, is the third largest country in the region after Brazil and Argentina. It spans over 1.28 million square kilometers and has a total population of 28 million people, of which an estimated 7 million people live in rural areas. 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.

Domestic and Productive Uses of Electricity



With a GDP per capita of US\$9200 in 2010, Peru has one of the best performing economies of Latin America (GDP growth averaged 7.2 percent from 2006 to 2010). The poverty rate was estimated at 35 percent nationally in 2009. However, the national poverty rate masks important differences across urban and rural areas and across regions. Poverty levels are significantly higher in rural areas, particularly the Sierra region where the rate was 65.6 percent vs. 14.1 percent in Lima.

The 2007 Census showed that 30 percent of rural households had access to electricity, one of the lowest leverages of rural coverage in Latin America. In recent years, the Government of Peru has made a strong effort to increase rural access and electricity coverage, introducing the Rural Electrification Law of 2006 and providing more than US\$100 million per year for investment in rural electrification. The National Plan for Rural Electrification for 2011-2020 proposes the ambitious target of increasing the rural electrification coverage from 55 percent in 2010 to 65 percent by 2011 and 88 percent by 2020. It estimated that reaching these goals will require mobilization of US\$2.2 billion over ten years.



As part of this effort, the World Bank and GEF-supported the Rural Electrification (RE) Project (US\$144 million total, including US\$50 million IBRD and US\$10 million GEF), under implementation by the Directorate of Competitive Funds of the DGER of MEM since mid-2006, is contributing significantly to meeting the Government's rural electrification goals (see Annex 1 for details). The Project's objective is to increase access to efficient and sustainable electricity services in rural areas of Peru. This is being done through: (a) investment in subprojects co-financed and carried out by electricity service providers, using both conventional grid extension and renewable energy sources; (b) demonstration of a model that attracts investment from private and public sector electricity providers, as well as from local governments; and, the subject of this document, (c) a pilot program to increase productive uses of electricity in rural areas.

Key elements of the productive uses program design. The program is being carried out through a series of activities, each one in a specific geographical area that was selected based on its potential for increased use of electricity in productive areas and the willingness of the distribution company to participate. For each activity, the DFC-DGER first signed a memorandum of understanding with the distribution company that defined the responsibilities and commitments of the distribution company to serve rural productive users. The DGER, on behalf of the RE Project, then signed a contract with a competitively selected non-governmental organization (NGO) to assess the market and carry out promotion activities to increase productive uses of electricity, in collaboration with the distribution company and other development efforts in the local area. Key elements of the program design are described below.

Selection of the communities. Roundtable and individual discussions with the distribution companies resulted in the selection of the first three electricity companies with a strong interest

in efforts to increase productive uses. Within the concession areas of these companies, target communities were selected based on the criteria that indicate possible untapped opportunities for productive uses: a surplus of electricity supply, 24 hour electricity service, adequate physical infrastructure, availability of complementary support services and programs, and the presence of sub-sectors or micro-enterprises with relatively high potential to increase electricity consumption (MWh/year) for productive uses.

Memorandum of understanding with distribution company. A standard memorandum of understanding was signed by the RE Project with each distribution company involved, establishing the role, responsibilities and support to be provided by the distribution company and the to-be-contracted NGO and the coordination (distribution company, NGO, DFC-DGER) arrangements.

Contracts with NGOs to implement promotion activities. NGOs were chosen to implement the promotion projects, under contract to the DGER on behalf of the RE Project. The choice of NGOs to execute the promotion activities proved to be extremely effective. Their links with the community, field experience and the professional motivation towards social development in rural areas helped to achieve better than expected and faster results.

The NGO contracts established common objectives, implementation frameworks, business development services approaches (see box) and measurements of achievement for the three assignments. The measurements of success include: (a) the number of producers benefited; (b) the estimated increase in the annual electricity use of each of the benefited producers; and, (c) the investment made by producers in new equipment and electricity supply infrastructure for productive uses. The contracts allowed significant space for the NGOs to custom tailor their approaches to the on-the-ground realities of the different communities and their own skill sets.

Business Development Services (BDS) in Indonesia

The Indonesia Rural Electrification Projects I & II pioneered the application of BDS for productive uses of electricity. The project focused on outreach to small businesses through NGOs, and developed a marketing strategy for the electricity supplier, which addressed issues of lack of information, tariff barriers and quality of service. Impact studies show 66,000 enterprises were assisted and over 20,000 jobs created.

An effective outreach program, such as BDS, can help generate economic activity and employment, as well as improve finances of the electricity company. However, although the Indonesia utility company recognized the need for marketing and outreach, efforts toward “mainstreaming” in the organization did not take hold as hoped. It may be that “outsourcing” to NGOs is the most effective way to initiate an effective outreach program, given the potential resistance and “mind set” of many utility companies.

Source: Robert E. Fishbein, "Survey of Productive Uses of Electricity"

The use of a short term, two-phased contract with a decision step between assessment and implementation proved to be a good strategy. Phase 1 is a three month period for surveys, assessments, building of linkage with other programs and sectors, and opportunity identification. The Project then negotiated performance targets with the NGO based on the findings, before the NGO implemented Phase 2, which consisted of nine months of marketing and assistance campaigns to promote adoption of electrical equipment by the producers identified in Phase 1. The first phase, although referred to as the 'assessment phase', was also designed to raise awareness and interest and be the first step of the 'marketing phase'.

An approach based on Business Development Services (BDS) techniques was implemented. The NGOs used Business Development Services (BDS) methods to assist small and home-based enterprises in gathering information, finding credit and addressing technology constraints through marketing and assistance campaigns. The approach in Peru was modeled on that used in the Indonesia Rural Electrification Projects described above. The BDS approach has been applied in rural programs targeting income generating activities in other sectors by working, often in collaboration with other institutions, to assist enterprises improve and start small businesses by addressing technical skills, markets, finance, technology and other constraints. For its application to promote productive uses of electricity, the NGOs followed a strategy that included the following elements: (a) market assessment; (b) preparation of business plans; (c) marketing to the community and potential entrepreneurs; (d) coordination with complementary institutions; and (e) links with the electricity distribution company.

Context of the first three productive uses pilot activities. In order to analyze the first three pilot activities and be able to extrapolate and distill lessons learned, it is important to consider the context in which the pilots took place. In general, the context is defined by the stakeholders, the geographic conditions, the types of economic activity and the sector policies and regulations regarding electricity tariffs and subsidies.

The main stakeholders in any productive uses of electricity initiative are the individual producers that are expected to benefit, the agents of change that were responsible for the promotion, in this case the NGOs that were contracted to promote productive uses of electricity, and the electricity distribution companies that are needed to ensure adequate connections and electricity supply infrastructure.



The projects were carried out in three areas with different geographical conditions and economic activities. The pilot project areas ranged from the semi-arid coastal communities in Lima provinces, to the Andean highlands in Junín and Cusco, Amazon rain forests in Junín and the steep terrain of the high altitude cloud forests in Cusco region. The main economic activities in the targeted communities are home based or located in or near the fields of the producer. They vary within the range of small scale agriculture, livestock and dairy production, artisanal mining, textiles, off-farm industries and services like transport or product distribution. While agricultural production is usually at the individual level, agricultural processing is often done at a cooperative or association level.

The DGER contracted three development NGOs - Soluciones Practicas (ITDG) in Cusco, Swisscontact in Junín and Desco in Lima Provinces- to do the promotion and implement the pilots in coordination with the distribution company in each area. The main characteristics of these NGOs include: a) extensive multi-decade experience working in Peru's rural communities; b) commitment to the participative development of poorer communities, the sustainable use of local resources and development learning; c) a vision of promotion of productive uses as an

opportune entry point for catalyzing and supporting broad-based local development; and (d) strategic knowledge to involve and obtain the support of other institutions associated with the productive chain.

Three different electricity distribution companies participated: two state-owned distribution utilities, Electrocentro and Electro Sur Este, and the state asset holding company for rural electrification system investments, ADINELSA. Electricity companies in Peru, public or private, are usually self-financing, obtaining sufficient revenues from tariffs to cover costs and finance investments. ADINELSA which operates state owned rural electrification systems that are remote or considered unprofitable, is an exception, making a loss each year that must be covered by the Treasury.

The electricity tariffs are based on full-cost recovery and are complemented by cross-subsidies that are financed within the sector, with larger customers subsidizing smaller ones. One important characteristic of electricity distribution concessions in Peru is that the companies are obliged to provide service to customers within 100 meters of the existing lines. If the customer is at a greater distance, the electricity company has one year to provide service and may request the customer to finance the installation, to be later repaid by the electricity company.

Results achieved to date. By mid 2011, three productive uses promotion contracts were completed under the RE Project. The first pilot was implemented by Soluciones Practicas (ITDG) in the Cusco region over 2008-9, the second was by Swisscontact in Junín over 2009-10, and the third was implemented by Desco in Lima Provinces over 2010-11. These first three activities helped over 4,760 families/micro-enterprises to adopt electricity using equipment to process cereals, coffee, cocoa, baked goods, meat products, milk, wood and metal products and handicrafts, as well as to pump water for expanded agricultural production and processing (see Table S1).

Table S1. Summary Results of First Three Productive Uses Pilot Activities

Distribution company	Electro Sur Este	Electrocentro	ADINELSA	Total
NGO	Soluciones Practicas	Swiss Contact	Desco	Total
Region / communities	Cusco	Junín	Lima provinces	Total
Number of individual producers benefited	1501	2356	865	4761
Estimated increase in electricity use (Mwh/yr)	470	1071	314	1863
Investment (000 US\$)	104	494	113	711

Many of the producers that benefited from the pilot activities were women, as shown in Table S2. This resulted naturally as women entrepreneurs play a significant role in areas of production such as baked goods, milk production, ceramics and textiles and are represented in all types of productive activities. The implementation approach, while not deliberately designed with gender in mind, seems to have been effective in reaching women producers. As can be seen in the photo below, women often made up the majority of participants in training workshops.



Table S2. Gender of the Producers Assisted in the first Three Activities of the Productive Uses Pilot Program

N°	Pilot Project	Location	Productive units (%)		
		Region	Women	Men	Total
1	Soluciones Practicas- ELSE	Cusco	58.7%	41.3%	100.0%
2	Swisscontact – Electrocentro	Junín	18.6%	81.4%	100.0%
3	Desco – ADINELSA	Lima	28.3%	71.7%	100.0%
Total			33.0%	67.0%	100.0%

Future promotion activities planned in Peru. As noted above, during the implementation of the first three activities in Peru, over 4,760 individual producers adopted electrical equipment for productive uses in the sectors of agricultural processing, irrigation, dairy production, bakeries, metal processing, carpentry and textiles. An additional three productive uses promotion contracts were awarded in the departments of Arequipa, Puno and San Martín/Loreto in mid 2011, and are now in Phase 2 of implementation, in the concession areas of SEAL, Electro Oriente and Electro Puno. At the same time, the Project signed a follow-up contract with Swisscontact in the concession area of Electrocentro, to complete the projects of eight cooperative coffee processing plants in Junin. A similar follow-up contract was awarded to Soluciones Practicas in the concession area of ELSE in Cusco. A further group of five contracts was signed in late December 2011 and January 2012, for activities in Piura y Tumbes, Lambayeque/Cajamarca Norte, La Libertad/Cajamarca Sur, Ancash Ucayali and a follow-up in Lima Provinces. Finally, an additional six months contract was awarded to Desco for the province of Huarochiri in Lima. These activities are now in Phase 1 of implementation.

These new contracts improve on the BDS model used in the first three activities, with several modifications in the tasks of the NGOs, the contributions of the distribution companies and the supervision by the Project:

- There is a sharper focus on the efficiency of the interventions; the performance targets for kWh sales that are to be agreed between MEM and the NGO, with the concurrence of the distribution company, are to represent incremental revenues that yield a minimum 12 percent rate of return on the costs of the NGO contracts.
- There is a greater emphasis on knowledge sharing through consultations or workshops with other NGOs, distribution companies, the regulator, and MEM;

- Data will be collected separately on the costs of equipment and electricity infrastructure investments.
- There is a stronger emphasis on the NGOs sharing the learning that is being generated with other NGOs, MEM, the distribution companies and the regulator, and in verifying and documenting the results.

As shown in Table S3 below of projected results by the end of the RE Project in September 2011, the number of productive users assisted and the investments in electrical equipment are expected to exceed the targets established in preparation in 2005, while the projected consumption would reach 43 percent of the target originally set. The original targets were based on the experience of productive uses promotion in Indonesia. In the case of electricity consumption, they proved to be unrealistic given the nature of the activities carried out in Peru. However, even though the increase in electricity consumption is less than targeted, the activities are still cost effective. The costs of the productive uses contracts have an economic rate of return estimated at over the 12 percent hurdle rate set by the GoP for public investments, when the costs are compared with the additional revenues generated for the electricity companies, not including the benefits of additional income generation to the producers.

Table S3. Summary of Projected Results of Productive Uses Activities in the First RE Project

	Nº of Activities	FPU	Consumption (MWh/yr)	Investment (million US\$)
Activities Completed	3	4,761	1,864	0.711
Activities in Implementation since mid 2011	5	5,881	4.041	0.956
Activities in Implementation in 2012	6	6,818	1.862	0.686
Total Activities	14	19,820	7.769	2.353
Target First RE Project		9,000	18.000	1.810
% Compliance with Target		220%	43%	130%

A Second Rural Electrification (RE2) Project in Peru has been under implementation by MEM since July 2011, with assistance from the World Bank. The RE2 Project will continue the promotion of productive uses of electricity, which has been adopted by the new administration as part of its agenda of social inclusion. Productive uses of electricity was specifically mentioned by the Premier as a priority of his administration in his speech to Congress in August 2011 setting out the incoming Government's objectives. The broad strategies for promoting productive uses under the RE2 Project in Peru are to continue the approach taken in the RE Project with increased attention to the cost effectiveness of the BDS marketing and assistance; ensuring the sustainability and replicability of the results; and increasing the sharing of best practices across the distribution companies and NGOs to raise overall performance level.

In parallel to the Second Rural Electrification Project and beyond it, the DGER is expected to continue and expand the promotion of productive uses of electricity. The theme of productive uses of electricity has been integrated into government objectives—MEM's National Plan for Rural Electrification mentions capacity building for productive uses as a key objective. The RE2 Project will work to make productive uses promotion an integral part of rural electrification activities of the DGER rather than a separate pilot activity.

Challenges and barriers. As has been found in other countries, rural communities in Peru face multiple barriers to increasing the use of electricity for production. The challenges can be categorized in relation to demand and supply side constraints. The constraints on promoting demand for electricity from productive units include:

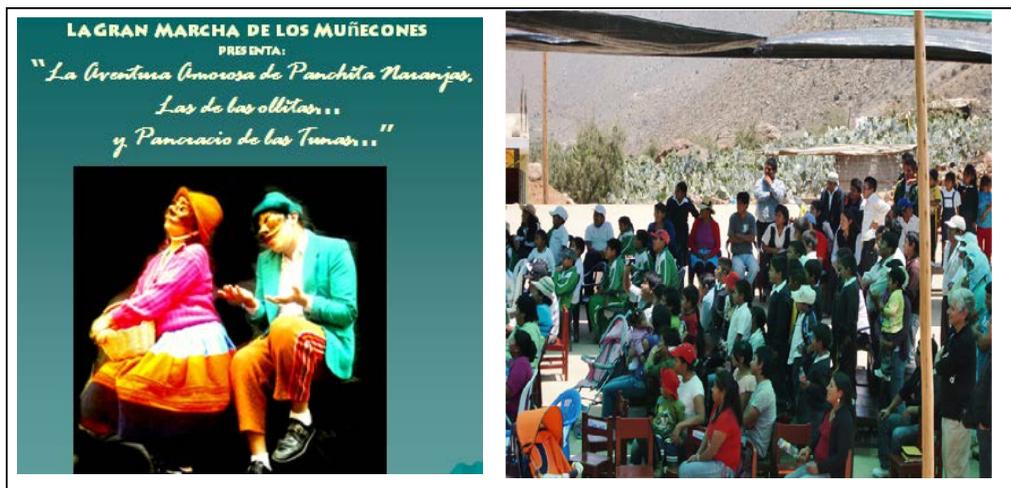
- The rural producers often have limited technical and management skills;
- Producers have inadequate access to capital and financing;
- They often have inadequate knowledge about: a) market opportunities, particularly for products based on additional processing; b) technology options, for example there has been little supply or promotion of electric tools; and, c) costs of productive electricity connections, or cost effectiveness of electrical equipment;
- There is a perception of poor quality of grid-supplied electricity, which reduces the interest in considering electrical equipment.

On the other hand, the constraints identified from the perspective of supplying the electricity to meet the additional demand include:

- The distribution companies do not market to or track productive use customers;
- The companies maintain few own offices or staff in rural communities, limiting their access to information and insights on their rural markets;
- The companies do not coordinate rural electrification efforts with other complementary institutions, e.g., those involved in microfinance, equipment supply, and agricultural production and processing services.
- Rural electrical system designs and network layouts are optimized for least cost household connections, rather than maximum development benefits.
- Service quality in many of the poorer communities is inconsistent, with interruptions and voltage drops.

Unexpected aspects of implementation. There were both positive and negative unexpected aspects identified by the NGOs in their implementation of the pilots. Positive aspects included:

- *Finding opportunities was easier than expected.* The opportunities for using electricity for production were substantial and, once catalyzed, adoption by the enterprises was fast.
- *Leverage effect of first adopters was strong.* Several of the targeted production chains have large numbers of primary producers. The successes of the early adopters of electricity have the potential to attract other producers to adopt electrical equipment.
- *Financing was often accessible.* Financing was generally available from municipalities, cooperatives, producers associations and other programs to support productive uses investments.
- *NGO team's creativity and imagination added value.* The NGO's experience in social activism, engineering skills and innovative solutions added great value. For example, Desco used community theatre to create enthusiasm for the program. They also added value by preparing the analyses of multiple irrigation pumping systems and developing technical designs for electricity infrastructure.



On the other hand, the teams identified several unexpected, constraints:

- *Tariffs were not fully understood.* The availability of the lower cost, off-peak tariff, was largely unknown in the rural communities at the outset of the pilot projects.
- *Coordination of the NGO with the distribution company required more effort than expected.* Securing practical coordination with the companies was time consuming for the NGOs and producers.
- *Single Wire Earth Return (SWER) systems were perceived to limit equipment use.* While it is possible to use converters to enable the use of three phase motors on SWER lines, the distribution company needs to assess and monitor the total demand that is permitted on the SWER line and to add additional lines when the capacity reaches its limits. The distribution companies in Peru lack experience in management of these issues and as a result may discourage producers rather than responding to their requests. Additionally, in many cases, the investment cost for the producers included the expenses for additional electricity infrastructure as well as electrical equipment.

Lessons learned. Rural electrification programs often do not include active promotion of productive uses of electricity. However, the experience of the promotion of productive uses in Peru was pragmatic, achieved greater than expected results and could be replicated in many other situations where similar conditions exist. These basic conditions for replication would include: (a) economic growth that is reaching into rural areas; (b) the presence of strong NGOs that are active in rural development; (c) availability of financing for productive investments; and, (d) willingness of distribution companies to make productive connections and investments in electricity infrastructure.

Where these conditions exist, best practices for increasing productive uses suggested by the experience and results of the three pilots of the RE Project include:

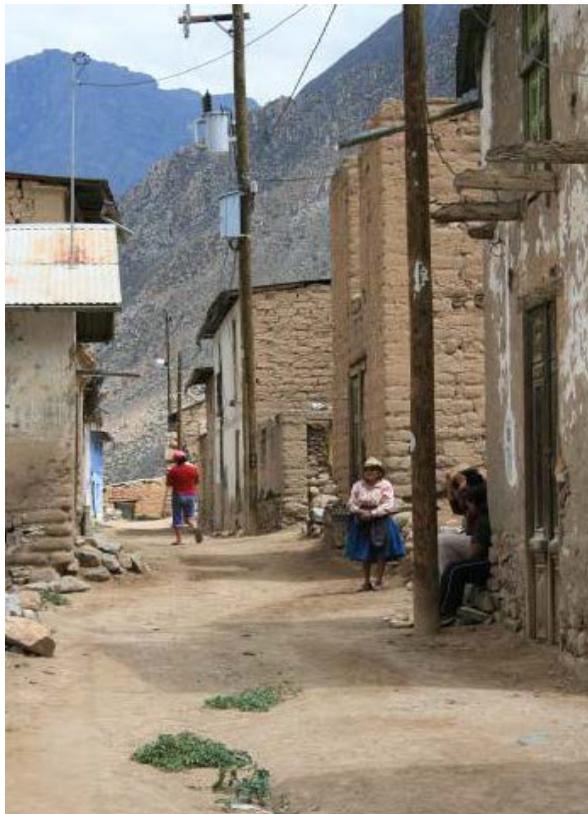
- Include productive uses objectives and targets in rural electrification projects, to make them rural development projects as well as electricity access projects;
- Promote productive uses before or in parallel to rural electrification projects, to improve viability and reduce subsidies required;

- Incorporate business development service (BDS) type assistance in rural electrification project design;
- Outsource the marketing and BDS services to development NGOs or similar organizations with the relevant experience, methods and commitment to the development mission using time limited, targeted, performance based contracts;
- Ensure that distribution company business plans address productive user customer demands and constraints; and,
- Consider modifications to distribution system design and financing criteria, regulatory practices for handling rural marketing costs and for covering the costs of additional electrical infrastructure required.

The productive uses pilot promotion effort in Peru has been largely successful in achieving the first four points above, which are mainly related to demand side issues. However the last two points, which address the regulatory environment, rural electrification design criteria and regulatory issues have not yet been addressed in Peru and are still a work in progress.

Introduction

Figure 1. Electricity Lines in Rural Village Peru



With a GDP per capita of US\$9,200 in 2010, Peru has one of the best performing economies of Latin America. Average annual GDP growth has been 7.2 percent from 2006 to 2010. Sustained economic growth over the last six years has had a positive impact on reducing poverty and creating jobs, but poverty (35 percent nationally in 2009) and inequality still remain major concerns, especially in rural areas. The national poverty rate masks important differences between urban and rural areas, and across regions. An estimated 24 percent of the population lived in rural areas, according to the 2007 census. Poverty levels are significantly higher in rural areas, particularly the Sierra region where the percentage of people living in poverty was 65.6 percent versus 14.1 percent in Lima in 2009.

At the end of 2010, about seven million people, mainly in the rural and marginal urban areas of Peru, did not have access to electricity. Although the official electricity national coverage is just over 80 percent, this figure hides the disparities of the different regions, ranging from 64 percent electrification in Cajamarca to 99 percent in Lima. While rural electricity coverage is

estimated to have increased from 30 percent in 2007 to 55 percent at the end of 2010, Peru's rural electrification rate is still one of the lowest in Latin America. As part of its efforts to reduce poverty and inequality between urban and rural areas, the Government is committed to improve the coverage of rural electrification to 72 percent by 2012 and 88 percent by 2020. The aim is not only to provide electricity for household use but also to generate economic development in rural areas.

It is well known that making electricity available in rural areas can help to improve the well being of a community. In general, the most immediate benefits of electricity are related to lighting and the use of television and radios. However, the coming of electricity also presents the possibility to transform the economy of a rural area. Electricity can allow the extension of working hours, the introduction of new activities and the modernization of traditional production methods to increase output, add value and ultimately raise local incomes.

Productive uses of electricity, in this report, are defined as those that generate income, including activities in services, industry and agriculture. As well as benefiting rural communities, realization of productive uses of electricity is essential for the viability and sustainability of rural

electrification and the operations of distribution companies in rural areas and can reduce the capital cost subsidies required.

Access to electricity can result in productivity gains and economic growth, but the path to obtaining that outcome is challenging. As documented in previous reports and studies in other countries, achieving increased productive uses of electricity in rural areas does not happen automatically and confronts constraints on both the demand (rural producer) and supply (electricity company) side.

Recognizing that increases in productive uses often do not occur rapidly or spontaneously following rural electrification, a pilot program to promote productive uses is being carried out under the Peru Rural Electrification Project, implemented by the Ministry of Energy and Mines with support from the World Bank and the GEF.

The objective of this report is to provide an assessment of some of the key opportunities and challenges in the implementation of the program by distilling the experience of the first three activities completed in Peru. This report contains the following chapters: (1) international experience with promotion of productive uses of electricity; (2) Peru's rural electrification program and the incorporation of productive uses promotion; (3) the implementation of the first three productive uses pilot activities; (4) the results of the first three productive uses pilots; (5) lessons learned so far; and (6) conclusions and recommendations for the future.

Section 1: International experience with productive uses of electricity in rural areas

International experience suggests that rural electrification alone is not sufficient to cause producers to adopt electrical equipment to increase productivity. While most rural electrification programs do not promote productive uses, work has been done in some programs and projects worldwide to seek methods to promote productive uses of electricity within the framework of rural electricity projects. This chapter presents a brief summary of international activities to promote productive uses of electricity, including important considerations for success. It provides a background for the analysis of the lessons learned from the practical experience of the initiative to promote productive uses of electricity in Peru.

Objectives and challenges of productive uses of electricity

The main goal of rural electrification is to increase the well-being and the economic activity of people living in rural areas (see Figure 2).



Figure 2: Rural Chinese Village with Electric Poles. (Photo from the World Bank Photo Library.)

The immediate benefits of making electricity available to rural households and businesses come from the improvement of the living conditions of individuals and their community through more

and better quality lighting, increased disposable income (since cost of electricity is usually less than that of alternatives), more flexible working hours through better quality light, improved access to news, information and entertainment, and enhanced public safety through street lighting.

To achieve the full development benefits of electrification, electricity can also be used to boost business productivity and catalyze economic growth within a community. In the context of rural areas, this generally implies productive use of energy for the provision of process heat or motive power for agricultural, small industrial or commercial uses (see Figure 3).

Figure 3. Uses of Electricity



In the household

For production

Examples of productive uses of electricity are the use of motors to grind grain, operate power tools, power pumps to irrigate farmland, process agricultural produce and facilitate many commercial activities (see Table 1 below for more examples). The advent of electric power can contribute to productivity gains in these processes and economic growth. The scope of the opportunities for each community will also depend on the availability of ancillary services such as market access, human and enterprise capacity, financial services, and resources/raw materials.

Table 1: Examples of Productive Uses of Electricity

<p>Agriculture</p> <ul style="list-style-type: none"> • Pumps (groundwater, surface water) • Modern irrigation (sprinkler, drip) • Collection and processing centers (fruits, cereals, coffee, root) • Grain mills <p>Animal husbandry</p> <ul style="list-style-type: none"> • Centers for processing dairy products and meat • Stables (heated shelters, feed mixing and processing) <p>Metalworking and Carpentry</p> <ul style="list-style-type: none"> • Soldering equipment, saws, lathes and sanders <p>Crafts ,Tourism (cultural, adventure, ecological)</p>

However, beyond the use of lighting to extend working hours of existing shops and artisan businesses, experience has shown that the introduction of electricity alone in rural areas may not result in productivity increases.¹ In the absence of well-targeted support measures, productive uses of electricity often catch on much slower or to a lesser extent than initially expected.²

Even when a number of other inputs, such as complementary infrastructure and services, are present, promotion may be required to address several challenges: identifying new market opportunities and technology options, building capacities to meet the organizational demands and skill requirements of new operational techniques, facilitating agreements among all the parties involved (e.g., electricity distribution company, producer, NGO's, credit providers, etc.) and mobilizing financing for the new productive equipment and electricity connection.

As poorer and more scattered and remote rural communities are connected, productive connections are often fewer than in the communities connected earlier. The development benefits are mainly ones associated with better household lighting and mobile phone charging, the use of radios, televisions, fans and other small appliances, with few connections for cooking or major appliances, or income generating activities.³ The low level of productive activities is reflected in the classic electricity demand profile of poor rural communities with 24 hour service; morning and evening peaks of electricity demand, mainly for lighting, with low demand during the daytime.

The low level of electricity use for production results in low utilization of the electricity infrastructure. This in turn poses financial challenges for the electricity distribution companies and sometimes makes rural electricity distribution investments unattractive even with capital cost subsidies.⁴ In the absence of sufficient increases in economic activity, the financial sustainability of the infrastructure is more fragile and the contributions of the electrification investments to rural well-being are limited.

The long-standing challenge has been to accelerate the adoption of productive uses of electricity as a way to contribute to more rapid, extensive and sustainable increases in rural well-being.⁵

¹ See Pinstrup-Andersen, P. and S. Shimokawa, "Rural Infrastructure and Agricultural Development", in "Rethinking Infrastructure for Development", World Bank, Washington, 2007.

² See "Productive Use of Energy-PRODUSE. A Manual for Electrification Practitioners", GIZ and euei pdf, Eschborn, 2011, p.13.

³ On measuring benefits of rural electrification, see: World Bank, "Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits", ESMAP report, 2002; Douglas Barnes, Henry Peskin, Aleta Domdom, "Quantitative Measures of Benefits from Rural Electrification in the Philippines", 2002. More recently, evaluations based on randomized approaches have been used: Maximo Torero, "Impact Evaluation Design for MCC, Rural Electrification Interventions in El Salvador", Social Impact, Inc., October 24, 2009; Taryn Dinkelman, "The Effects of Rural Electrification on Employment: New Evidence from South Africa", Princeton University, December 2009; Tanguy Bernard and Maximo Torero, "Randomizing the "Last Mile"", International Food Policy Research Institute, March 2011.

⁴ World Bank, "The Welfare Impacts of Rural Electrification", IEG Impact Evaluation Report, 2008.

⁵ Stimulating productive uses of rural electrification is not a recent concern. Barnes cites a 1925 article on the US experience; Douglas R. Barnes, ed., *The challenge of rural electrification: strategies for developing countries*, Resources for the Future, Washington, 2007, citing Ernst Bradford, "The Influence of Cheap Power on Factory Location and on Farming." *Annals of the American Academy of Political and Social Science* 118 (March 1925):91–95. Also, NRECA, "Productive Uses of Electricity in Rural Areas: Workshop Proceedings", Dhaka, 1982. http://pdf.usaid.gov/pdf_docs/PNAAU715.pdf

Constraints to increasing electricity use for rural production

Electricity on its own cannot spur significant increases in income generating activities. Rural communities face multiple, interlinking barriers to increasing their economic activities. The most frequently identified barriers include market barriers to increased production such as low income levels, limited ancillary services and physical and institutional support infrastructure, or limits on the market's size and its absorptive capacities for products. Similarly, there are limitations within the potential productive enterprise itself such as lack of knowledge of markets and technology options for production, limited access to capital, small scale of operation, lack of business and other technical skills. Throughout this paper, we will refer to these factors as demand side barriers.

In addition to the barriers on the demand side, there are significant obstacles on the electricity sector supply side, which are less frequently examined in the discussions of constraints to productive uses. Supply side constraints include high electricity connection costs, inadequate physical design of the distribution systems, poor reliability and service quality issues including voltage fluctuations, interruptions and slow service response times, and internal organization and methods of the distribution companies that are not oriented to the needs of potential rural productive users.

Taken together the demand side constraints and the challenges posed from the supply side impose barriers to the use of electricity to modernize rural production.

International experience with promoting productive uses in major electrification programs

Universal or near universal household electrification is frequently a national political goal and marker of development. As a result, rural electrification programs in most countries are driven by the goal of rapidly connecting as many households as possible. In practice, this leads to projects based on installing distribution lines, increasing the numbers of households served and waiting for productive activities to emerge later.⁶ Connections for existing producers as well as public services like schools, clinics and some street lighting are normally covered as rural distribution lines are extended, but there are few or no activities aimed at increasing income generating activities. Demand and supply side constraints to expanding productive uses of electricity are not analyzed, and targets for increasing the electricity demand by productive uses are not set or tracked. Common drivers of these rural electrification projects are the maximization of the numbers of connections and the minimization of line and other costs per household connection.

In this "access oriented" approach to rural electrification, producers that are already operating power equipment will shift to grid supply and service businesses may extend operating hours, depending on the electricity price and service quality. Beyond these producers that are already using electricity, however, the uptake of electricity for productive activities is typically slow. Communities that have been connected for longer periods of time will often have higher levels of economic activity associated with electricity use than ones that have been connected for fewer

⁶ OECD/IEA, "Energy Poverty: How to make modern energy access universal?", September 2010; World Bank, "One Goal, Two Paths, Achieving Universal Access to Modern Energy in East Asia and the Pacific", 2011.

years.⁷ However, this passive approach to increasing electricity use for production delays and reduces the potential improvements in well-being from rural electrification investments.

As a general practice, electricity distribution companies do not actively market their services; the marketing or customer service departments tend to be passive, receiving requests for connections and handling customer complaints. The companies do not promote kWh sales growth by promoting rural productive uses and rarely assist with efforts to address either supply or demand side constraints. However, in one of the few examples of broad-based promotion, Indonesia's national distribution utility, PLN, under the World Bank supported Rural Electrification I and II projects, competitively awarded contracts to 26 NGOs to promote electricity for income generating activities (See Box 1).

The Indonesian NGOs used Business Development Services (BDS) methods to assist small and home-based micro-enterprises within recently electrified communities to gather information, find credit and address technology constraints through marketing and assistance campaigns. The NGOs coordinated their activities and linked the micro-enterprises with finance organizations, equipment suppliers, public and private development organizations and market channels. These PLN projects included also several measures to address supply side constraints, such as training of the utility's staff on rural customer needs, tariff reclassifications, quicker responses to requests for new or increased power connections for producers, steadier voltage, fewer outages, and more accurate tracking of productive use connections and consumption.

Box 1: Utility-contracted Business Development Services (BDS) in Indonesia

The Indonesia Rural Electrification Projects I & II pioneered the application of Business Development Services (BDS) to promote productive uses of electricity. Initial surveys showed that a main constraint to increasing loads and profitability was insufficient information – market price and technical options – to potential electricity users. Consequently, the project focused on outreach to small businesses through NGOs, and developed a marketing strategy for PLN, the electricity supplier, which addressed issues of lack of information, tariff barriers and quality of service. Impact studies show 66,000 enterprises were assisted and over 20,000 jobs created.

Insight/Lessons. An effective outreach program, such as BDS can help generate economic activity and employment, as well as improve the finances of the electricity company. The concept of customer-responsive service to increase rural development and better utilize electricity system capacity is transferable. However, although the Indonesia utility company recognized the need for marketing and outreach, efforts toward “mainstreaming” promotion within the organization did not take hold as hoped. It may be that “outsourcing” to NGOs is the most effective way to initiate an effective outreach program, given the potential resistance and “mind set” of many utility companies.

Source: Robert E. Fishbein, "Survey of Productive Uses of Electricity in Rural Areas". World Bank, 2003.

In Senegal, the World Bank financed Electricity Services in Rural Areas Project is testing and implementing multi-sectoral approaches to promotion of productive uses of electricity.⁸ Two options are being tested in the Senegal program described above. One option is to begin with an analysis of all productive activities in an area, identify the main productive activities that could benefit from the introduction of electricity, then develop a promotional campaign to increase

⁷ Shahidur R. Khandker, Douglas F. Barnes, Hussain A. Samad, "Welfare Impacts of Rural Electrification: A Case Study from Bangladesh", World Bank, 2009

⁸ "Maximizing the Productive Uses of Electricity to Increase the Impact of Rural Electrification Programs", ESMAP Formal Report 332/08, April 2008, Washington.

awareness and remove obstacles to adoption of electricity in targeted production sectors. A second option is to look across the various productive sectors in the targeted area, and look for ongoing programs and activities that could be enhanced by the introduction of electrical equipment, then make formal agreements among stakeholders to implement the introduction of electrical equipment.

India and Bangladesh are notable for rural electrification projects that addressed demand side constraints through promotional pricing, financing, and other coordinated supports that closely tied the projects to irrigation and agricultural production.⁹ Thailand's rural electrification program provides another of the few examples of concerted efforts to address supply side constraints in a major national electrification program. Village selection criteria, line design, market assessments, active load promotion, close tracking of productive uses and follow-up activities were features of Thailand's successful rural electrification.¹⁰ The American National Rural Electrification Cooperative Association, NRECA, has summarized its experience in promoting rural electrification worldwide and produced design guidelines for such programs.¹¹

More limited examples of actively promoting productive uses include cooperative projects in Bolivia and the Dominican Republic that included elements to address specific demand side constraints, such as a productive uses loan program in the Dominican Republic.¹²

Elements of successful productive uses programs

To increase their contributions to rural economic development, rural electrification projects must include initiatives to promote productive uses of electricity in the community. World Bank operational guidance to staff for off-grid rural electrification projects includes a clear statement on productive uses that applies equally to grid extension projects: "Project designers must take advantage of any opportunity to initiate or enhance productive activities as they significantly increase the prospects for long-term project sustainability. The key ingredients are providing small private entrepreneurs or community organization technical assistance and financing."¹³

For a regulated distribution utility engaged in rural electrification, with an obligation for quality service and full cost recovery tariffs as well as a significant investment in infrastructure, productive uses of electricity are essential to grow their rural electricity market. For such companies, the model for promoting productive activities must be a commercially viable one, based on cost effective interventions that increase sales. If a distribution company has affordable, competitive prices and good quality service, it can present an attractive opportunity for productive users to switch from more costly energy sources to improve their business or to start up new activities using grid electricity. In this case, the marketing challenge for the utility is to

⁹ Rural electrification programs for irrigation were noted as an exception to the conclusion that rural electrification programs have a limited impact on productive activities. World Bank, "The Welfare Impacts of Rural Electrification", IEG impact evaluation report, 2008.

¹⁰ Tuntivate Voravate and Douglas F. Barnes, "Public Distribution and Electricity Problem Solving in Rural Thailand", chapter in, Barnes, ed., op.cit

¹¹ See NRECA International, "Guides for Electric Cooperative Development and Rural Electrification, Module 9: Productive Uses of Electricity", Arlington VA.

¹² NRECA, "Final Report, "Implementation of the Rural Electrification Plan", USAID Dominican Republic, 2008

¹³ World Bank, "Operational Guidance for World Bank Group Staff: Designing Sustainable Off-Grid Rural Electrification Projects: Principles and Practices", Washington 2008.

remove the obstacles that hinder their potential or existing productive use customers from adopting or using more electricity.

Overcoming these barriers requires the active promotion of the potential benefits of using electricity, and the sharing of techniques and know-how with community members to define a route to put innovation in practice. To fully realize the potential benefits is likely to also require shaping the technical, regulatory and legal framework for the supply of electricity in rural communities in such a way that it supports development of productive uses of electricity.

Options for marketing grid electricity for productive uses will vary by company and with local circumstances. As noted above, various options exist for development of programs to promote productive uses of electricity.

While there are different options for design of activities to promote productive uses of electricity, it is clear that all successful programs involve cross-sectoral efforts to assist micro and small enterprises to act on opportunities to introduce electrical equipment that will enhance their productivity, by addressing constraints related to technical and business skills, markets, finance, technology and other constraints on both the demand and supply sides.

The Peru experience within the international context

This report summarizes the early experience of a pilot program to promote productive uses in Peru. The approach used was based mainly on the BDS approach, as introduced in the World Bank-assisted Indonesian projects described above. This approach involves working through a combined effort of NGOs and distribution companies at local level, in collaboration with other institutions, to identify opportunities to increase income generating activities by assisting micro and small enterprises to improve and start businesses.¹⁴ The cross-sectoral activities take place at the local level and are developed by each NGO, resulting in a bottom-up approach to identifying opportunities and designing the promotion program.

Since the size of the program was small, efforts were targeted to particular areas with known potential, where NGOs that were already active in development efforts were contracted to promote productive use of electricity, with the cooperation of the electricity company. The design is built on the international experience explored above, especially the experience with the use of business development services in Indonesia.

The focus of the report is on the implementation experience, the ways in which the model worked well and the problems encountered along the way.

¹⁴ For a review of BDS methods, see, Alexandra O. Miehlebradt and Mary McVay, Jim Tanburn Editor, "From BDS to Making Market Work for the Poor, the 2005 Reader", ILO International Training Center, 2005; Alfons Eilgmann, "Making Business Development Services Markets Work for the Poor", elaborated for the OECD-PovNet Task Team on Private Sector Development and Pro-poor Growth, Eschborn 2005.

Section 2: Rural electrification efforts in Peru

This section contains a brief summary of Peru's rural electrification program and describes the collaboration between Peru's Ministry of Energy and Mines and the World Bank through the Rural Electrification and Second Rural Electrification Projects, which include the pilot initiative for the promotion of productive uses of electricity.

Peru's Rural Electrification Program

Peru's geographical and economic characteristics have shaped its rural electrification efforts (See Box 2). According to the 2007 Census, only 30 percent of all rural households had electricity service. The rural electrification effort faces difficult physical challenges in Peru. The large distances separating communities, low population densities and the rugged terrain have made extending access to electricity in rural areas difficult, resulting in high installation, operation and maintenance costs.

Furthermore, the low level of electricity consumption in most rural households poses an additional challenge. Almost 30 percent of electricity users have a monthly consumption less than 31 kWh/month. The average consumption among these users is about 20 kWh/month. Low consumption limits the profitability of rural service in distribution companies thus imposing a barrier on future infrastructure investments.

The concession areas of distribution companies in Peru cover only a small part of the national territory (see Figure 4). There are 23 electricity distribution companies in Peru. The distribution companies in rural areas are mainly public sector companies. Distriluz, comprising four regional companies (Electrocentro, Electro Noroeste, Hidrandina and Electro Norte), is the largest public company, with about 1.53 million customers. Distriluz's market is not highly profitable but has a reasonable rate of return. Sociedad Electrica del Sur Oeste (Arequipa) and Electro Sur Este (Cusco) have similar characteristics. Three other public companies, Electro Oriente (Iquitos), Electro Puno (Puno), and Electro Sur (Tacna), serve medium-sized and small cities and towns and rural areas with dispersed communities and low demand and operate with marginal profits. Eight other very small public distribution companies serve less than 3 percent of the market and are generally not profitable. Private distribution companies are mainly in cities, including Luz del Sur and Edelnor (Lima), and Electro Sur Medio (mainly Ica). Edelnor co-financed one of the

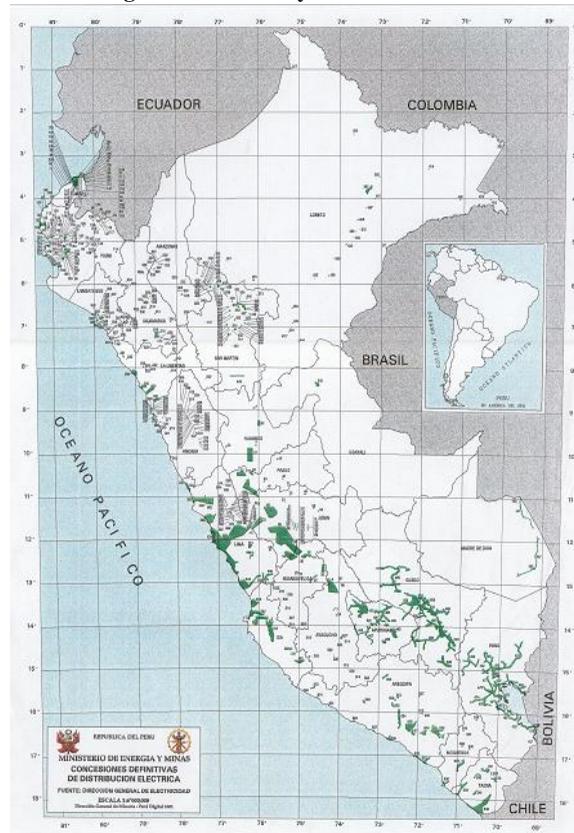
Box 2. Peru's Geography and Economy.

Peru, located in the west central portion of South America's Pacific coast, is the third largest country in the region after Brazil and Argentina. It spans over 1.28 million square kilometers and has a total population of 28 million people, of which an estimated 7 million people live in rural areas. 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.

With a GDP per capita of US\$9200 in 2010, Peru has one of the best performing economies of Latin America (GDP growth at 8.8 percent from 2006-2008, 1 percent in 2009 and 8.8 per cent in 2010 respectively). However, the national poverty rate masks important differences across urban and rural areas and across regions. Poverty levels are significantly higher in rural areas, particularly the Sierra region 65.6 percent vs. 14.1 percent in Lima in 2009. However, urban areas—most notably Metropolitan Lima—have the most income inequality.

subprojects in the first RE Project. ADINELSA is a public company that administers the electricity distribution assets directly owned by the state.

Figure 4. Electricity Concessions in Peru



Tariffs in Peru are set using the efficient company model, based on full cost recovery principles. Electricity companies, public or private, are generally self financing, obtaining sufficient revenues from tariffs to cover costs and finance investments. ADINELSA, which is the Government holding company for electricity assets, is an exception, running an annual loss and requiring a subsidy of around US\$4 million a year from the Treasury.

The electricity sector reforms that established the framework of the sector in 1992 did not address the issue of rural electrification. However, in 1993, the Ministry of Energy and Mines (MEM) established the Direccion Ejecutiva de Proyectos (DEP) to implement construction of rural electrification systems with public financing. In May 2007, the General Directorate of Rural Electrification (DGER) was established within the Ministry of Energy and Mines (MEM), based on the Rural Electrification Law of 2006.

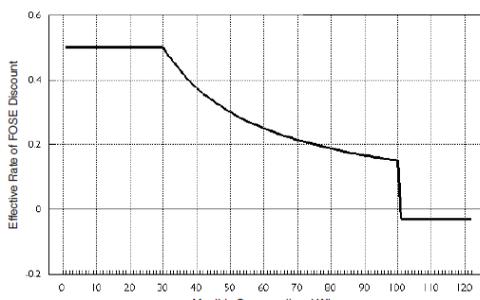
The DGER is organized in two divisions which implement complementary electrification schemes aligned with the government's priorities and goals: (1) a larger, fully subsidized centralized program implemented directly by the Direction of Projects (DP, formerly the DEP), which constructs projects and transfers them to distribution companies or ADINELSA; and (2) a

smaller program implemented by the Direction of Competitive Funds (DFC) to provide partial capital cost subsidies to projects initiated and implemented by the distribution companies, aimed at increasing economic efficiency and attracting broader participation and financing. The World Bank is providing financing to this second scheme through the Rural Electrification Project and, beginning in July 2011, the Second Rural Electrification Project

Complementing the programs of DGER to finance construction of rural electricity systems, Peru has several regulatory measures aimed at making electricity more available to poor households. These include: (a) the connection charge, including the meter, of about US\$100, part of the capital cost, is recovered over time rather than charging it initially, reflecting best international practice; and (b) a cross-subsidy on the tariff from larger consumers to those who consume less than 100 kWh/month (the Electricity Social Compensation Fund, FOSE, cross-subsidy, see Box 3).

Box 3. FOSE Cross Subsidy

Introduced in 2001, this cross-subsidy subsidy aims to lower the tariff for those households that consume 30-100 kWh/month. The total amount of the subsidy is about US\$31 million per year, collected through a surcharge of 3 percent on households consuming more than 100 kWh per month. It is channeled through the FOSE (Electricity Social Compensation Fund). The graph below shows the effective discount of the energy tariff in the range of 0-100 kWh/month consumption. Example: a rural household uses 25 kWh/month and receives a 50 percent FOSE subsidy. Then, a 200 W refrigerator is installed consuming 50 kWh/month, increasing consumption to 75 kWh/month. The FOSE subsidy would be reduced to only 20%, therefore the unit price of electricity would be 30% more expensive after installation of the refrigerator.



In recent years, the Government has made a strong and concerted effort to increase rural electricity coverage, introducing the Rural Electrification Law of 2006 and providing more than US\$100 million per year for investments in rural electrification. The National Rural Electrification Plan of 2011-2020 estimates that rural coverage had reached 55 percent nationally by the end of 2010. However, electrification coverage (urban and rural) varied by department from 99 percent in Lima to 64 percent in Cajamarca. There is a close correlation between the levels of poverty and electrification of the different regions of the country.

The Plan for 2011-2020 proposes ambitious targets for rural coverage of 72 percent by 2012 and 88 percent by 2020, requiring mobilization of US\$2.2 billion in ten years and aiming to benefit an estimated 7 million people. The Plan also stresses promoting the use of renewable energy to provide electricity access in isolated rural areas and capacity building for productive uses of electricity in rural areas.

Since the Government places strong emphasis on increasing rural electricity coverage ratios, the main driver of the rural electrification program is on increasing access of households, at the lowest cost per connection. Subsidies for rural electrification are primarily intended to cover the costs of service to households. As a result, the design standards emphasize single wire earth return (SWER) designs, as the preferred distribution supply alternative in communities with low demand (See Box 4).

Box 4. Single Wire Earth Return (SWER) Systems

In Peru, single phase SWER systems recently have become the preferred economic alternative. The distinguishing feature of SWER systems is that the earth (or sometimes a body of water) is used as the return path for the current, to avoid the need for a second neutral wire to act as a return path. A SWER line is a single conductor that may stretch for tens of kilometers, with a number of distribution transformers along its length.

SWER's main advantage is low cost, which is appropriate for rural areas with low demand profiles. However, SWER systems require the use of electromagnetic converters to permit the use of three phase motors while maintaining line voltage. In Peru, OSINERGMIN permits the distribution companies to include the cost of electromagnetic converters in the cost of their assets for tariff purposes. However, distribution companies in Peru have limited experience in the management of SWER lines to enable productive uses while ensuring quality of service.

Productive users are included in service provision if they are located directly along the distribution line. Under Peru's concession law, distribution companies are obliged to provide service to customers within 100 meters of the existing line. Those located at further distances from the existing distribution lines must pay the full cost of the line extensions or upgrades required to provide three phase service or increases in capacity. There is no explicit targeting or tracking of productive uses in rural electrification projects financed by the DGER, other than the pilot program under the RE Project described below.

Cooperation efforts: The WB and GEF assisted Rural Electrification Project

The Rural Electrification (RE) Project (US\$144 million total, including US\$50 million from IBRD and US\$10 million from GEF), has been under implementation by the DGER of MEM since mid-2006 (see Annex 1). It is contributing significantly to meeting the Government's ambitious rural electrification goals. The objective of the RE Project is to increase access to efficient and sustainable electricity services in rural areas of Peru. This is done through: (a) investment in subprojects co-financed and carried out by electricity service providers, using both conventional grid extension and renewable energy sources; (b) demonstration of a model that attracts investment from private and public sector electricity providers, as well as from local governments; and (c) a pilot program to increase productive uses of electricity in rural areas.

The RE Project has been providing cost-effective access to electricity service, and is expected to provide electricity to 110,000 households, representing 473,000 people, by its close in September 2012. This would increase rural electricity coverage by an estimated 6 percent.¹⁵ The Project has

¹⁵ The number of connections expected is 30 percent below the original indicator of 160,000, due to higher average costs per connection, \$1,085 actual versus US\$715, due to inclusion of meter, exchange rate changes and inflation.

succeeded in mobilizing participation and financing from ten distribution companies, achieving broad national coverage, with projects in sixteen departments.

The RE Project's approach of co-financing subprojects that are initiated by the distribution companies has been institutionalized with the establishment of the Directorate of Competitive Funds (DFC) within the Directorate General of Rural Electrification (DGER) of MEM. The DFC's sole purpose is the implementation of the Rural Electrification Project and the Second Rural Electrification Project. While the Project's financing is small compared to the DGER's total funding (about 16 percent in 2009), it has the advantage of leveraging the government's funds as subsidies are partial and calculated based on the characteristics of each subproject. Distribution companies have contributed 24 percent of the capital cost of the subprojects, on average. Consequently, the Government subsidy averaged only 76 percent of the subproject cost. More importantly, the electricity service providers own the subprojects, have strong incentives to maximize commercial connections and are responsible for long-term sustainable provision of service. No operating subsidies are required.

The RE Project, is also supporting, hand in hand with the distribution companies and the regulator, OSINERGMIN, the introduction of an innovative regulated service model for the electrification of remote off-grid communities using household PV systems. Following RE supported cost studies and business plan preparation with two distribution companies and the regulator's own cost studies, OSINERGMIN in 2010 for the first time incorporated full cost recovery tariffs for regulated electricity service with PV systems in the national tariff framework. In parallel, it made customers of such service eligible for the FOSE cross subsidy. Based on this tariff framework, the RE Project assisted four distribution companies and local communities to prepare subprojects to provide service to more than 8,000 households using PV systems, and a private operator has invested in service to an additional 600. It is envisioned that this model could now be used to provide sustainable electricity services to many of the estimated 300,000 isolated and dispersed households in Peru that cannot be reached by grid extension. The distribution companies will provide the service, while commercial and technical operation and maintenance of the systems will be done by SMEs contracted by the distribution companies in each community, similar to practices already used for grid service in remote communities.

Finally, the RE Project initiated efforts to work with the distribution companies to promote productive uses of electricity, the program that is the subject of this report. Contracts with three NGOs to assist three distribution companies have been completed, in Cusco, Junín and Lima Provinces. While these pilots are expected to benefit more than 16,000 individual producers by the Project's close, the main impact is expected to be from the demonstration of effective methods to increasing social and economic benefits of rural electrification, many of which can be mainstreamed and continued in the operating practices of the distribution companies and applied more broadly by the Ministry.

The IBRD-supported activities of the Rural Electrification Project are expected to close by September 2012, while the GEF-assisted activities, mainly with respect to financing small hydropower plants, are expected to close by June 2013.

Second Rural Electrification Project. Given the satisfactory performance of the First RE Project, the Government requested and the World Bank has approved US\$50 million of IBRD

financing for a Second Rural Electrification (RE2) Project. This new project continues the activities of the RE Project, with a focus on investment in provision of electricity service in a more challenging environment as households to be served are further from the grid and more dispersed; and selected related technical assistance activities including promotion of productive uses and renewable energy. The RE2 Project was approved by the World Bank Board in April 2011 and was declared to be effective in July 2011. It is beginning implementation at the time of preparation of this report.

Section 3:

Implementation of the first three productive uses pilot activities

This section describes the implementation experience of the first three productive uses pilot activities completed under the RE Project from 2009 to mid 2011, including: the main elements of the productive uses promotion activities; the characteristics of the three main stakeholders in the activities- the participating distribution companies, NGO's and the targeted communities; and the common promotion methods of the NGOs; and finally, the customization of the approaches considering the distinct circumstances for every pilot activity.

Main elements of productive uses promotion in the three pilot activities

The program is being carried out through a series of activities, each one in a specific geographical area that was selected based on its potential for increased use of electricity in productive activities and the willingness of the local distribution company to participate. For each activity, the Project first signed a memorandum of understanding with the distribution company that defined the responsibilities and commitments of the distribution company to assist in carrying out the activity. The Project then signed a contract with a competitively selected non-governmental organization (NGO), to assess the market and then design and carry out promotion activities to increase productive uses of electricity. The key elements of the design are described below.

Memorandum of understanding with the distribution company. Roundtable and individual discussions with the distribution companies resulted in the selection of three companies with a strong interest in participating in efforts to increase productive uses. A memorandum of understanding was signed by the DGER, on behalf of the RE Project, with the distribution company, establishing the role, responsibilities and support to be provided by the distribution company, the to-be-contracted NGO and the coordination arrangements. The responsibilities of the distribution company included:

- (i) Assist in the identification of target areas within their concession areas;
- (ii) Provide the information required by the contracted NGO for the identification of potential beneficiaries of the productive uses.
- (iii) Participate in the training of technical personnel of the NGO and business groups;
- (iv) Participate in marketing efforts (e.g., distributing brochures, attending promotional meetings and advising on technical aspects);
- (v) Implement new connections or authorize load increases as identified through promotional activities;
- (vi) Monitor the implementation of the program and contribute to the evaluation of results. Provide information on increases in kWh sales to customers for new or increased productive applications that can be attributed to program interventions.
- (vii) Where possible, provide incentives to customers who make new connections or request supply capacity increases during the implementation of the activity.

Selection of the communities. Within the concession areas of these companies, target communities were selected based on the criteria indicative of possible untapped opportunities for

productive uses: a surplus of electricity supply, 24 hour electricity service, adequate physical infrastructure, availability of complementary support services and programs, and sub-sectors or enterprises with relatively high potential to increase MWh/year for productive uses.

Contracts with the NGOs. The DGER decided to contract NGOs to implement the promotion activities in the identified areas. The decision to use NGOs to execute the promotion activities proved to be extremely effective. Their links with the community, field experience and the professional motivation towards social development in rural areas helped to achieve better than expected and fast results.

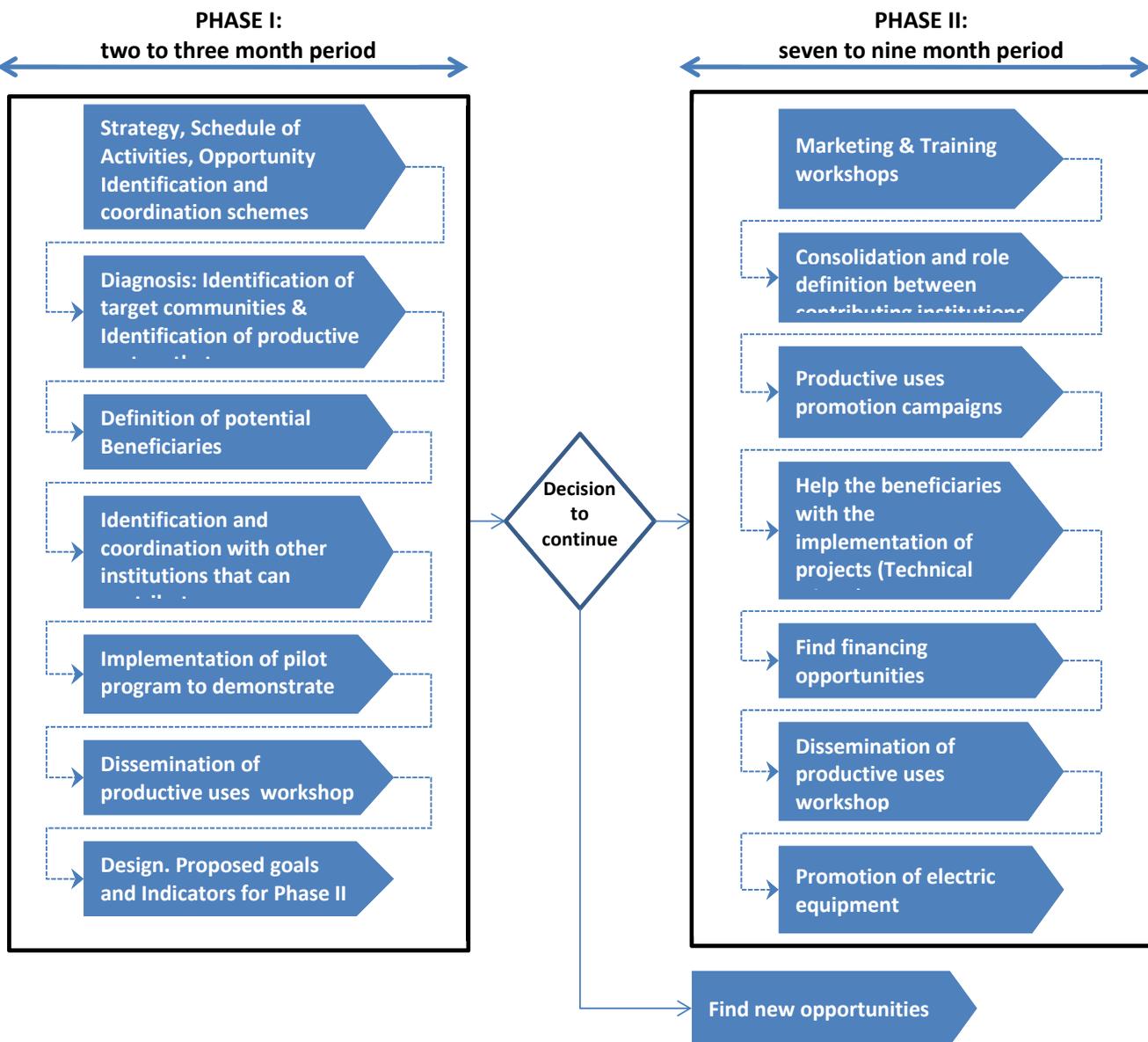
The NGO contracts established common objectives, implementation frameworks, business development services approach and measures of success for the three assignments. The indicators of success were defined in each contract and included targets for: (a) the number of entrepreneurs benefited; (b) the estimate of the increase in the annual electricity use for each of the benefited producers; and, (c) the investment made by producers in new equipment and electricity connections for productive uses.

The contract's design allowed significant space for the NGOs and distribution companies to custom tailor their approaches to the on-the-ground realities of the different communities and their own skill sets. The NGO was in charged with actively seeking distribution company participation and support.

The immediate aim of the contracts was to develop and demonstrate low cost methods to increase the use of electricity by businesses in rural areas. The main design elements were:

- The NGO contracts were output based, phased, and time limited:
 - output based: the final payment to the NGO was based on the results against agreed performance targets for: i) increased MWh/year, and ii) numbers of enterprises that increased productive uses, establishing a results-based payment for the NGO.
 - two phases, with pause between the phases to agree targets: *Phase 1* was a two to three month period for surveys, market assessments, linkage building, opportunity identification and the negotiation of performance targets based on the findings. This was followed by a seven to nine month *Phase 2* of active marketing and assistance campaigns to promote productive uses by the producers identified in *Phase 1*. The first phase, in addition to being an 'assessment phase', was used to raise awareness and interest as the first steps of the 'marketing phase'. The second and third contracts included a pause between the two phases to allow time to review the assessment report, agree on performance targets and determine whether to proceed with the second phase implementation. (See Figure 5)

Figure 5. Example of Phasing and Approach



- Limited, time-based promotion campaigns were implemented through the contracts with NGOs, rather than a long term program with the potential to displace or compete with efforts of other rural development programs. The limited duration of the contracts motivated the NGOs, distribution companies, communities, equipment suppliers, local governments and the beneficiary producers to urgently follow up on productive use opportunities.

- The contracts required the NGOs to use Business Development Services (BDS) methods:
 - field based teams of leaders, specialists, and promoters
 - household surveys, community consultations, focus groups and key informant interviews, often on an opportunistic basis, to assess constraints and opportunities in the targeted communities
 - active identification of market participants, channels and potential market opportunities and agents - buyers, suppliers of inputs, equipment fabricators, etc.
 - market assessments to target high potential kWh/year increases and opportunities for electrical equipment to add value, particularly by micro, small and medium enterprises, that could be captured in the near term.
 - delivery of multiple business support services for start-up or expansion of electricity-using enterprises, such as information on business opportunities, assistance to access finance and link with suppliers and buyers, skills training, and facilitation of contact with the distribution company on electricity supply and connection.
 - collaboration with other programs operating in the communities (e.g., activities of microfinance organizations, municipal governments, equipment suppliers, agricultural extension programs). The NGOs were tasked to mobilize a "multi-institutional platform" as a framework for collaboration with other organizations with complementary missions.

Participating communities, NGOs, distribution companies

Table 2 summarizes the regions, distribution companies and NGOs that were involved in the three pilot activities.

Table 2: Communities, NGOs and Distribution Companies Participating in the Pilots

Variable	Case 1	Case 2	Case 3
Location - region	Cusco	Junin	Lima Provinces
Locations - provinces	Paruro, Calca, Urubamba, Quispicanchi, La Convencion, Canchis and Acomayo	Jauja, Tarma and Chanchamayo	Huarochoiri, Cajatambo, Yauyos and Huaura
Distribution Company	ELSE	Electrocentro	ADINELSA
NGO	Soluciones Practicas (ITDG)	Swisscontact	Desco

The Regions. The three pilots were implemented in communities located in poor rural areas in the Costa, Sierra and Amazon regions (Figure 6). The areas ranged from the semi-arid coastal communities in Lima provinces, to the Andean highlands in Junin and Cusco, Amazon rain forests in Junin and the steep terrain of the high altitude cloud forests in Cusco region. Poverty and social exclusion¹⁶ in Peru are concentrated in rural areas.

¹⁶Luis Manrique Morales, "La Focalización Geográfica Intradistral: Un Mapa de Pobreza para Ámbitos Municipales", FONCODES, Lima, 2007

Figure 6. Peru's Geography

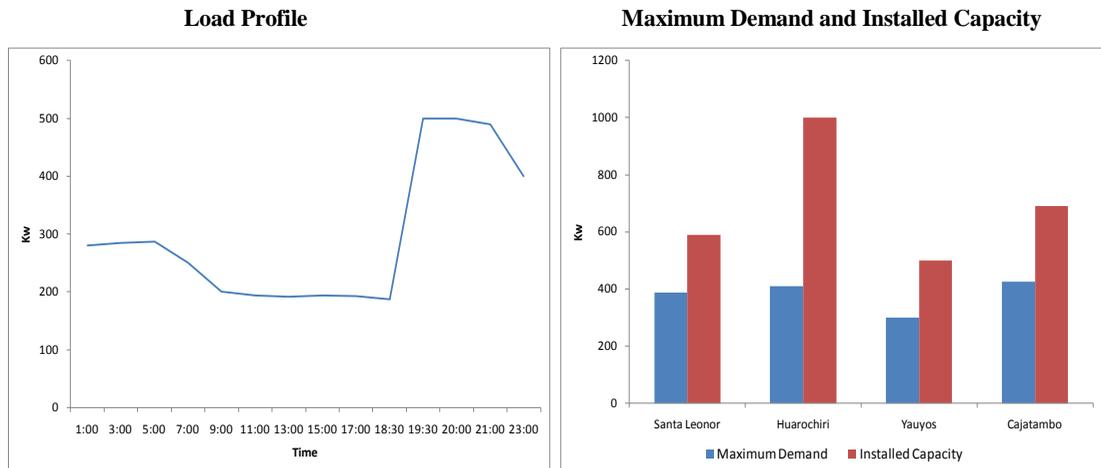


The main economic activities in the communities targeted are home based, small scale agriculture (coffee, cacao, grains, cereals, fruit production), livestock and dairy, artisanal mining, textiles, off-farm industries (carpentry, metal working, bakeries, ceramics) and service (transport and distribution). While farm production is often individual, agricultural processing is often done at a cooperative or association level.

In Cusco, the main productive activities targeted included grain milling, coffee processing, agricultural processing, and milk products. In highland areas, producers tended to be individual, while in the “ceja de selva”, producers tended to be organized in cooperatives. In Junin, the focus was on coffee production and grain milling, working mainly with cooperatives. In Lima Provinces, the focus was on pumping for the production of “prickly pear”, ceramics and dairy products.

All the communities have access to single phase, 24 hour electricity service with adequate grid supply, with demand well below the maximum demand capacity of the system. (See Figure 7)

Figure 7. Typical Load Profiles, Maximum Demand and Installed Potential, Santa Leonor, Nov. 2009



The electricity distribution companies. The activities were implemented in partnership with three electricity distribution companies: two distribution utilities, Electrocentro and Electro Sur Este, and the state asset holding company for rural electrification system investment, ADINELSA. The three companies each serve between 150,000 and 450,000 customers with electricity sales of 33 to 111 KWh/customer/month, see Table 3). The sales figures include sales in urban areas within the concession of the company, as the companies do not keep separate data on rural sales.

Electrocentro and Electro Sur Este are small, state owned companies with customers in regional towns, rural villages, and no high density urban concentrations. The companies were identified during project preparation as serving large numbers of communities with low electrification ratios and low levels of productive uses, but with the interest to actively participate in efforts to increase productive uses. They represent a sample of the 10 public companies in Peru serving 100,000 to 500,000 households in relatively low profitability markets.

ADINELSA is the government’s asset holding corporation that owns rural electricity installations that were developed through MEM, typically with government or donor funds, and were not incorporated into the distribution companies. These installations are in loss making or low profitability communities and are usually operated under contract by distribution companies or municipalities. ADINELSA loses money every year and receives a transfer payment from the national government, currently about US4-5 million per year. While ADINELSA’s resources are more limited than the other companies, it has a clear commitment to social objectives.

	Electro Sur Este	Electrocentro	ADINELSA
Location	Cusco	Junín	National
Customers, 2008	287,000	450,000*	150,000*
MWh sales, 2008	330,000	600,000	60,000
KWh sales / customer/month, 2008	96	111	33

* includes about 50,000 customers in ADINELSA owned systems operated by Electrocentro

The NGOs. Three NGOs, Soluciones Practicas (ITDG)¹⁷, Swisscontact and Desco, were contracted to implement the pilots. While having unique histories and capabilities, they have development missions and carry out activities that are similar in many respects:

- All three NGOs have the following characteristics: a) extensive multi-decade experience working in Peru's poor rural communities; b) a commitment to participative development, the sustainable use of local resources and generating development learning; and, a perception of their contracts to promote productive uses as an opportune entry point for catalyzing and supporting broad-based local development in the communities.
- Two of the Peruvian NGOs are affiliated with larger international groups (Soluciones Practicas with Practical Action, the former ITDG of the UK, and Swisscontact with the head office of Swisscontact based in Switzerland)
- Soluciones Practicas has a particular emphasis on appropriate rural technologies and small enterprises. Soluciones Practicas used similar BDS methods to promote small enterprise and employment opportunities for youths in other communities in the Cusco region under a separate project during the implementation of the pilot with ELSE.
- Swisscontact has had a strong interest in micro and small enterprise development.
- Desco has a particular focus on marginalized groups and community empowerment.

¹⁷ Soluciones Practicas was known as Intermediate Technology Development Group (ITDG) at the time of signing the contract. It entered into a consortium with S&Z, a small Peruvian firm, for implementation of the contract.

Promotional methods of the NGOs

Based on their contracts, the promotional methods of the NGO teams were broadly similar, with many common elements in their strategies to motivate and enable entrepreneurs and communities to increase productive uses. The promotion methods included: strong field-based teams; market assessments; analysis of market opportunities for electricity use based on the productive chain; preparation of business case profiles; targeting low risk agriculture based businesses; integrated, collaborative approach involving coordination with other actors, projects, sectors; BDS assistance provided to enterprises; and, coordination with distribution companies on how to fill any gaps in electricity infrastructure needed to provide adequate connections for the productive use of electricity.

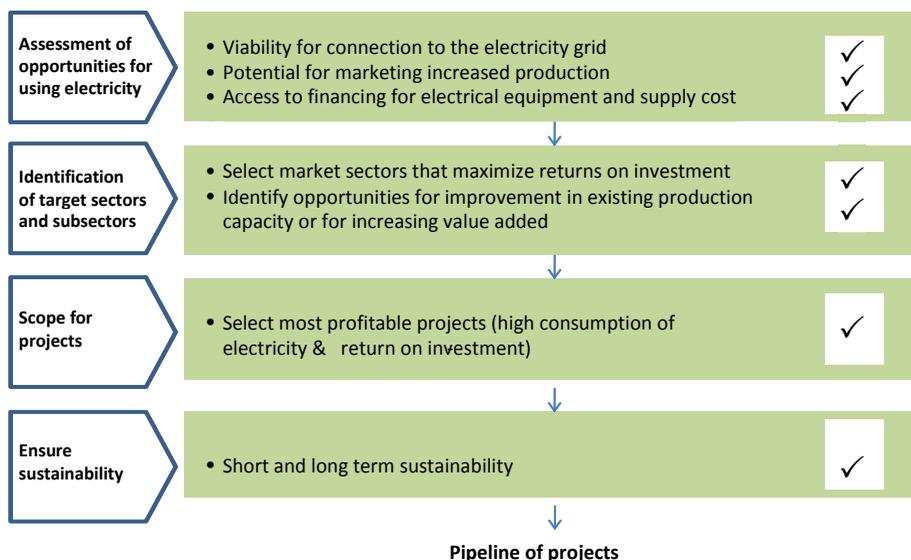
Multi-disciplinary, field based teams. Each NGO assigned a multi-disciplinary team comprised of about fifteen professionals: a full-time leader, finance, marketing and technology specialists, and about a dozen promoters. The team leaders and specialists all had significant field experience in rural Peru. Each of the team leaders had exceptional technical and management skills and long standing interest in the development of rural communities. They provided leadership in recruiting, motivating and guiding their teams and in establishing working relationships with the distribution companies, communities, enterprises and other organizations and market agents. The promoters were mostly recently graduated students whose homes were in the target regions.

Market assessments. The NGOs used distribution company data, census and other secondary sources to assess and scope the market and to identify potential opportunities segmented by communities, sub-sectors and access to the electricity system. District level census data on electrification ratios and numbers of generators and households were cross-referenced with distribution company data on the capacities and load factors of the electricity systems serving each district. Additional secondary data and leads on possible opportunities were gathered through networking with local governments, key institutions and individuals.

Participatory rural appraisal techniques,¹⁸ consultative meetings, focus groups and structured interviews with businesses and households were used to supplement, validate and refine the data. These methods helped to create a better understanding of the communities, sub-sectors and opportunities. The bottom-up methods used by the NGOs yielded practical results, for instance, names and locations of enterprises and data on current costs (Figure 8). The close interaction with the community also helped to mobilize the support of local governments and other agents.

¹⁸ For participatory, rapid rural appraisal methods and technique, see: FAO, "Marketing Research And Information Systems", available at: <http://www.fao.org/docrep/W3241E/w3241e00.htm#Contents>

Figure 8. Steps to Identifying Target Communities, Subsectors, Enterprises (Descso)

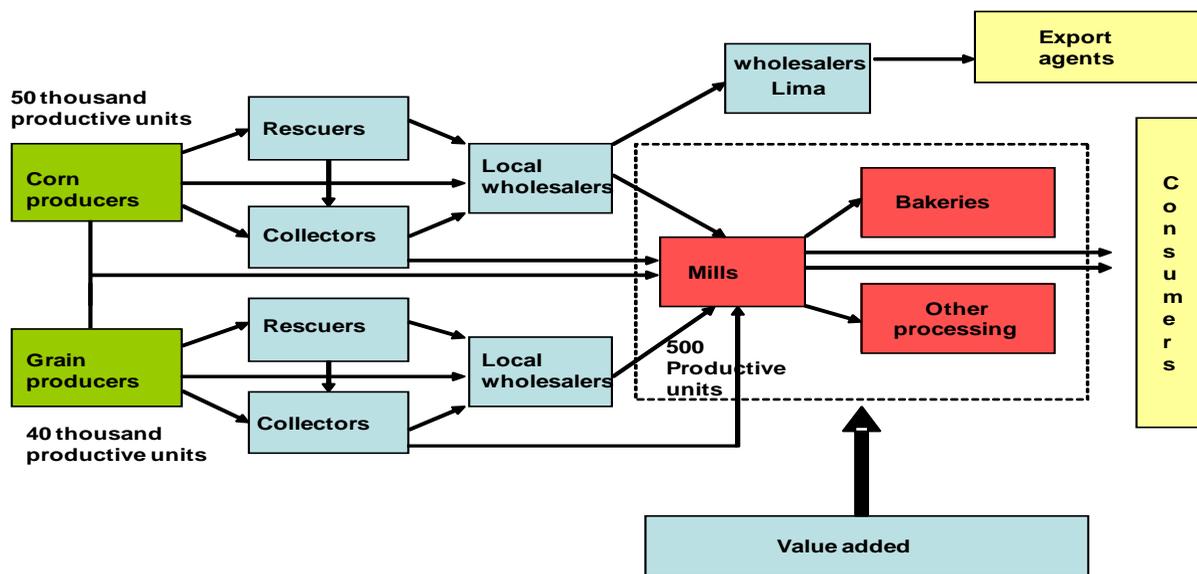


Productive chain based market opportunity analysis. The NGO teams used productive chain or sub-sector market analysis modeling techniques to systematically identify the main opportunities.¹⁹ These techniques, which are well known in Peru,²⁰ take a comprehensive view of the participants and analyze the sequence of value generating activities in the commercialization of products and services, from the initial production to the final consumer (Figure 9). The NGOs prepared analyses of the main sub-sectors in their target communities, identified the competitive opportunities to add value locally using electricity, and estimated the scope of the opportunities in terms of numbers of enterprises and incremental MWh/year.

¹⁹ See, Damien van der Heyden, “Guia Metodologica para Analisis de Cadenas Productivas”, RVALTER, SNV, Quito, 2006; on the nuanced differences of sub-sector and value chain analysis techniques, see, Alexandra O. Miehlsbradt and Mary McVay, Jim Tanburn Editor, "From BDS to Making Market Work for the Poor, the 2005 Reader", ILO International Training Center, 2005; an early description of subsector analysis for rural enterprise development is: James J. Boomgard, Stephen P. Davies, Steve Haggblade and Donald C. Mead, "Subsector Analysis: Its Nature, Conduct and Potential Contribution to Small Enterprise Development", MSU International Development Paper, 1986.

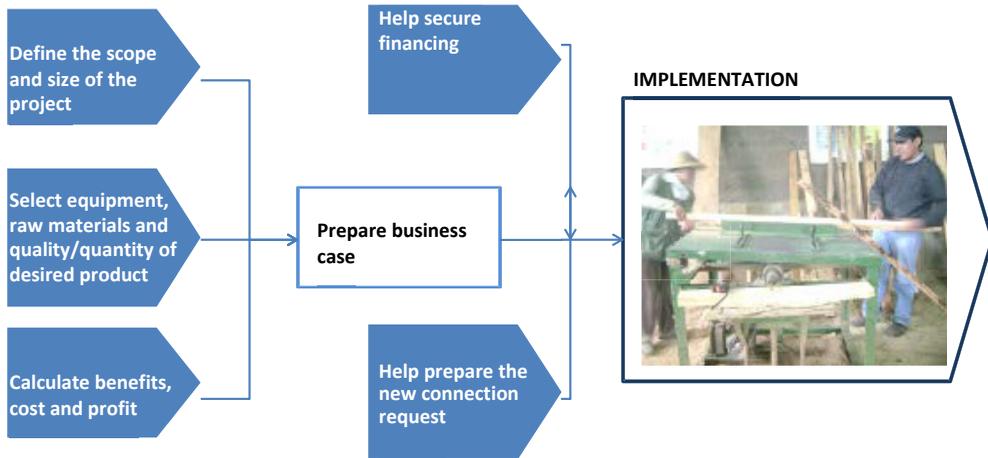
²⁰ For introduction to productive chain analysis in Peru, see <http://www.cadenasproductivas.org.pe/>. For 20 examples, see, <http://www.mincetur.gob.pe/comercio/otros/penx/productos.htm> For a Peru coffee productive chain análisis: Martha Huamán Garibay, “Diagnostico de la cadena de valor del Banano en el Valle del Chira, Piura, del Café de Satipa y Chanchamayo y del Olivo en la Provincia de Caraveli”, Catholic Relief Services, Lima, 2006.

Figure 9: Example of the Production Chain



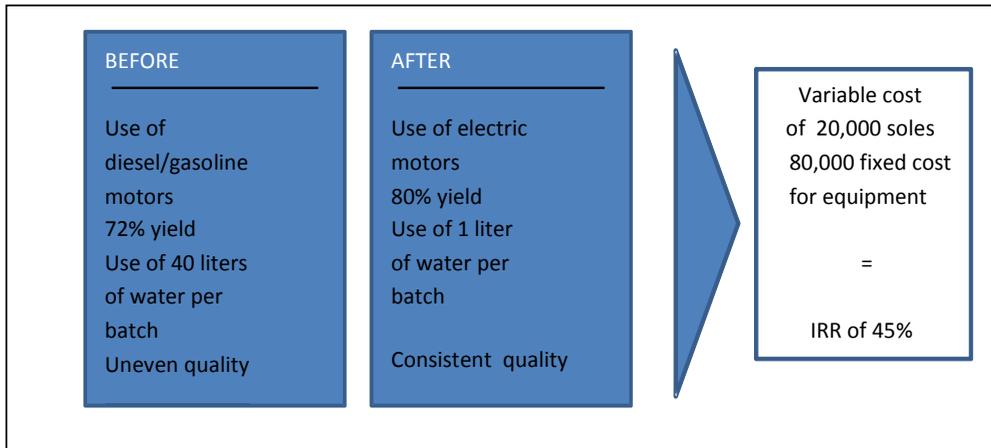
Preparation of business case profiles for analysis and promotion. Following their initial sub-sector analyses, the NGOs worked with representative enterprises in each sub-sector to prepare detailed business case profiles, including technology and market elements and cash flow and profitability projections. The sub-sector analyses and additional information were used to scope the requirement for assistance (Figure 10) and prepare the business cases for potential enterprise projects. The analyses and business case profiles were also shared with the communities in open presentations. The investment, operating costs and the revenue of the identified business, with and without electricity, were compared in these discussions with the communities and businesses. The meetings focused on discussing the main enterprise level decision factors like cost savings, additional income and the number of years to payback the investment costs.

Figure 10. BDS Assistance at the Enterprise level, Cusco (ITDG)



The business case profiles (Figure 11), which effectively define the benefits to the business of using additional electricity, were later used in the promotion campaigns.

Figure 11. Business Case to Adopt Electric Motors for Coffee Processing, Cusco (ITDG)



Targeting low risk agriculture-based businesses.

In the context of the mainly agricultural local economies, the NGOs assisted mainly agricultural based businesses to adopt productive uses of electricity. Common strategies of the NGOs were to enable the enterprises to use electricity to move some production from self-consumption to market, to add more value locally through additional processing and to enter new markets with new or improved products. The NGOs gave priority to opportunities with many potential beneficiaries and those with relatively low risk and a short payback period.

High priority sub-sectors were those for which the first round of projects that could be implemented by early adopters would have the potential to leverage follow-on adoption by a significant number of additional beneficiaries. For instance, in Cusco, most coffee producers de-husk the beans manually. ITDG provided technical advice and guidance, and secured the support of Electro Sur Este, to assist 53 early adopters to shift to 1 and 2 HP electric motors for removing the husks, saving time, lowering costs, increasing the yield and increasing quality, with a payback period of less than five months. (See Figure 12)

Figure 12. Coffee Processing, Sierra



Figure 13. NGO Working with Local Communities



Integrated, collaborative approach involving coordination with other actors, projects, sectors.

All three NGOs worked closely with other organizations in their assessment, promotional and assistance activities. The success of the relatively small NGO teams depended on active collaboration with multiple other actors, for example municipalities, for supporting the promotion and assisting with financing for equipment or investment in additional electricity infrastructure. In some cases, finance organizations gave credit support

for equipment purchases and local associations assisted with promotion activities. Most of the organizations targeted for coordination were identified during the productive chain analyses in the assessment phase. Other key collaborators in the promotion of productive uses of electricity, depending on the area, included INEI (Instituto Nacional de Investigación Agraria), SENATI (Servicio Nacional de Aprendizaje y Trabajo Industrial), ALIADOS (Programa de Apoyo a las Alianzas Productivas de la Sierra), AGRORURAL (Programa de Desarrollo Productivo Agrario Rural), CIED (Centro de Investigación y Educación), Programa de Compensaciones para la Competitividad, SENASA (Servicio Nacional de Sanidad Agraria), Ministry of Agriculture, as well as local universities and technical institutes.

The NGOs' collaborative working style, their favorable reputations built over decades of working with local communities, and the positive reputations of the team members themselves, built in meetings during the assessment phase with local leaders and community groups, appear to have been crucial in their being able to rapidly establish credibility as development partners (See Figure 14). This perception helped in gaining the commitments of local entrepreneurs and associations to undergo the transformations and make the investments that would increase their productive use of electricity. In several cases, the NGOs entered into written agreements with the communities to set out the responsibilities of both the communities and the NGOs.

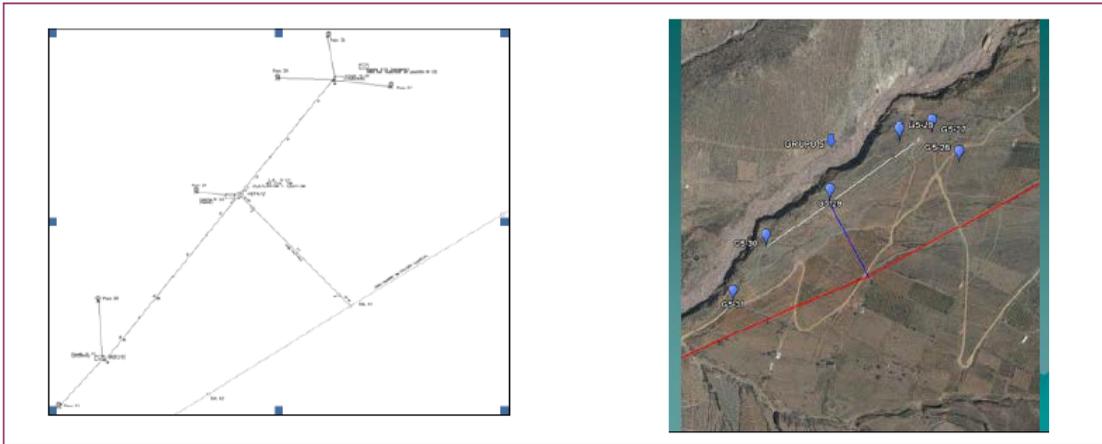
In all the communities, the participation of the district and regional municipal leaders was a vital element in leveraging support across many organizations and, in some cases, mobilizing financing.

BDS assistance provided to enterprises. With comprehensive productive chain analyses, business case profiles with projected cash flows for specific businesses, collaboration with sources of finance and technology, and links to specific markets, the NGOs were well equipped to provide practical assistance to the enterprises both individually and in group contexts. The NGOs assisted the small scale producers and cooperatives to define and assess the business opportunities available to them, to make estimates of their cash flow, to analyze the profitability of equipment and electricity infrastructure investments and to create links with buyers, equipment suppliers, sources of finance and training. The NGOs provided guidance on negotiating for, purchasing and installing electrical equipment. Finally, the NGOs provided training to assist the entrepreneurs to develop management skills and organizational arrangements to fit the higher operational level that often accompanied the adoption of electric equipment.

Coordination with distribution companies on necessary infrastructure. From the distribution company perspective, the NGOs marketed grid electricity by assisting the cooperatives and individual enterprises to prepare applications for new connections or increases in connected power and by providing guidance to the enterprises to ensure that the new equipment was compatible with the power supply. The NGOs also provided help to the enterprises in following up their applications with the distribution companies. Accomplishing these tasks involved often intense interactions between the distribution companies and the NGOs.

The NGOs played an important role in organizing electricity supply for the producers. They accessed electricity company data, lobbied with the electricity company to build additional electricity infrastructure (e.g., line extensions, transformers) or, if necessary, facilitated agreements on the technical requirements for infrastructure to be financed and procured by the businesses themselves, and helped in the scheduling of new business connections. In most cases, additional investments in poles, wires, transformers and other electricity infrastructure were required. Depending on the location, the costs of these infrastructure investments would be the responsibility of the business or the distribution company. Frequently, the NGOs' engineers prepared the technical designs and cost estimates for the line strengthening and extension investments (Figure 14), which were later essential to facilitate timely responses of the distribution companies to the enterprises' applications for new or upgraded connections.

Figure 14. Electricity Infrastructure Designs for Extending ADINELSA System (Desco)



Custom tailoring the BDS methods to fit different communities and each NGO's unique capacities and skills

While the main characteristics of the assistance methods of the three NGOs were similar, there were often striking differences in their operational styles and the details of their methods. The three NGOs took full advantage of the flexibility built into the contracts to customize their BDS approaches to fit the local circumstances, e.g., in the detailed designs of promotional and training materials and events, formats of community meetings, and types of collaboration with local officials, micro-finance organizations and equipment suppliers. They targeted different production subsectors based on the opportunities available and adapted their activities based on the characteristics of the enterprises and communities.

Equipment Financing. Desco decided early that ADINELSA did not have the resources to finance additional electricity distribution infrastructure in Lima Provinces. As a result, Desco spent little time on seeking ADINELSA support and focused intensively on mobilizing funding from other sources, mainly local governments, and focused on sub-sectors in which the investments in the infrastructure, as well as in the individual electrical equipment could be financed by these other sources and recouped in an acceptably short period by the businesses. In contrast, ITDG and Swisscontact spent considerable time in trying to mobilize the distribution companies to get support for infrastructure improvements.

Technology choices. Soluciones Practicas (ITDG) and Swisscontact centered their activities on identifying necessary equipment modifications, including designing and supervising the fabrication of modified models of equipment for coffee de-husking and drying at the individual and cooperative levels. The emphasis on technology improvement reflected the technical backgrounds of the Soluciones Practicas (ITDG) and Swisscontact team leaders and Soluciones Practicas (ITDG)'s long experience managing appropriate rural technologies.

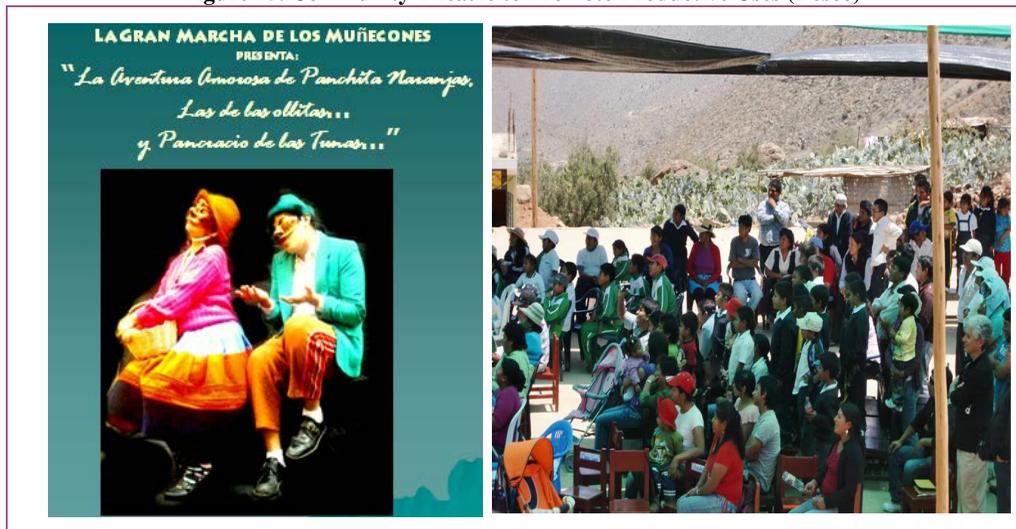
Intervention approach. All three NGOs worked extensively with groups, associations and cooperatives of producers. In the Soluciones Practicas (ITDG) and Swisscontact cases, the emphasis was on adding value through increased centralization and improvement of processing to

improve the quantity and quality of the agricultural products. Desco focused on modifying existing equipment and processes: for example, substituting underground diesel pumps with safer, lower cost electricity pumps operated from above ground pumping stations.

Identification of opportunities. After reviewing secondary information and having discussions with Electro Sur Este and other key institutions, Soluciones Practicas (ITDG) compiled a preliminary list of potential target communities who met the screening criteria in the contract: i) adequate electricity supply, ii) low load factor, iii) potential economic opportunities, and, iv) otherwise good business environment. It then systematically conducted structured interviews with 229 respondents in 39 of Cusco's 104 districts, while also networking with leaders, informants and others to identify high potential communities, sub-sectors and enterprises. Swisscontact and Desco, in contrast, placed more emphasis on extensive but less structured discussions and local networking as a method of gathering information and insights to identify the community and subsector opportunities.

Promotion activities. Soluciones Practicas (ITDG) organized an electrical equipment fair to bring together producers and electrical equipment suppliers, the distribution companies, finance organizations and the regional news media to raise awareness and to have the opportunity to rapidly fill in many data gaps for their sub-sector analyses. Desco, with more of a background in community mobilization activities, worked extensively with community groups, including participating in local level fairs and organizing community cultural events. For example, the NGO organized a theater play for children and parents, to promote electricity use for productive uses (Figure 15). Desco's activities also included the establishment of a partnership with an institution that coordinated a program to provide small computers to primary schools; an effort which indirectly enhanced the profile of the productive use program and increased the confidence in Desco as a development partner in the community.

Figure 15. Community Theatre to Promote Productive Uses (Desco)



Unexpected aspects of the implementation experience of the NGOs

The NGO teams in their own reviews highlighted a number of aspects of their implementation experience on the demand and supply sides that, in some instances unexpectedly, facilitated or complicated their promotion of productive uses. Positive and negative aspects of this kind included:

Finding opportunities was relatively easy. The latent opportunities for switching from manual or diesel-gasoline sources to grid electricity supply were quite substantial and, once catalyzed, were implemented rapidly by the enterprises, with the main constraint being the responsiveness of the distribution company in completing electricity infrastructure investments, or at least, approving the designs and connecting the facilities that were constructed by the producers to the network.

The leverage effect of first adopters is strong. Several of the targeted production chains, notably coffee and prickly pear production, have large numbers of primary producers. The successful experiences of the early adopters of electricity were found to have the potential to leverage significant numbers of additional enterprises to shift to electricity in the near term.

Financing was often accessible, with assistance from collaborating institutions. Financing was available from municipalities and other programs to support productive uses investments by cooperative, associations and groups that benefited multiple producers and groups. On the other hand, individual primary producers and micro and small enterprises in the communities generally did not have access to financial services for investments in electrical equipment or infrastructure. Given the availability of municipal and other programs to support financing for income generating investments, and considering the low access of individuals to financial services and widespread aversion to incurring debt, the NGOs targeted cooperatives and to a lesser extent individual enterprises with established access to finance.

Market constraints were not as great as expected. The capacity of the market to absorb increased production was not as severe a constraint as anticipated. The NGOs were successful in identifying strong urban markets and buyers for the products, reflecting a positive macroeconomic environment where the real per capita income in Peru grew 4.6 percent in 2009.

Technical skills of NGO teams added value. In several cases, the NGOs' engineering skills and innovative technology solutions added a great amount of value. The NGOs in Junin and Cusco identified necessary equipment modifications and designed the fabrication of new equipment. In Lima Provinces, the NGO prepared the analyses of multiple irrigation pumping contexts, while in all three regions, the NGOs prepared technical designs for electricity infrastructure.

Tariffs were not fully understood by producers. The availability of the lower cost, off-peak tariff (BT5A), was largely unknown in the rural communities at the outset of the pilot projects, and was apparently not advertized by the distribution companies. The existence of this tariff was critical in establishing the competitiveness of electricity for a number of businesses and it became necessary to market its benefits to the potential users.

Distribution company presence in local communities was limited. The companies have few staff in rural areas, since they outsource billing, collection and minor technical tasks to local subcontractors. As a result, producers interested in using electricity have little access to electricity

company staff for advice on technical possibilities. At the same time, the companies have limited access to information on existing or potential productive users, reducing the possibility to develop a marketing strategy to expand their services.

NGO coordination with the distribution company required effort. Given the situation noted above, practical coordination with the companies was time consuming for the NGOs. No commercial or marketing staff were available locally for either load promotion or for timely responses to requests for new connections.

Need for producers to finance electricity infrastructure. In many cases, the investment cost for the producer went beyond the costs of electrical equipment for production, to include the expenses for necessary additional electricity infrastructure, especially in the cases of Junin and Lima Provinces. This raised the financing required of producers and increased the level of assistance required from the NGOs to define technological options, as it was necessary to provide assistance to select and finance equipment and design and finance electrical infrastructure.

In some cases, one year NGO contracts did not allow sufficient time for follow up activities. The NGO teams uniformly were of the opinion that contracts longer than 11 to 12 months were necessary. A main issue was the time required to realize the investments in electrical infrastructure necessary. Much of the training, marketing support and other assistance for the enterprises could only be provided after the electrical infrastructure was installed and equipment was operating.

Section 4: Results to date and further activities planned

This section of the report will first review the results of the first three pilot activities carried out by the RE Project, then present a summary of the results obtained to date and a forecast of the results expected by the close of the RE Project in September 2012 as well as the long term perspective.

Case 1: Soluciones Practicas (ITDG) in the area of Electro Sur Este (ELSE) in Cusco

Soluciones Practicas (ITDG) was the first NGO to obtain a contract for promotion of productive uses. Under the leadership of Donald Tarnawiecki, the team was successful in creating a path for future activities. A good example of the results achieved by Soluciones Practicas in the Cusco region took place in the Maranura coffee pulping cooperative, in La Convencion province in Peru. Most individual coffee farmers in La Convencion belong to cooperatives to which they sell their coffee. There are also producers who sell their coffee to independent middlemen. These farmers are responsible for the pulping of coffee, which is done manually or by diesel motors. Soluciones Practicas proposed to add electric motors to existing manual pulping equipment, or replace the diesel motor with an electric one, resulting in significant cost reductions.

During harvest season, farmers suffer from a shortage of labor, which limits the amount of coffee that can be harvested and processed because considerable labor is needed for manual pulping. Harvesting activities are done in daylight, while the processing is done at night. With the introduction of electric motors for pulping, time is saved, allowing the harvesting of a higher percentage of coffee, at a lower cost, and improving the quality of the product.

Figure 16. Electric Equipment for Pulping Coffee

The electric motor was usually purchased through the cooperative, which deducted the cost of the motor from the revenues due to each producer at the end of the harvest. The cooperative used an existing credit line, which facilitated the change. Some farmers opted to buy the engines directly.

Specific activities carried out by Soluciones Practicas to enable the change from manual pulping or diesel motors to electric motors included:

- Preparation of detailed coffee productive chain analysis to identify possible opportunities and their scope.
- Preparation of business case profiles to demonstrate the profitability and other benefits of replacing the manual pulping or diesel motors by electrically powered pulping.
- Conducting several in-depth promotional and training workshops for groups of about 20 families.
- Identification and assistance with negotiations for purchase of appropriate equipment.



- With support from ELSE, the distribution company, installation of a demonstration electric motor for coffee pulping, to train people about its operation and safety. ELSE promotes the acquisition of converters at the point of electrical connection to the pulper motor.
- Soluciones Practicas assisted farmers in selecting individual motors, at an average price of about S /. 500, plus S /. 100 for installation, including masonry support for motor.

The assistance resulted in the installation of 53 motors for farmers of the Cooperative Maranura. Most of these engines were 1 HP; 6 of the farmers opted for 2 HP engines. Total investment by the cooperative was about US\$ 16,977 and annual projected electricity consumption is 34,200 kWh for the season.

Other activities carried out by Soluciones Practicas, based on the findings of their initial assessment, focused on the introduction of electricity equipment for grain milling, dairy production, agricultural processing, and bakeries. In total, 22 projects were initiated by the NGO in Cusco, of which eleven projects have been completed (completion includes the installation of production equipment, electrical connection and initiation of production, see Table 4).

Table 4. Results Soluciones Practica-ITDG/Electro Sur Este in Cusco

Name of Project	Number of Producers	KW	Kwh/yr	Investment US\$ (*)
1) Processing of grains in la C.C. Cucuchiray, Paruro	117	63	121,536	50,859
2) Casa Santuario Señor de Huanca, San Salvador	78	22	31,248	5,208
3) Water pumping, Cachiccata, Ollantaytambo	8	11	26,640	9,375
4) APVV Andahuaylillas (certified 30.09.09)	16	14	15,120	15,770
5) Electrification of manual coffee processing CAC Maranura	53	48	34,200	16,977
6) Expansion of agroindustrial plant CAC Maranura	346	34	63,648	41,771
7) Electrification of manual coffee processing CAC Aguilayoc	6	5	3,240	1,875
8) Processing of cheese and yoghurt, dairy plant Pomacanchi	120	22	47,520	51,563
9) Substitution of diesel by electricity in the plaster industry C.C. Sily	181	33	62,338	13,203
10) Installation of a bakery in Sicuani, Canchis	456	6	8,640	46,875
11) Grain processing in C.C. Chosecani	120	45	56,160	36,328
TOTAL	1,501	302	470,290	289,804

Case 2: Swisscontact in the area of Electrocentro in Junin

Swisscontact's activities with Electrocentro in Junin were aimed mainly at coffee processing, grain milling, carpenters and enterprises in the service industry. As shown in Table 5, Swisscontact's activities benefited 43 individual coffee producers, carpenters and service providers; 556 producers involved in coffee and grain mills in the highlands, and 1757 producers involved in cooperative coffee processing plants, the largest of which was Café Peru described below with more than 1500 producers.

Table 5. Results Swisscontact/Electrocentro in Junin

Business segment	N° Productive Units (Actual)	Annual electricity consumption Kw-hr.	Investment in equipment (S/.)
Individuals in the Jungle	43	191.789	111.350
Coffee producers	23	43.770	81.980
Carpenters	16	125.035	21.970
Services	4	22.984	7.400
Mills in the Highlands	556	33.750	75.000
Community of Ricrán	289	11.250	25000
Community of Sacas	172	11.250	25000
Community of Yuracmayo	95	11.250	25000
Coffee Processing Plants in the Jungle	1.757	845.420	3.688.443
Cooperativa Pichanaki	47	25.607	221.959
Walter Valenzuela	8	25.607	208.383
Leonidas Navarro	12	25.607	208.101
Café Perú (Pilado Pichanaki)	1.560	676.200	2.800.000
Mountain Coffee	130	92.400	250.000
Total	2.356	1.070.959	3.874.793

The Swisscontact team had a strong technology focus, and aimed at capturing opportunities for fuel switching and, in particular for coffee, adding value added through additional equipment for more processing. For small individual producers, for instance coffee growers and carpenters in the Amazon jungle and grain millers in the Sierra, the main opportunities for use of electricity in production came from switching from diesel to electric motors.

The largest success, in terms of producers assisted and future kWh sales, was assistance to Café Perú²¹ (Pilado Pichanaki). In Junin, the coffee producers in the central jungle have associated in cooperatives and producer associations for marketing, financing, coffee processing, agronomy and crop management. These groups provide member services including organic certification, guidance on improving productivity and quality of coffee and educational services to farmers and their families through Productive Technical Centers. The economic aim is capturing more of the value added for the producers. Farmers also receive social assistance, health insurance and retirement benefits.

The main organizations of producers in the Junin central jungle area are Coffee Cooperatives of Florida and Pangoa Tahuantinsuyo. Most coffee in this area comes from a cooperative consortium composed of fifteen organizations and associations which bring together 4,859 members. Café Perú involves those producing coffee in the immediate hinterland around Pichanaki, 1,560 producers in total.

²¹ <http://cafeperu.org.pe/cafe/>

The Swisscontact team assisted Café Perú to identify and execute a project for a new electric-powered coffee processing plant in Pichanaki, where coffee beans are to be dried in large capacity rotating machinery. The project aims to save costs of milling and freight transport, as the de-husking was formerly done in Lima. Coffee husks, accounting for 5 percent of the total weight, were transported first to Lima for processing and then back to Junin as fuel for drying of parchment. In addition to lower transport costs, the benefits of the local and centralized washing and drying with modern equipment are higher yields and higher quality as compared with more artisan manual or diesel motor based processing. The change in processing has made the coffee more competitive in the global market, benefiting the producers.

Swisscontact's team prepared the complete business case for the equipment, warehouse and ancillary investments and assisted in the financing and installation. The assistance included guiding the Café Perú leaders on best practices for designing and making contact with suppliers of the equipment and power supply. With the relatively large loads and no off-shelf-solutions available, the Swisscontact team designed modification to commercial electrical equipment that would meet the needs of Café Perú while also complying with regulations and Electrocentro requirements. The equipment has an electrical capacity of 155 kW, and the added processing will require 676 MWh per year.

The Swisscontact team also facilitated the request for electricity supply from Electrocentro, meeting the utility's requirements. Following Electrocentro's approval, Swisscontact advised Café Perú on the contracting of the construction of the medium voltage lines required to meet Electrocentro's existing lines, the purchase of a three-phase transformer and advised on commissioning and the interconnection to the Electrocentro system.

Figure 17. Electrical Equipment used in Pichinaki



Case 3: Desco in the area of ADINELSA in the Lima Provinces

While working in areas that are near the city of Lima, the areas targeted by Desco are among the poorest and most difficult areas to be targeted in the productive uses program. They are near desert areas with limited interventions by development NGOs. As in the other cases, Desco's activities depended on the coordinated participation of producers, suppliers, as well as the engineers and technicians of ADINELSA and the Desco team. Desco's activities depended on

the leaders of the communities and local government to raise awareness and mobilize interest in the opportunities that they identified to use electricity for productive uses. Additionally, as the main opportunities were in lowering the costs and increasing the volume and value added in prickly pear and cochineal production, the team worked in partnership with INIA and AGRO RURAL to tap into their expertise and linkages. Together, they prepared business plans for their products, coordinated participation of different actors - including the mobilization of producers, suppliers and community local government leaders, as well as the engineers and technicians of ADINELSA and Desco.

The electrification of six pumping stations of groundwater for the production of prickly pear and cochineal in Big Stone for 46 farmers organized by Desco was the model project to promote the productive use of electricity. Desco produced a study that allowed producers to make the decision on the investment in equipment and organized its execution.

Figure 18. Gasoline Pump in Huarochiri



Previously, to operate the diesel or gasoline pumps, the farmers descended into the well to turn the pumps on and off up to 6 times a day, with the risks of working at depth and in a confined space full of carbon monoxide. This resulted in fatal accidents, the most striking involving a family that in a single event lost five members, who tried to rescue those affected, one after another. These tragic losses and to a lesser degree the high costs of fuel led to a strong commitment by the community to take advantage of electric pumps with above ground switches.

Decisions concerning the acquisition or maintenance of equipment, as well as operation and maintenance of each well, are made by the associations of producers that own and operate the wells. Favorable prices of prickly pear and cochineal encouraged investment in the electrification of pumping equipment. However, since the wells were located at a considerable distance from ADINELSA's network, it was necessary to build distribution lines. The construction of the lines could not be assumed by ADINELSA due to financial constraints. Therefore the farmers had to provide funding and manpower for the purchase of equipment, the implementation of the pumping works at the wells, and also the construction of the distribution lines.

Another important project assisted by Desco was the installation of an electric furnace for production of ceramics by the Crafts Committee of Matara and support to the craftsman committees of Huallanchi and Llanac. It is important to note that the installation of the furnace was achieved with financial support from the Municipality of Huarochirí. The consultancy also included training of the women committee members and support for their participation in fairs. In addition, the NGO supported the participation of local producers in food fairs in Lima.

Desco promoted projects with producers of milk products in the Cajatambo and Gorgor districts. In this context, the Agricultural Producers Association of Los Molinos Gorgor invested their own resources to purchase a freezer, a semi-industrial vacuum-sealing machine and an industrial milk processor of 1,050 liters capacity. The business plan recommends also the purchase of additional machinery, that is beyond the economic possibilities of the producers but a commitment of support has been obtained from the City of Gorgor.

Desco also helped the Association of Agricultural Producers and Agroindustrial San Lorenzo de Putinza, Yauyos prepare a business plan to develop production and marketing of apple liqueur, apple cider vinegar and dried apple chips, building on the area's production of a variety of apples called Delight. Additionally, small productive projects were implemented with three carpenters and one bakery in Cajatambo. Finally, it supported the electrification of a school in the town of Paccho, Huaura.

The quantitative results achieved by Desco under the promotion activities were: (i) 314 MWh/year increase in consumption of electricity for productive uses compared to 231 MWh/year targeted, (ii) 865 productive units were helped in comparison to the 505 units targeted; and (iii) S/869.344 was invested in equipment and electrical installations compared with the originally planned S/428.524 local investment.

Summary of results to date

The results of the pilot activities confirmed that the benefits from implementing the promotion of productive uses are large and worth pursuing. During the implementation of the first three activities in Peru, more than 4,700 individual producers adopted electricity for productive uses in the sectors of agricultural processing, irrigation, dairy production, bakeries, metal processing, carpentry and textiles. A summary of the results for the pilot cases in Peru is presented in Table 6.

Table 6. Summary Results of First Three Productive Uses Pilot Activities

Distribution company	Electro Sur Este	Electrocentro	ADINELSA	Total
NGO	Soluciones Practicas	Swisscontact	Descos	-
Region / communities	Cusco	Junin	Lima provinces	-
Number of producers	1501	2356	865	4761
Electricity use (Mwh/yr)	470	1071	314	1863
Investment (000 US\$)	104	494	113	711

Beneficiaries by gender

The productive uses promotion activities and contracts did not specifically target women. The NGOs did not actively seek out women and the contracts did not require identification of beneficiaries by gender. However, since the contracts required the identification of beneficiaries by name, an analysis was made of the results that showed in fact that a significant proportion of the beneficiaries, 33 percent in total, were women (see Table 7).

Table 7. Summary of Producers that Benefited from the Productive Uses Activities, by Gender

	Number Female Producers	Number Male Producers	Number Total Producers	Percentage Female Producers	Percentage Male Producers
Agroindustrial	97	237	334	29.0	71.0
Education	118	110	228	51.8	48.2
Water pumping	43	354	397	10.8	89.2
Milk products	114	142	256	44.5	55.5
Coffee processing	288	1602	1890	15.1	84.9
Grain Milling	259	514	773	33.5	66.5
Bakery	429	11	440	97.5	2.5
Production plaster	92	89	181	50.8	49.2
Various individual	30	106	136	22.1	77.9
Ceramics	102	16	118	86.4	13.6
Total	1572	3190	4762	33.0	67.0

It is notable that women accounted for more than 10 percent of all beneficiaries in all categories of producers. The analysis showed that women accounted for a particularly significant share of producers in the following types of activities: bakeries 97.5 percent, ceramics 84.4 percent, educational facilities 51.8 percent, plaster production 50.8 percent, milk products 44.5 percent and grain milling 33.5 percent. On the other hand, women accounted for less than 20 percent of beneficiaries in water pumping 10.8 percent, coffee processing 15.1 percent and individual activities 22.1 percent.

The presence of women producers among the beneficiaries seemed to be a natural occurrence. None of the NGOs reported targeting women specifically. On the other hand, Soluciones Practicas, working in the highlands and with the most diverse and smaller groups of producers had the highest percentage of women producers, 58 percent, while Swisscontact, which targeted mainly

large coffee processing cooperatives had only 18 percent women producers, while Desco was intermediary at 28 percent.

Although the three NGOs all used valued chain analyses, their approaches were customized to fit their communities and were driven by the targets of numbers of direct participants and KWh sales.

The main factor that affected the degree of female participation seemed to be the types of activities targeted. The direct participants in the coffee processing activities comprise 40 percent of the total beneficiaries of the three programs, and 85 percent of these are recorded as male. Most of these participants are members of coffee cooperatives. While small scale coffee farming is a family endeavor, cooperative membership is predominantly male, as members are those in whose name the land title deeds are listed, which are mostly male.²² There have been long standing efforts in Peru to better understand and improve the participation of women in the coffee production value chains, including by the Junta Nacional de Cafe,²³ Peruvian and international development organizations and by organic and Fair Trade stakeholders.²⁴

Forecast of results to the completion of the program and beyond

An additional three productive uses promotion contracts were competitively awarded for Arequipa, Puno and San Martin/Loreto in August/September 2011 and are now in Phase 2 of implementation, in the concession areas of SEAL, Electro Puno and Electro Oriente. The Project also awarded Swisscontact a follow-up to complete the projects of eight cooperative coffee processing plants in Junin that were not connected by Electrocentro during the period of the first contract. A similar contract was awarded for a supplemental period of promotion by Soluciones Practicas in the concession area of ELSE. These follow-up contracts include a stronger emphasis on the NGOs sharing the learning that is being generated with other NGOs, MEM, the distribution companies and the regulator, and in verifying and documenting the results.

These new contracts improve on the BDS model used in the pilot projects, with several modifications in the tasks of the NGOs, the contributions of the distribution companies and the supervision by the Project:

- There is a sharper focus on the efficiency of the interventions; the performance targets for kWh sales that are to be agreed between MEM and the NGO, with the concurrence of the distribution company, are to represent incremental revenues that yield a minimum 12 percent return on the costs of the NGO contracts.
- There is a greater emphasis on knowledge sharing through consultations or workshops with other NGOs, distribution companies, the regulator, and MEM;
- Data will be collected on the costs of equipment and electricity infrastructure investments.

A further group of five contracts was signed in December 2011, including contracts in Piura y Tumbes, Lambayque/Cajamarca Norte, La Libertad/Cajamarca Sur, Ancash and Ucayali. Finally, a follow-up contract was signed with Desco in Lima Provinces in early January 2012. Table 8 shows an estimate of the expected results of the entire pilot program by the close of the RE Project in September 2012, as compared with the targets established in 2005 during RE

²² <http://womensenews.org/story/entrepreneurship/060205/female-coffee-growers-find-new-freedoms-in-peru>

²³ <http://www.juntadelcafe.org.pe/?r=conamucc>

²⁴ <http://www.uwlax.edu/urc/JUR-online/PDF/2008/hoesly.pdf>; <http://www.acdivoca.org/site/ID/Peru-Coffee-Value-Chain-Productivity-and-Production/>

preparation. With the exception of electricity consumption, these initial targets will have been exceeded. Meanwhile, the performance targets set after the detailed market assessments of potential opportunities during the first phase of the NGO contracts for the first three pilots, were in each case exceeded.

Table 8: Summary Table of Expected Results Productive Uses Pilot Program

	Nº of Projects	Prod. Units	Increase MWh/yr	Investment (000 US\$)
Projects completed	3	4,761	1,864	0.711
Projects in implementation since mid 2011	5	8,241	4.041	0.956
Projects in implementation since 2012	6	6,818	1.865	0.686
Total Results Productive Uses Activities	14	19,820	7.769	2.353
Original Program Targets		9,000	18.000	1.810
% achievement of target		220%	43%	130%

Finally, agreements will be reached with the nine utilities involved in the pilots²⁵ to monitor and document the sales of electricity (kWh) to the assisted producers for the year following the conclusion of the NGO contracts under the Rural Electrification Project in September 2012.

A Second Rural Electrification (RE2) Project in Peru has been under implementation by MEM since July 2011, with assistance from the World Bank. The RE2 Project will continue the promotion of productive uses of electricity, which is now mentioned as a key overall objective of rural electrification in MEM's National Rural Electrification Plan. The new Government also has adopted the theme of productive uses of electricity as part of its social inclusion agenda, as mentioned in the speech of the Premier to Congress in August 2011.. The broad strategies for promoting productive uses under the RE2 Project in Peru are to continue the approach taken in the RE Project with increased attention to the cost effectiveness of the BDS marketing and assistance; ensuring the sustainability and replicability of the results; and increasing the sharing of best practices across the distribution companies and NGOs to raise overall performance level.

²⁵ Electrocentro, Adinelsa, ELSE, SEAL, Electropuno, ENOSA, ENSA, Hidrandina, Electro Ucayali

Section 5: Lessons learned so far

The implementation experiences and results of the three pilots provide insights into the opportunities and practical barriers to increasing productive uses of electricity in remote rural communities in Peru. Recommendations are made based on these lessons.

Lessons learned

Contracting development NGOs for promotion was effective and efficient. Contracting development NGOs for promotional activities worked efficiently in the Peru pilots. The professional motivation and internal incentive structures of the three NGOs, as well as their established ways of working in rural communities, were well suited to assisting the communities and enterprises. It is expected that the three NGOs will continue helping rural communities and enterprises to address information, finance, technology, market and organizational constraints in rural electrification initiatives as part of their ongoing development activities.

The structure of the NGO contracts was one key to success. Important elements of the NGO contracts included:

- The Project's performance based contracts were effective in providing the NGOs with incentives to achieve and document results. The performance payment risk was not a disincentive to NGO participation. On the contrary, the internal operating methods of the NGOs appear to have reinforced the incentive effect.
- Clarity and practicability of the measures of success (enterprises assisted, kWh increases) and verification methods were important in these performance target-based contracts.
- The two phase structure of the contracts, with a decision point to go forward after the first phase, was effective in focusing the efforts on specific, reasonable targets. However, the pause between the two phases, which was introduced for the second and third pilots, should be short to maintain the momentum established during the assessment phase, and to avoid losing staff, in particular the rural promoters, who have the most direct contact with the enterprises and communities.
- The relatively short contracts (12 months in the first three activities) provided incentives to all participants to move quickly. They also were a signal to the distribution company staff and the field staff of other development programs that the NGOs were not competing or usurping their roles, and thus facilitated collaboration. The NGOs, accustomed to longer periods for implementation, considered the 12 month period to be too short given the poor resource circumstances of the communities and enterprises. In this regard, the inclusion of a third phase for follow on assistance is being considered for future contracts to permit a longer implementation and a period for the tracking and evaluation of results.
- The even shorter duration of nine months for the last six contracts was mandated by the closing date of the projects, with the results still to be seen.

Business Development Services (BDS) methods were effective. The BDS assistance and marketing methods were successful in increasing productive uses of electricity. The BDS techniques, as customized by each of the three NGOs, were well suited to the communities and businesses.

The productive chain analyses, a core element in the BDS methods, implemented from a bottom up perspective, with rapid rural appraisal techniques and collaboration with local governments and other organizations, were effective in identifying and realizing viable business opportunities. The types of opportunities identified typically were based on investments in electrical equipment like standard electric pumps for irrigation or adaptations of existing machinery for coffee processing. The availability of this relatively low hanging fruit reflected the previous lack of attention of the distribution companies and rural electrification planners to productive uses potential. Without the BDS marketing and assistance, many of these untapped opportunities likely would not have been realized in the near term.

Access to credit for productive uses was not as limiting as expected. The access of the micro and small businesses to credit, as well as the reluctance of many of the enterprises to incur debt, was a constraint that was not resolved fully during the pilots. However, this situation did not prove to be limiting as it was possible to raise funding for cooperative and group ventures through local government or other programs. In some cases, it was possible for individual businesses to arrange financing through their cooperatives or directly with finance providers.

Supply side constraints were encountered and not fully addressed. The supply side constraints were more extensive than those identified in the pre-project assessments or anticipated in the design of the component. The experience with the three pilots highlighted aspects of the electricity sector in Peru that limit the adoption of productive uses:

- a. *Design criteria for rural electrical systems optimize access and do not prioritize productive uses.* The layout of rural distribution networks and system designs are optimized based on least cost for household connections, seeking to maximize the numbers of households per kilometer line, with minor deviations to incorporate large or small anchor customers. A result is the need for three phase converters for productive use applications that require three phase supply. While OSINERGMIN permits the electricity companies to purchase such converters and include them in costs for the tariff calculation, distribution companies perceive difficulties in management of productive uses on SWER lines.

Investment costs of additional infrastructure must be paid by new productive users. Under Peru's concession system, the costs of electricity infrastructure line extension and strengthening to service customers beyond 100 meters of the existing lines are borne by the customers.

- b. *Distribution companies' strategies do not include productive uses* There is much goodwill among distribution company staff, a sense of corporate social responsibility, interest in promoting productive uses, a general recognition that distribution companies benefit from the higher demand and the increased income that result from successful

productive use marketing. However, there is no clear strategy within the distribution companies to increase sales to rural productive uses.

- c. *Distribution companies' business models include no incentives to increase productive uses.* The "efficient enterprise" model used by the regulator does not incorporate costs of rural marketing of electricity in the calculation of the full cost recovery tariff. As regulated firms seeking to avoid unrecoverable costs, the companies do not do rural marketing other than the administrative processing of requests received for new connections. Moreover, there is no promotion to enterprises of the cost advantages of the off-peak tariff (BT5A).
- d. *Outsourcing of commercial contacts with customers reduces distribution companies' sensitivity to rural markets.* To reduce and control costs, the distribution companies outsource to local SMEs the commercial and some technical tasks in rural communities, including meter reading, bills distribution, collections, some disconnections, minor line maintenance and repairs. The SMEs are not tasked to market to existing or potential productive users. The outsourcing model isolates distribution company staff from their rural markets, leaving key staff without direct contacts with the communities. At times, this has contributed to wrong information being provided to customers about the locations of the lines, system capacities and connection costs, contributing in turn to unfortunate decisions (e.g., enterprises purchasing three phase motors where such supply is not available). In the absence of promotion activities such as those of the RE Project, this lean business model of Peru's distribution companies provides no incentives for staff or the third party agents to seek new productive customers, other than in "corporate social responsibility" activities.
- e. *Quality of service issues.* There are also few incentives to improve the quality of service (outages, voltage fluctuation) in deep rural areas with low demand. Low service quality, or at least the perception of low service quality, limits the competitiveness of grid supply for rural businesses. Marketing productive uses in contexts of poor quality service is pointless unless the service quality can be raised.

Recommendations for Peru's productive uses program based on pilot experiences using BDS

Specific measures to improve the efficiency of the productive uses promotion efforts in Peru in future include:

- *Seasonal timing.* The start up of the productive uses promotion activities needs to take into account the seasonal nature of the main productive activities in the communities.
- *Prepare the ground.* Given the importance of local governments, cooperatives and associations in the productive sectors in Peru's rural areas, MEM and the distribution companies should approach them to generate interest and jumpstart the promotion process, in advance of the activities to be developed by the NGOs.

- *Improve pre-project data.* Improved data on the communities, e.g., electrification ratios, date of electrification, load profiles, is needed in advance of on-the-ground implementation to facilitate operational planning and, later, to provide baselines for later analyses of performance. MEM should identify and compile data on comparable communities that have not received productive uses promotions to facilitate analysis of the causality of the results found in the communities with the promotions.
- *Standardize reporting, improve monitoring and cost benefit analyses* Documentation and results verification requirements need to be streamlined and more clearly specified in order to strengthen the monitoring and the comparison of results data. Better data will assist to address questions of causality and economic viability, and whether results (such as increased kWh sales) can be attributed to a specific measure like promotional pricing, BDS services, or credit assistance. The data will also need to be expanded to include, for instance, estimates of jobs created, additional work hours and profits, and on the company side additional data will need to be analyzed on the costs of supply, to enable a fuller economic evaluation of the costs and benefits of the promotion activities. At present, only the costs of the NGO contracts and the increased revenues generated by the projected additional kWh sales are used to determine whether the promotions meet the hurdle rate used by MEF for public investments. While this is a useful proxy, an analysis based on more data and more thorough vetting of some of the data methods (e.g., for the projections of future kWh sales) is warranted.
- *Establish new communication channels.* Locally based mass communication and indirect marketing techniques can be used more intensively to attract businesses into making their first contact with the program.
- *Share best techniques and materials across companies and communities.* Standardized marketing materials and advisory instruments, developed by the NGOs with the different utilities, should be used across companies and communities as much as possible. These would include brochures, leaflets, advertisements, posters, training videos, comparative cash flow analyses, studies and equipment demonstrations. These would also include promotional information on the off-peak tariff. The productive chain analyses, which are time consuming to prepare but essential for opportunity identification, should also be shared. Under the initial three pilots of the RE Project 1, all materials and instruments were developed by each NGO and used exclusively in the communities it was assisting. In the following contracts, each NGO was provided with the reports and other materials available from completed contracts.
- *Better networking to lower costs, improve performance.* Networking and information sharing among the NGOs and distribution companies should be facilitated by MEM. The training of NGO field staff, with distribution company staff participating, should include information on past experiences and the identification of methods that appear to be most viable.
- *Enhance sustainability.* To improve the sustainability of results, a third implementation phase for follow up support in the consulting contracts with the NGOs may be warranted. Many of the participating enterprises are expected to need some mentoring, training or other support during the initial period following the adoption of electricity.

- *Strengthen supervision* The capacities of the MEM unit supervising the productive uses contracts with the NGOs to generate and pass on operating lessons and insights need to be strengthened.

An increased focus on supply side constraints should be considered in developing further productive uses projects. The following are recommended supply side initiatives to improve effectiveness:

- *Increase responsiveness of distribution companies to rural productive customers.* The distribution company retains a key role in the success or frustration of marketing to productive users, even when the frontline marketing is outsourced to NGOs. This requires more than the requirement for the company to deliver an electricity supply of satisfactory quality. The standard MEM - distribution company agreement should directly address the issue of companies responding more quickly to requests for productive connections or increases in power, perhaps by setting maximum response times. The agreement should highlight and strengthen the role of the companies' third party agents, who handle the utility's commercial and basic technical services in the communities in which the promotions are conducted. The agents are typically the utility's only point of contact with rural customer, and are a potentially valuable source of information and guidance on adopting electricity for productive uses. The agreements should be modified to strengthen the role of the distribution company in providing the NGOs access to their data and guidance on system layouts, capacities and locations where service quality will not be adequate for productive users.
- *Appoint a focal point within the distribution company for increasing productive uses and tracking and verifying results.* The solid commitment of the distribution company to fulfill its role should be a condition for promoting productive uses in a company's concession area. This will include: i) appointment of a distribution company official responsible for the promotions who will serve as the operational contact with the NGOs; and, ii) setting and tracking corporate targets for productive uses, including the numbers of productive users and the level of kWh sales for productive uses.
- *Strengthen capacities of distribution companies to support marketing of productive uses.* The distribution companies have limited experience in rural load promotion. The companies should be assisted to develop the capacities to better support the marketing of productive uses, including improved systems for data collection, tracking of productive uses targets and improved staff capacities to support NGO contracts for promotion of productive uses.
- *Systems design.* Adjustments to the basic regulatory guidance in Peru to use single phase SWER systems are unlikely to be considered in the short and medium term. However, options for criteria and mechanisms for guiding layouts, system designs, operational procedures and financing arrangements should be studied with a view to identifying modifications that would encourage the cost effective inclusion of higher numbers of potential productive users. The design aspects to be considered would include more extended use of three phase supply where there is the potential for sufficient productive users.

Section 6:

Conclusions for inclusion of productive uses promotion in rural electrification efforts

Rural electrification programs can be more effective in contributing to economic growth and social development when the promotion of productive uses of electricity is included. These promotion activities, in rural electrification projects, can facilitate the communities' access to the full benefits of electricity. As we have reviewed in this report, in addition to immediate benefits of electricity like lighting or access to media and news, the adoption of electrical equipment by producers can help to achieve higher incomes in rural businesses and communities thus contributing to the overall well-being improvement.

Unfortunately, many rural electrification programs focus on access objectives looking only to connect the maximum number of users at the lowest cost per connection. The overall result is often that the level of productive uses is low and the electrification contributes less to rural development than it could.

The implementation of the pilot program shows that there are important supply and demand side challenges to the adoption of electricity for productive uses. The demand side challenges have been discussed above and were largely successfully addressed through the contracts with NGOs to promote productive uses of electricity through provision of targeted business development services.

The productive uses promotional activities carried out encountered problems on the supply side that were not fully addressed. Generally in Peru, from the supply side there are two main limiting factors to the adoption of electricity for productive users: a) a strategy for rural electrification that fails to target productive businesses; and, b) a model of distribution company operations that results in minimal presence in rural areas and little marketing or efforts to serve potential productive users of electricity in rural areas.

A fundamental supply side challenge in Peru is that the criteria for the financing of rural electrification focus on achieving the highest ratio of electricity household coverage at the least cost. Each subproject must be approved by the National System for Public Investment. This system provides subsidies for each project considering capital costs of electricity service to households and public facilities but not for private productive users. Single wire earth return systems are required unless there is sufficient demand to justify higher quality service. As standard practice, the main measures for monitoring performance, as well as for cross country comparisons, are the household electrification ratio and the cost per household connection. Until the definition of successful access to electricity is expanded to include productive users as well as quality of service, promotion of productive uses will continue to require special efforts in Peru.

Additionally, the electricity distribution company model of operations places little emphasis on providing service to productive users in rural areas. Since the electricity distribution company outsources commercial operating activities to third parties in rural areas, the presence of company staff with direct contact with rural customers is minimal. This in turn makes it difficult

for the companies to assess the potential productive uses or to appreciate the requirements or methods for tapping into this market.

The access strategy and the distribution company model of rural electricity service need to be improved to include producers. Rural electrification programs would have stronger impact on increasing economic activity and development of rural areas if their objectives included providing access and reliable service not only to households but also to producers. Moreover, mainstreaming rural marketing and assistance services within a distribution company can help to identify potential users. Outsourcing these tasks to development NGOs that already have the capacities and mission to stimulate income generating activities will for the foreseeable future remain a cost-effective, viable practice that fits the established business methods of the distribution companies.

This would create a virtuous cycle-- productive uses of electricity benefit both the community and also the distribution company. In addition to improving productivity of local producers, the use of electricity for production benefits the electricity distribution companies by increasing revenues. Underutilized electricity infrastructure can be utilized to supply rural business, improving its financial sustainability.

For promotion of productive uses to be effective, the distribution companies are key. During implementation of the pilot it became clear that the success of each rural business initiative for productive uses was closely related to the capabilities and responsiveness of the distribution company. Positive results of the promotion efforts are linked to the proactivity of the electricity distribution company in the selection of communities, in providing information to and collaborating with the NGO teams, in assisting in the design and costing of additional infrastructure, in sharing the costs of the additional infrastructure, and in responding to new connection requests.

In addition to the supply side challenges, demand side issues also limit the use of electricity for productive uses. The use of electricity for production in rural communities does not often materialize on its own. Some of the main challenges identified during the preparation and implementation of three pilot projects were the lack of available information on market opportunities, access to financing, and the limited technical or operational capacities of potential rural entrepreneurs.

Promotion, marketing and sharing knowledge are key to overcoming these barriers. The design of a promotion of electricity for productive uses program must include the answer to basic questions like: who does the promotion? where to do the promotion?, and how to do the promotion?. The answers to these questions have to be adequate to the reality of each country (considering factors like geography, diversity and presence of institutions, local and regional government involvement, type of economic activities, size of the market, design of the electricity sector, etc). The implementation of the three pilot activities showed that NGOs, Business Development Service (BDS) methods and incentivized contracts were part of an efficient design of the promotion activities.

Local NGOs were effective. The development NGOs were effective in promoting productive uses of electricity, in partnership with the distribution companies. Their links with the communities,

field experience and professional motivation towards social development in rural communities helped to achieve better and quicker results than expected. In the communities across the Sierra, Costa and Amazon regions in which the pilots were implemented, community, cooperative and local government leaders were important entry points for the assessment and promotion activities of the NGO teams. With the leaders on board, efforts to motivate technology changes could move forward fairly rapidly, especially when early adopters and cooperatives were involved.

Business Development Service methods helped achieve the promotion goals. One of the main lessons drawn from the experience in Peru is the effectiveness of Business Development Service (BDS) approaches, particularly when used by NGOs that have strong skills and development missions. In applying these methods, the NGOs followed strategies that included: (a) market assessments, to identify opportunities by market sectors, subsectors and specific enterprises; (b) preparation of business cases, to analyze the viability and attractiveness of adopting electrical equipment; (c) marketing the profitable opportunities to the community and potential entrepreneurs; (d) coordination with other institutions to facilitate access to technical assistance and/or financing; and (e) strengthening links between customers and the electricity distribution company to facilitate connections and, when necessary, investments in additional infrastructure.

Phased, time limited contracts were efficient. The use of a short term, two phased contract with a decision step to go forward between the phases and a performance based final payment proved to be a good strategy to incentivize the NGOs and maximize results.

Promotion activities can help to overcome both supply and demand side barriers. The pilot projects found significant numbers of untapped opportunities for using electricity that required only small technological changes and modest investments. Successful channels for financing were mainly municipal and local government institutions, cooperatives or existing social programs that had financial resources available and missions compatible with objectives of the pilots to increase income generating activities in the communities. Cooperatives, in particular, were effective in providing access to credit.

Promotion of productive uses of electricity is worthwhile pursuing. The three pilot activities exceeded expectations in assisting family production units to adopt electrical equipment. The pilots will be followed by eleven additional similar initiatives to be implemented in different communities. The new projects, taking advantage of the lessons from the pilots, aim at more efficiently addressing both demand and supply barriers to the adoption of productive uses of electricity.

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ANNEX 1

Detail of Peru's Electricity Sector and Rural Electrification Program

Background

Peru is favored by abundant indigenous sources of energy, mainly hydroelectricity and natural gas. The power sector in Peru was reformed and restructured between 1991 and 1993, followed by a privatization and concession process. As result, a modern legal and regulatory framework was established in the Electricity Concessions Law (ECL) of 1992/93.²⁶ Ownership of major sector assets was transferred from public to private hands, together with the management and operation of the main electricity facilities. The legal framework also stipulated the methodology for tariff setting, the granting of concessions, customer service guidelines and accountability of the operators, plus changing the role of the State from owner and operator to policy maker, rule maker and regulator. In July 2006, Congress passed Law N°28832 to “Ensure the Efficient Development of Electricity Generation.” This new law introduced important changes, mainly to generation and transmission regulation, the administration and functioning of the electricity market and the determination of electricity prices.

Although electricity service in urban areas is satisfactory and the industry in general operates quite well in Peru, the situation is different in rural areas. At the end of 2010, about seven million people, mainly in the predominantly poor rural and marginal urban areas of Peru, did not have access to electricity. At 55 percent coverage in rural areas at end 2010, Peru's rural electrification rate is one of the lowest in Latin America.

Sector Organization

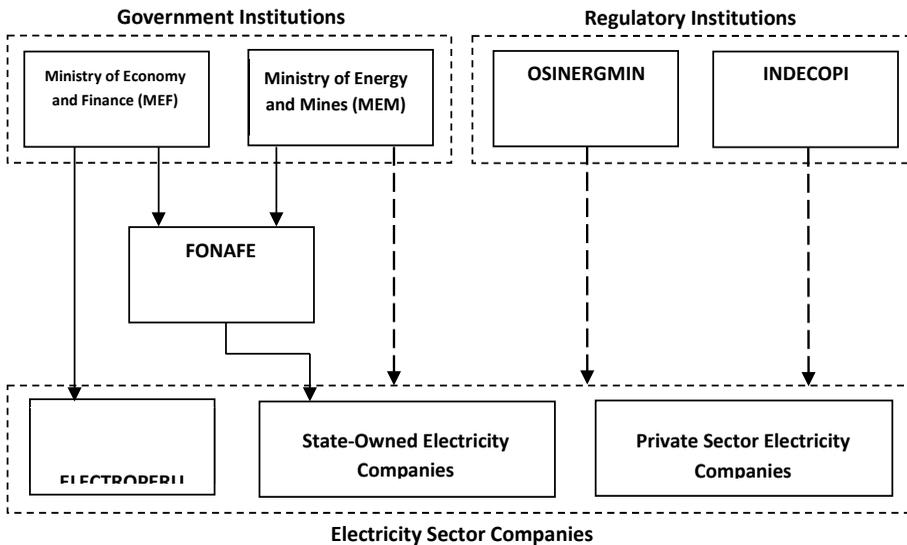
The Ministry of Energy and Mines (MEM) is the main sector institution, in charge of policy setting, sector general planning, legislation and regulations, and rural electrification. FONAFE²⁷ is the public holding company that manages all public-owned enterprises. MEM is also a member of FONAFE's board of directors, together with the Ministry of Economy and Finance (MEF), and other production sectors' ministries. The main regulatory body in the sector is the Organismo Supervisor de la Inversión en Energía y Minería or OSINERGMIN (see Figure A.1).

Within MEM, energy is the responsibility of the Vice Ministry of Energy and three General Directorates: (i) Electricity (DGE), for planning, general regulations, norms and codes, concessions and authorizations for electricity generation, transmission and distribution; (ii) Rural Electrification (DGER), for planning and implementation of rural electrification projects and the promotion of small renewable sources of energy and productive uses of electricity in rural areas; and (iii) Hydrocarbons (DGH), for petroleum and natural gas activities.

²⁶ The Electricity Concessions Law (ECL) and its regulations; Law N°25844 and Supreme Decree (DS) N°009-93-EM.

²⁷ “Fondo Nacional de Financiamiento de la Actividad Empresarial del Estado”, the National Fund for Financing State Enterprise Activities

Figure A.1: Electricity Sector Institutional Framework



The total installed generating capacity was close to 8,000 MW in 2010. System generation capacity for public service was about 6,715 MW; the remainder was self-generation. Of the capacity for public service, 5,850 MW (about 87 percent) is connected to the national grid, the remainder is in isolated systems. Maximum demand in 2010 was 4580 MW and production was 35,790 GWh, 56 percent of which was hydroelectricity.

The private sector owns 78 percent of the generation supplying the national grid (some 4,585 MW). EDEGEL (of the ENDESA Spain and ENEL Italian groups) with 1,474 MW, is the largest private generation company, and ENERSUR (of the Suez Energy group) the second largest, with 1,030 MW. In the public sector, Electroperu with 990 MW is the largest generating company and Empresa de Generación de Arequipa (EGASA), the second largest with 324 MW.

The private sector also owns most of the high voltage transmission system, with the public sector owning only some sub-transmission lines to supply remote areas. There are seven private transmission companies operating in Perú. Red de Energía del Perú, Consorcio Transmantaro and ISA Perú (all three are part of the Interconexión Eléctrica, ISA, group of Colombia) own about 5,300 km of 220 and 138 kV transmission lines, which represent close to 80% of the high voltage transmission system, not directly part of generation or distribution companies.

The electricity sector has roughly 4.88 million customers, of which 2.06 million are served by private companies, and the remaining 2.82 million are served by regional public distribution companies. The two largest private distributors are Luz del Sur and Edelnor, which serve Lima, with 1.89 million customers in 2009. These companies have a concentrated and profitable market, with good technical and financial indicators. There are a few other private-owned distribution companies, of which the largest are Electro Sur Medio, serving mainly the Department of Ica, with about 166,000 customers, and Empresa de Distribución de Cañete with about 30,000 customers.

Distriluz,²⁸ comprising four regional companies (Electrocentro, Electro Noroeste, Hidrandina and Electro Norte), is the largest public company, serving seven departments with medium-sized cities (with about 1.63 million customers, some 6.7 million people). Distriluz's market is not highly profitable but has a return sufficient to sustain the business and make profits. Two other distribution companies, serving Arequipa (Sociedad Electrica del Sur Oeste, with about 292,000 customers) and Cusco (Electro Sur Este, with 306,000 customers), have similar characteristics.

The remaining public distribution companies serve medium-sized and small cities and towns with low load concentration, and rural areas with disperse communities and low demand. The three largest of these companies are Electro Oriente in Iquitos, with about 172,000 customers, Electro Puno, in Puno, with about 175,000 customers and Electro Sur, in Tacna, with about 119,000 customers. About 126,000 customers are served by eight other distribution companies. Most of these small companies are not profitable; some barely covering operating costs, others have operational deficits.

One other state-owned company acts in the sector- ADINELSA. This company serves as a government electricity assets holding company that operates small isolated distribution systems that were left over during privatization or created by rural electrification projects, through third party contracts, mainly with local governments (municipalities).²⁹

Electricity Prices and the Tariff System

The electricity regulatory system is based on several principles: (i) the electricity business is segmented into generation, transmission and distribution; (ii) generation is competitive, with prices that are determined mainly by "free" negotiated transactions and the results of supply auctions; (iii) transmission and distribution/commercialization are regulated businesses; and (iv) prices to the regulated market are determined by cost-causation and/or benefit-causation.

The LCE established two different kinds of electricity users, small retail users under regulated prices (regulated users), and large users with demands above 1,000 kW ("free" users), that could contract their electricity service directly to generators or distributors under bilateral contracts at negotiated generation prices. Another important characteristic of the tariff scheme is that supply charges and payments to/from final users and between wholesale market participants are based on a two-part tariff system of capacity and energy charges.

The tariff for a typical regulated residential final user consists of: the generation tariff, GT (the busbar price) + the transmission tariff, TT + the distribution tariff, VAD (VADM + VADL, the distribution added value for MV and LV networks.)

Generation Tariff. The generation tariff for small users is regulated. Distribution companies pay for generation sold to the regulated market at the regulated generation energy tariff. This tariff is determined by OSINERGMIN every year, according to the expected evolution of demand and

²⁸ Distriluz was privatized in 1998, only to be returned to public hands in August 2001, after the private operator failed to comply with its contractual obligations with the State.

²⁹ ADINELSA ("*Company for the Administration of Electrical Infrastructure*") owns and operates small systems in rural areas serving some 140 thousand electricity users. It runs annual deficits in the order of US\$4 million.

generation supply capacity, fuel prices, competitive generation auction prices and other economic parameters (like price indexes and inflation).³⁰ Real-time dispatch of generation supply is carried out by COES, following a cost-based merit order procedure, independently of any bilateral contracts or the results of generation auctions. COES also manages the wholesale market, establishing payment obligations between generators, large users and distribution companies, in accordance with individual balance of energy dispatch.

There is also a capacity payment that is based on the annualized investment and O&M costs of a peak-load generation unit, of “adequate capacity in relation to the size of the system and the reserve requirements.” The regulator determines the main characteristics of this unit each year, for application in the periodic review of generation tariffs. The present reference peaking unit is a 175.6 MW open-cycle natural gas-fueled unit.³¹ The capacity payment is expressed in US\$ per kW-month, and its value for 2009 was US\$5.8 per kW-month. This value could be converted to an (approximate) equivalent in US\$ per kWh, adding about 1.15 cents of US\$ per kWh to the generation energy price, to obtain the total generation price.

Distribution Tariffs. The distribution system, consisting mainly of medium voltage (MV) distribution lines/feeders and low voltage (LV) distribution circuits, is regulated under a cost-based efficient model company, for each of five distinct “distribution demand sectors/areas.” Distribution tariffs applicable to final users are based on consumers’ average maximum demand and consumption, load density and geographic dispersion. The distribution tariff is called the VAD (Value Added for Distribution). The VAD for the different demand sectors/areas and distribution companies are recalculated every four years (details on distribution tariffs and subsidies are presented in the next section).

The costs of a distribution system are the costs of building and operating and maintaining the system of service lines, mains and transformers. These costs depend upon: (i) the total number of customers served; (ii) the maximum demand on the system; (iii) the size of the distribution area; (iv) the capacity of the transformers; (v) the length of distribution lines; (vi) the total kWh sold; (vii) the price of labor; and (viii) the price of capital. Theoretical analysis and empirical evidence show that cost functions in electricity distribution exhibit important economies of scale, increasing returns to scale and economies of output.

As indicated in a previous paragraph, distribution tariffs are determined considering cost-based efficient model companies, one for each of five distinct distribution demand sectors/areas: Sector 1: urban high density; Sector 2: urban medium density; Sector 3: urban low density; Sector 4: urban-rural; and Sector 5: rural; and a newly introduced sector for rural electrification systems (*Sistemas Eléctricos Rurales-SERs*). Based on characteristics and density, Lima is the only area belonging to sector 1. Classification of distribution systems as sectors 2 to 5 is determined by regulations based on efficient standard costs of representative electrical distribution systems.

³⁰ The reference regulated “busbar” energy price is calculated by the regulator as the average marginal energy cost of the system, based on a three-year operation simulation (of the historical previous year and the next two prospective years). This reference price is weighted with the prices resulting from the supply auctions to obtain the final energy busbar price applied in the tariffs. At present, 65% of the regulated energy price comes from auctions and 35% directly from the reference busbar price (resulting from supplies with direct contracts or without contracts).

³¹ Reference investment requirement is taken from statistics of last five years published by “Gas Turbine World.”

SERs are classified as such if conditions specified in the General Law for Rural Electrification and its regulations are met.³²

Figure A.2 below shows the distribution of costs of the different electricity distribution systems, indicating a trend of increasing costs from the urban high demand density sector to the disperse low rural demand sector and the SERs. Also, it should be noticed that for sectors 2 to 4, the costs of the systems could be represented by the average costs with minor differences. This is not the case for sector 5 or the SERs, which show important costs differences between systems.

Figure A.2: Characteristic of Distribution Costs

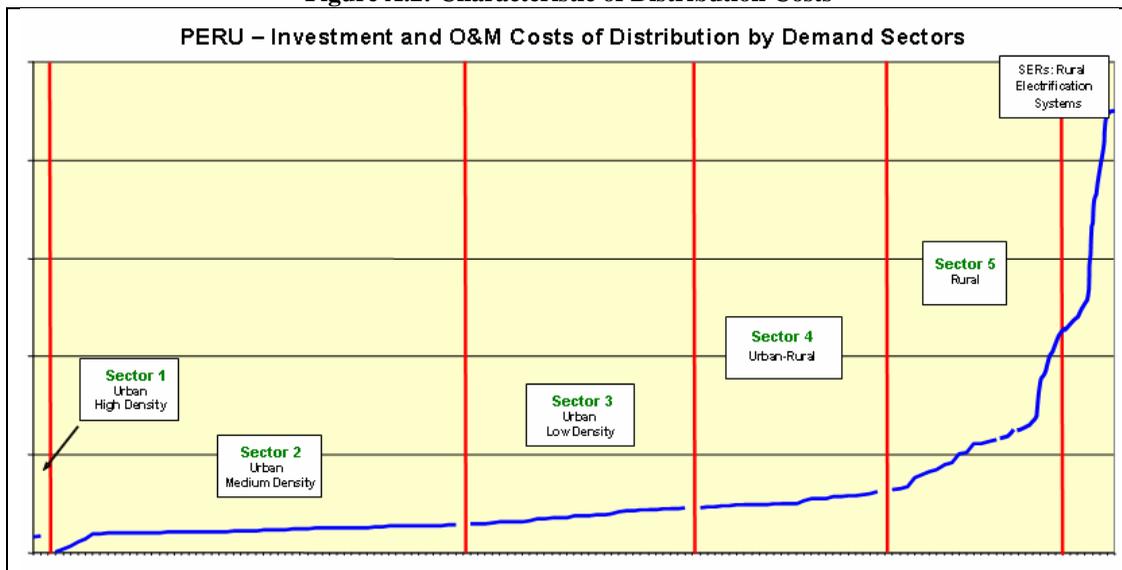


Table A.1 below summarizes the main results of the 2009 distribution tariff review process (valid for the period 2010-2013). The new SER tariff contemplates the possibility of a direct public subsidy to the investment, the participation of the distribution company in part of the investment and the O&M of the systems, and the optional utilization of prepayment. The four VADs for the SERs correspond to full-cost or zero subsidies of investment, and pre-payment or conventional metering. The VAD for partial subsidy is calculated by linear interpolation.

³² *Ley General de Electrificación Rural* – N° 28749 passed in June 2006, and its regulations DS-025-2007-EM approved in 2007.

Table A.1: Distribution Tariffs as of December 2009 (in S/kW-month)

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	SERs1	SERs2	SERs3	SERs4
VAD _M	12.254	9.171	18.396	23.618	40.667	18.340	19.157	46.508	47.325
VAD _L	45.553	38.540	56.531	61.803	92.208	32.425	31.078	97.251	81585

Notes: (1) SERs1: 100% public subsidy of investment and prepayment
(2) SERs2: 100% public subsidy of investment and conventional metering
(3) SERs3: 100% of investment by the distribution company and prepayment
(4) SERs4: 100% of investment by the distribution company and conventional metering
(5) Tariff with prepayment for a system with X% of investment by the distribution company = $[(100-X)/100]*SERs1+(X/100)*SERs3$
(6) Tariff with conventional metering, system with X% of investment by the distribution company = $[(100-X)/100]*SERs2+(X/100)*SERs4$

Distribution tariffs (the VAD) are established for each distribution company as the weighted average of the VADs of each typical distribution sector within its service area, with respect to the percentage of the total demand of each typical sector.³³ Therefore, all electricity users of a distribution company have the same tariff, independently of belonging to a particular demand sector. This implies an implicit cross-subsidy between users of different typical sectors within the service area of a distribution company.

The per unit VAD capacity costs are converted to more suitable energy units, using typical consumers' demand curves, for establishing consumers' final tariffs. For example, the electricity tariff for a residential consumer in Lima, the capital city, with a consumption above 100 kWh per month, is S/. 0.3181/kWh (US\$0.112/kWh.) The tariff for a similar consumer in a rural area of Peru is S/. 0.5068/kWh (US\$0.178/kWh), almost 60 percent higher. The tariff for a SER system is S/. 0.6395/kWh. There is also a fixed monthly charge of about S./3.0 which is noticeable for these small consumers.³⁴ All these are full-cost tariffs, before FOSE, or other, subsidy is applied.

Subsidies on the Tariff

Extending access in rural areas requires a system of subsidies that acknowledges the lower income and electricity consumption levels³⁵ of rural households and higher costs of supply resulting from the remoteness of the location, as well as the government's social objectives.³⁶ The inability of rural consumers to pay fully for the cost of supply in particular highlights the importance of designing a system of cost-effective subsidies to ensure the recovery of the costs of an efficient operation, while permitting small and rural customers to pay an affordable amount for basic service.

³³ The general formula would be as follows: let say that p_1, p_2, p_3, p_4, p_5 and p_{SER} , are the percentages of demand, and $VAD_1, VAD_2, VAD_3, VAD_4, VAD_5$ and VAD_{SER} are the VADs, of each typical sector 1, 2, ..., SER, then the VAD for the distribution company would be: $VAD = (p_1 VAD_1 + p_2 VAD_2 + p_3 VAD_3 + p_4 VAD_4 + p_5 VAD_5 + p_{SER} VAD_{SER})/100$.

³⁴ For example, for a SER user with 20 kWh monthly consumption, the bill would be $20 \times 0.3198 + 3.00 = 9.396$ S..

³⁵ The average monthly consumption per customer in rural areas is 30 kWh, and around 12 kWh for newly connected customers. This contrasts with the average urban consumption of around 100 kWh.

³⁶ While Peru's power sector policy does not mandate a single tariff structure nationwide nor universal access, the political objective that all citizens be treated equally is reflected in the country's tariff and subsidy policies.

The Peruvian tariff system includes three types of subsidies, which are applied to meet social equity objectives, while maintaining financial sustainability of distribution companies:

- **Subsidy on capital costs** applied to grid extension, mini grids under 500 kW and off-grid electrification. The subsidy varies from an average of 75 percent of the capital cost in the RE Project to 100 percent in the DP/MEM program. Sources of funding are MEM’s budget, government social and electricity funds (FONCODES, the RE Fund and others), donors and local government contributions. The capital subsidy has been estimated to be more than US\$200 million per year in recent years.
- **Internal tariff subsidy.** This is a system of cross-subsidies that includes two components aimed at reducing the prices of generation in isolated systems and to compensate for the differences of distribution costs between urban and rural areas.
 - Subsidy to generation in isolated systems. In this scheme, revenues from grid-connected customers are channeled through the RE Fund to compensate for the differential between the generation costs in isolated systems and the bus bar prices of the national interconnected system. The annual compensation is in the order of US\$24 million, allowing a reduction in electricity prices in isolated areas by 16 to as much as 61 percent (for the extreme case of private diesel-fuel generation).
 - Internal subsidy on the VAD. The subsidy is a classical cross-subsidy and is funded mostly by urban consumers through the tariff. As indicated previously, the subsidies are implied in the tariff calculations for each distribution company, considering its composition of typical distribution sectors. The annual compensation is in the order of US\$13 million. In the case of sector 5, rural, this mechanism reduces the VAD by around 22 percent.
- **Consumption Cross-subsidy (FOSE).** Introduced in 2001, this subsidy aims at protecting low-income households whose monthly consumption is below 30-100 KWh. It is channeled through the FOSE (Electricity Social Compensation Fund). The total amount of the subsidy is in the order of US\$31 million per year, which is collected through a surcharge of 3 percent on households consuming more than 100 KWh/month.

Table A.2: FOSE – Tariff Subsidy

Users of	Areas	Tariff Reduction for consumptions lower or equal to 30 kWh/month	For consumption greater than 30 kWh/month up to 100 kWh/month
Interconnected System	Urban	25% of the energy charge	A reduction of 7.5 kWh/month
Interconnected System	Urban-Rural and Rural	50% of the energy charge	A reduction of 15 kWh/month
Isolated System	Urban	50% of the energy charge	A reduction of 15 kWh/month
Isolated System	Urban-Rural and Rural	62.5% of the energy charge	A reduction of 18.75 kWh/month

When the FOSE subsidy is applied, the energy tariff for a rural user (sector 5), with a monthly consumption up to 30 kWh, is reduced from S/. 0.3198/kWh (US\$0.112/kWh) to S/.0.2534 per kWh (US\$0.089/kWh). Similarly, the tariff for a SER user, with similar monthly consumption, is reduced from S/.0.6395/kWh (US\$0.182) to S/.0.3198/kWh (US\$0.112/kWh).

The aggregate impact of the entire subsidy system is considerable. Annual cross subsidies on tariffs amount to a total of US\$68 million, accounting for 3.7 percent of total revenues.³⁷ The result is that, as shown in the Table A.3 below, in general rural households pay a tariff that is only slightly higher than the urban tariff, in spite of the fact that the supply cost could be from 2 to 5 times higher. In the extreme case of a high-cost isolated generation system, subsidies reduce the payment of a low-income rural household to 16 percent of the total cost (8.28 US cents/kWh with subsidies compared to 52.71 US cents/kWh at full cost).

Overall, the Peruvian subsidy system appears to be protecting low-income rural households and compensating for the higher costs faced in rural and isolated areas. At the same time, the system prevents distortions, such as the lack of attention to low-income customers that make lower contributions, since distribution companies are compensated on the basis of the services they provide in an amount that aims to cover fully the costs of an efficient operation.

Table A.3: Impact of Subsidies on Tariffs for an Isolated Mini-Grid (US cents/kWh)

	Full Cost	With internal tariff subsidy	With internal tariff subsidy plus FOSE
VAD secondary grid	22.01	9.01	3.38
VAD primary grid	9.58	3.98	1.49
Capacity cost	3.32	3.32	3.32
Energy cost	17.80	5.76	2.16
Total	52.71	22.07	8.28

Source: OSINERGMIN

However, the fast pace of rural electrification is testing the efficacy of the regulatory system, as VAD tariffs are recalculated only every four years. It is not clear whether the adjustments mechanisms of the VAD will be able to keep pace with the rapid changes in the cost structure of some distribution companies as large numbers of new rural customers are connected every year.

Rural Electrification

The rural electrification effort faces unusually difficult challenges in Peru. The large distances separating many isolated communities and the rugged terrain make extending access to electricity in rural areas very difficult, resulting in high installation, operation and maintenance costs. Furthermore, the low level of electricity consumption of most rural households poses an additional challenge.

However, the public sector is making a strong effort to increase electrification overall and reduce the gap between urban and rural areas. The sector authorities have increased public investment in electrification markedly, taking advantage of the country's current macroeconomic health, and are seeking alternative approaches, such as involving the distribution companies and regional governments as well as using new technologies—especially renewable energy—to serve remote populations. As a result of the joint efforts of MEM, the electricity distribution companies and

³⁷ Assuming that only 40 percent of the households contribute, the average subsidy contribution of a relatively wealthy household would be US\$3.25 per month.

regional and local governments, electricity coverage in rural areas is estimated to have increased from 30 percent in 2007 to about 55 percent at the end of 2010.

As shown in Table A.4 below, in 2008 almost 30 percent of electricity users had a monthly consumption of less than 31 kWh/month, with an average of about 20 kWh. Fifty five percent consumed less than 101 kWh/month. In the case of users in isolated systems, 45.4 percent have monthly electricity consumption of less than 31 kWh, and about 77 percent consume less than 101 kWh/month.

Table A.4: Number of Users by Average Electricity Consumption per Month, 2008

Range of Monthly Consumption	Grid Supplied	Isolated	Total	Percent
0 to 30 kWh	1,150,155	141,527	1,291,682	27.6%
31 to 100 kWh	1,188,228	97,166	1,285,394	27.5%
> 100 kWh	2,031,648	72,705	2,104,353	45.0%
Total	4,370,031	311,398	4,681,429	100.0%

After the reform of the early 1990s, the rural electrification effort was limited to direct investment by the central government. Investments were carried out from the national budget assigned to MEM. The electrification projects were planned, designed and implemented by the Executive Office of Projects (DEP) of the MEM. Once the construction was completed, rural electricity systems were turned over for operation either to state-owned distribution companies or to ADINELSA. This centralized top-down model had a number of limitations, including the lack of involvement of the distribution companies in selection and construction of the projects.

In recent years the government has strengthened its commitment to reduce the electrification gap. This renewed effort is supported by the legal framework established by the General Law for Rural Electrification (RE Law) and additional legal measures to promote the use of renewable energy.³⁸ The activities of MEM contributed to increasing national electricity coverage levels from 55 percent in 1993 up to 74 percent in 2007.³⁹ Over the same period, rural electrification coverage increased from 7.7 percent to about 30 percent.

MEM has carried out, with JICA technical support, a preliminary study/plan for electrification of remote households with renewable energy. The study estimated that there are about 33,700 villages, with some 362 thousand households, for which a grid extension for electricity supply would be uneconomical. Out of the above number, 519 villages (with some 18,500 households) have potential for local mini/micro hydropower generation. Another 10,829 villages, with 10 households or more (corresponding to 261,520 households), would be targeted for electrification by PV systems. The remaining 80 thousand households located in isolated localities with less

³⁸ *Ley General de Electrificación Rural* – N° 28749 passed in June 2006, and the Legislative Decree N° 1001 in May 2008. Among other stipulations, the GLRE established a Rural Electrification Fund with specific sources of finance, special conditions for Rural Electrification Concessions and opened the doors for private participation in rural electrification, with public subsidies.

³⁹ The indicated figures of levels of electrification correspond to the results of the national census of 1993 and 2007.

than 10 households will be left without electricity. The implementation of the plan would require about US\$220 million; US\$40 million for mini/micro hydropower systems and the remaining US\$180 million for PV systems.

The World Bank and GEF-Assisted Rural Electrification (RE) Project

The WB supported RE Project was designed with view to serving as a model for future programs and improving the sustainability of the rural electrification effort. The project is financed by a US\$50 million IBRD loan and a US\$10 million GEF grant, complemented by a contribution of US\$51 million from the Government of Peru and US\$33 million from service providers and private enterprises. At completion of the Project, an estimated of 110,000 rural households will receive new electricity connections, at a cost of US\$117 million, benefiting approximately a rural population of 485,000 inhabitants.

The Project is structured around the following five major components: (a) investment in rural electrification sub-projects by electric distribution companies, to provide new electricity connections for rural households, businesses and public facilities; (b) technical assistance to build capacity for a demand-driven approach for rural electrification, as well as promotion of renewable energy; (c) a pilot program to promote productive uses; (d) a small hydro generation financing facility to provide project financing, during construction and initial operation period, for grid-connected plants; and (e) project management.

Component One: Investment in RE Projects. The major component is investment in rural electrification sub-projects, with an estimated cost of US\$117 million. This component provides partial subsidies to cover the capital costs of electricity access projects implemented by service providers (usually public distribution companies). The subsidy is calculated as the amount required for the project to yield a return on the service provider's investment. MEM signs a contract that establishes the conditions of the subsidy and the parties' responsibilities with a service provider. Sub-projects include grid extension and the provision of services through individual household solar home systems.

Activities of the Project during the three-year period 2008-2011 have been intense; primarily due to the pace of implementation of the main component of the project, the rural electrification grid extension sub-projects. It is expected that a total of 64 sub-projects, involving 2,180 rural localities with 110,000 new connections, would be installed and in service by Project completion at the end of September of 2011. Table A.5 below shows the status and main characteristics of the rural electrifications sub-projects as of September 2011.

The Project has attracted broad participation from the distribution companies. Ten of the 23 distribution companies in Peru are participating in the RE Project.⁴⁰ Subprojects are being carried out in most of the major regions of the country including the departments of Ayacucho, Ancash, Cajamarca, Cusco, Huancavelica, Huanuco, Junin, La Libertad, Lambayeque, Lima, Loreto, Pasco, Piura, Puno, San Martin, and Ucayali.

⁴⁰ Electronorte, Electrocentro, Electro Noroeste, Electro Sureste, Hidrandina, Electro Ucayali, Electro Puno, and Electro Oriente.

Table A.5: Status of Implementation of Rural Electrification Sub-Projects of FONER Sept. 30, 2011

Status of Projects	Number of Projects	Total Cost	Subsidy FONER	Subsidy IBRD	Number Connections	Cost / Conex	Subs / Connection	Subsidy / Costt
		(million US\$)	(millions US\$)	(millions US\$)		(US \$ / Conex)	(US \$ / Conex)	
Total Rounds 1-4								
Completed	44	93.10	69.82	33.51	85,065	1,094.48	820.78	75.0%
In progress	10	20.69	14.74	7.07	17,792	1,162.96	828.39	71.2%
In bidding process or approved	5	4.60	4.14	2.03	4,469	1,029.63	926.66	90.0%
In process SNIP/OPI	3	2.06	1.85	0.91	2,004	1,026.07	923.46	90.0%
In evaluation FONER	2	1.73	1.56	0.76	1,689	1,026.07	923.46	90.0%
Total	64	122.18	92.11	44.29	111,019	1,100.57	829.68	75.4%

Another Project achievement has been to organize electricity service to isolated households with photovoltaic systems, as part of the regulated operations of the electricity distribution companies. Electricity companies in Peru have long used independent small and medium enterprises (SMEs) as contractors to assist in billing, collection, connection and basic operation and maintenance. With technical assistance mobilized under ESMAP's SME Program, the Project helped the distribution companies and local communities prepare subprojects to provide service to more than 7,000 remote households using PV systems. This involved assisting the companies to adapt their systems of third party contracting to off-grid service using renewable energy.

Component Two: TA. This TA component assisted MEM to review design and construction standards for grid connected and off-grid renewable energy systems, as well as assisting with review of quality of service standards which were used in the emission of new norms for service provision. At MEM's request, and using the model of regulated service through distribution companies pioneered by the RE Project, OSINERGMIN has established a regulated tariff for electricity service with PV systems and ensure that such customers are eligible for the cross-subsidy provided in the regulated system to small users. The Projects technical consultants and advisers hired under the ESMAP SME Program have assisted in preparing draft proposals for the BT8 tariff established for PV service in August 2010. In parallel, the Project assisted the distribution companies to prepare the projects for about 7,000 households using PV systems. Additionally, the Project has completed the evaluation of wind power at national and regional levels and an assessment of small to medium hydropower potential using state-of-the-art satellite and GIS systems (two computer mapping system were developed for wind power and hydropower potential, respectively, which are available on MEM's website).

Component Three: Promotion of Productive Uses of Electricity. The objective of this component is to contribute to increase the productivity of rural businesses by adopting electrical equipment, which would in turn increase economic development in rural areas of Peru as well as improve the utilization of electricity supply infrastructure and electricity service company revenues. Priority was given to operations that currently employ diesels or other power sources, and those with strong potential for electricity use if additional value-added processing is done in the region.

The component focused on target areas with: (i) low load factor rural distribution systems without supply side constraints; (ii) presence of a potential for energy intensive productive activities in farm and off-farm enterprises or individual productive units that might benefit from a shift to electricity; (iii) existence of basic supporting infrastructure; and (iv) a electricity service company with interest and commitment to support productive uses promotion.

Three contracts for productive uses promotion by NGOs in Cusco (Soluciones Practicas-ITDG with ELSE), Junín (Swisscontact with ELSE) and Lima Provinces (Desco with ADINELSA) have assisted more than 4760 family production units in rural areas to increase their income by adopting electricity using equipment to process cereals, coffee, cocoa, baked goods, meat products, milk, wood and metal products and handicrafts as well as irrigating crops such as prickly pear. ELSE has decided to offer a preferential tariff to these small users for off-peak consumption of electricity. Even though this may mean less income, the company will benefit from a better balance of energy demand. The Project is scaling up this experience in other areas. It has signed eleven additional contracts, including follow-up contracts in Cusco, Junin and Lima Provinces.

The process is helping to build capacity in the field and is also yielding important lessons in identifying the potential of increasing productive uses, its constraints and possible solutions (e.g. the development of an institutional platform that includes the financing institutions and/or tariff incentives in addressing the impact of a larger electricity bill). This promotion and capacity building effort has the potential of making a considerable contribution in increasing the productivity of rural business and improving the development impact of rural electrification, as well as achieving a more efficient use of the electricity supply infrastructure and the improving the revenues of the distribution companies.

Component Four: Small Hydro. The GEF assisted Financing Facility for Small Hydropower Plants has been delayed but is moving after an amendment to simplify arrangements and extend the GEF activities until June 30 2013 was approved.

Overall, the rural electrification activities of the Bank's supported RE Project are seen as successful by the Government, because: (i) implementation progress in the rural electrification subproject component has been strong; (ii) over 24 percent of the costs of the subprojects are financed by ten distribution companies that have been actively participating in the Project; (iii) the Project has developed a model for regulated household PV service provision hand in hand with the distribution companies and OSINERGMIN; and (iv) the Project's approach to promotion of productive uses is showing promising results.

Electricity Demand, Technical, Tariff and Regulatory Constraints for Productive Uses in Peru Rural Electrification

There is almost unanimous agreement that electric power can result in productivity gains and economic growth, thus transforming the underdeveloped rural landscape – if ancillary services such as market access, human and enterprise capacity, financial services, and resources/raw materials are available. From a electricity service company viewpoint, productive uses are essential to establish the long-term economic viability and sustainability of rural electrification.

Load factor and capacity utilization in rural areas of Peru are low. Power demand peaks usually occur at night while daytime loads are minimal, indicating that electric power is mainly used for domestic lighting and appliances (e.g. radio, TV). Load factors are often under 50 percent. For example, Electrosur reports that in its rural service areas, the load factor is only around 25

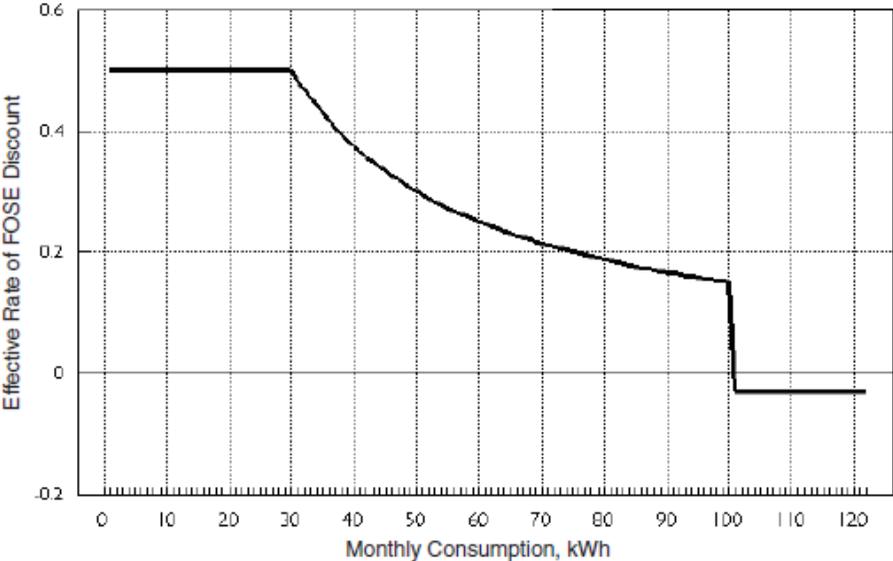
percent with a two hour evening peak from 6-8 pm. Many hydro grids have similar low load and capacity factors. According to MEM’s data, 50 percent of the hydropower plants with total installed capacities of 580 MW have capacity factors less than 60 percent (implying that daytime loads are typically less than 50 percent of peak generation capacity).

It is clear that productive uses of electricity in rural areas confront not only socio-economic and some cultural limitations but also practical constraints from the power sector itself, related mainly to: (i) characteristics of electricity demand for productive uses in rural areas; (ii) technical characteristics of rural electrical systems; and (iii) tariff and related regulatory issues.

Characteristics of Electricity Demand for Productive Uses. The traditional productive uses in rural areas of Peru have been small commercial applications like refrigeration, or motorized equipment for weaving cloth or for operating sewing machine within the household. Almost all of these applications can be accommodated in the standard rural electricity system used by distribution companies (single-phase 220 Volts system with single energy measurement or pre-paid equipment).

The only practical limiting factor to these small electricity applications is economic, due to “losing” part of the FOSE subsidy (or the total of subsidy if the monthly consumption of a household is greater than 100 kWh). The graph in Figure A.5 shows the effective discount of the energy tariff in the range of zero to 100 kWh/month consumption. Consider the following situation: a rural household has only domestic consumption of 25 kWh/month, and then a 200 W refrigerator is installed with an estimated monthly consumption of 50 kWh/month, increasing the consumption from 25 to 75 kWh/month. The graph in Figure A.3 indicates that FOSE subsidy for this household would be reduced from 50 per cent of the energy tariff to only 20 percent, therefore the unit price of electricity for this household would be 30 percent more expensive.

Figure A.3: Effective FOSE Nominal Energy Tariff Discount



Guidelines for evaluation of rural electrification projects for public financing contemplate the possibility of larger demands than only basic domestic or communal sites consumptions.⁴¹ These larger demands are important, particularly for the long-term economic and financial viability of the projects. The economic-financial modeling of projects in the WB financed RE Project considers explicitly two types of large demands: small industry and special loads (large users), in addition to the “standard” domestic, small commercial, communal and public lighting demands.

Of the 55 grid-extension rural electrification sub-projects of the RE Project, 35 of the projects included small industry demand, with a total of 886 such connections with an average monthly consumption of 1.325 MWh per connection.⁴² Also, 12 of the sub-projects included 142 very large users, with 7.162 MWh monthly average consumption per connection.

In the 55 grid-extension rural electrification projects, the total demand for productive uses (small industry and large users) represents 42 percent of the total demand, contributing considerably to the economic-financial viability of the subprojects. The impact is of course different for each individual project. For example in the Chillón project, 58.6 percent of the demand came from productive uses. This project required 60 percent of subsidy on investment to make the subproject financially viable. Other projects without larger demands required much more investment subsidy to make them economically and financially viable.⁴³

In all the cases mentioned, each large user (or group of applications served by the same rural system) has to be analyzed individually in the context of the distribution system electric characteristics, applicable tariff schedule, standard distribution service regulations and particular commercial practices (which are also subject to some general standard rules).

Motors that convert electrical energy to mechanical energy comprise two-thirds of total industrial demand for electricity, and are present in most of the productive uses applications in rural electrification. Given the characteristic of being a dynamic load⁴⁴ usually located at the end of relatively long, electrically weak systems, large motor loads in rural distribution systems require specific electrical system analysis.

Also, as will be explained in the next section, most of rural distribution lines/circuits are single-phase. One fundamental problem with single-phase motors is the very high starting current required to get the motor up to speed and the consequently voltage depression during motor starting. A typical single-phase motor may have starting currents that are six to ten times their normal running current. Newer motors with higher efficiency usually have even higher starting currents. This presents a major problem in rural areas where only single-phase lines are available, as the voltage drops in the system when such motors are started.

⁴¹ “Guía Metodológica para la Identificación, Formulación y Evaluación de Proyectos de Electrificación Rural a Nivel de Perfil”, published by the National System of Public Investments (SNIP) in June 2007.

⁴² To have a reference of the level of consumption for small industry equipment, a 1.00 HP (Horsepower – 1 HP = 0.735 kW) motor working 8 hours per day and 20 working days in a month, consumes about 120 kWh.

⁴³ For example, the Porcón project has no productive uses demand, and required a subsidy of 74% to be financially viable; 14% higher than in the case of Chillón. It should be also pointed out that financial viability of a project does not depend only on the size of the demand but, more importantly, on project costs

⁴⁴ Other type of loads, like heat production equipment and similar, are static (have no moving or rotating parts) and do not subject the electrical system to stress.

Because of high starting currents, single-phase motors are not generally available in sizes over 15 HP. Many distribution companies restrict the use of single-phase motors to sizes of less than 10 HP for ordinary electric motors. High motor starting currents on single-phase lines can cause line voltage dips that can cause problems for other loads.

It is clear from these considerations that large productive uses loads that require the use of electrical motors, in most of cases will require a three-phase supply system, which is not present in large sections of the actual rural distribution systems. Upgrading single-phase systems to three-phase or installing a new three-phase line/circuit could be the only solution in these cases, but would be expensive. Investment in the electrical system for these applications, on the part of the distribution company and the user, must be analyzed to ensure their economic and financial viability. There is no particular incentive or promotional policy for productive uses in the power sector; the regulatory framework is applied equally to all type of users.

Technical Characteristics of Rural Electrical Systems. The rural electrical systems in Peru consist basically of medium voltage (22.9/13.2 kV) primary three-phase and single-phase distribution lines and low voltage (380/440-220 V) secondary three-phase and single-phase distribution feeders/circuits.⁴⁵ The main line and major branches are three-phase at 22.9 kV and most of the other circuits are single-phase at 13.2 kV. The single-phase lines have two wires with one being a neutral conductor, or are single-wire with earth return (SWER systems).

SWER systems have been traditionally included in design guidelines as technical viable options in rural electrical systems in Peru but have not been imposed on distribution companies as the only possible electrical system alternative for rural electrification.⁴⁶ However, with the approval of the SER systems tariff in 2009, SWER lines are the preferred alternative since the economic efficient model company used by OSINERGMIN for calculating SERs tariffs assumes the use of SWER systems.

SWER systems are not free of their own technical problems, and their use in rural areas with rapid electricity demand growth may not be the best long-term economic efficient solution.

The distinguishing feature of SWER systems is that the earth (or sometimes a body of water) is used as the return path for the current, to avoid the need for a second wire (or *neutral wire*) to act as a return path. A SWER line is a single conductor that may stretch for tens of kilometers, with a number of distribution transformers along its length. At each transformer, such as a customer's premises, current flows from the line, through the primary winding of a step-down isolation transformer, to earth. The current completes the electrical circuit back to the main step-down transformer at the head of the line, through earth.⁴⁷ The Figure A.4 shows a typical SWER distribution system.

⁴⁵ A rural electrical distribution system usually starts in a three-phase transmission substation/transformer with a "star-connected" secondary winding with the neutral solidly connected to earth. The line to line voltage is 22.9 kV and the line to neutral voltage is 13.2 kV.

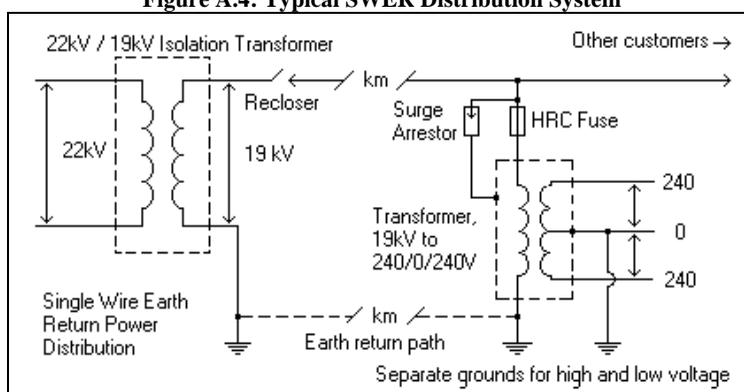
⁴⁶ At present, certain developing nations have adopted SWER systems as their main electricity systems, notably Laos, Cambodia, Vietnam and South Africa. SWER is also used extensively in Brazil where it is termed "Redes Monofilares com Retorno por Terra." In Spanish speaking Latin America countries, this type of electricity distribution is known as "*Sistema Monofilar de Retorno por Tierra*" or "MRT"

⁴⁷ The early work on SWER was carried out by Loyd Mandeno in New Zealand. Mandeno's paper "*Rural Power Supply, Especially in Back Country Areas*" is the classic reference for the technology and established New Zealand

SWER's main advantage is its low cost. It is often used in sparsely populated areas where the full cost of building an isolated three phase distribution line cannot be justified. For electrifying rural communities from the grid or from isolated mini grids, SWER serves as a low cost entry level technology. In this role it is best suited to areas where a) the initial energy demand per household is low, e.g. 30 to 100 kWh per month; b) the maximum demand per household in the first 10 years of electrification is below 500 VA; and c) lower population densities prevail.

A large SWER line may feed as many as 80 distribution transformers. The transformers are usually rated at 5 kVA, 10 kVA and 25 kVA. The load densities are usually below 0.5 kVA per kilometer of line. Any single customer's maximum demand will typically be less than 3.5 kVA, but larger loads up to the capacity of the distribution transformer can also be supplied.

Figure A.4: Typical SWER Distribution System



As demand grows, a well-designed SWER system can be upgraded without requiring additional poles. The first step could be as simple as replacing the type of conductor, using aluminum or copper based conductors, with much better electrical characteristics than steel wire, if it was used in the original construction.

If more capacity is needed there are basically two upgrade alternatives. First, a second SWER circuit can be run on the same poles to provide two SWER circuits 180 degrees out of phase (this configuration causes most ground currents to cancel out, reducing shock hazards and interference with communication lines). Second, a more efficient upgrade would be to single or two phase service with a two-wire system. These two schemes require more insulators and conductor, but could double the power capacity without requiring a second line.

As more power is needed the lines can be upgraded to match the load, from single wire SWER to two-wire, single phase or two-phase and finally to three-wire, three phase system. This ensures a more efficient use of capital and makes the initial installation more affordable. Customer equipment installed before these upgrades will all be single phase, and can be reused after the upgrade. If small amounts of three-phase power are needed, it can be economically "produced" (synthesized) from single or two-phase two-wire electrical power by on-site converters.

as a SWER pioneer. Since the publication of Mandeno's paper in 1947 things have moved on and we will examine the relevance of SWER today and explore the enhancements carried out in the intervening years.

Tariff and Related Regulatory Issues. The electricity law and its regulations establish in detail the conditions under which an electricity service must be supplied to a customer by a distribution company, the minimum level of quality provided (of the “product” itself – the electricity – and of the customer/commercial service), and the applicable tariffs. Understanding of these regulations is very important, in particular by electricity users in rural areas with potential productive uses of electricity.

Electricity distribution companies have exclusive concession areas for electricity distribution, established in the concession contract with the government. These concession areas could be relatively large territories or narrow polygons of specific areas, usually surrounding the electrical facilities of the distribution company. A distribution company has the contractual obligation to supply electricity to any user who requests the service and is located inside its concession area.

Electricity service is provided to a legally and physically identified unique household or property belonging to a specific owner. The contractual obligations of electricity service are between the distribution company and the owner of the household/property. Third parties, like renters, cannot request electricity service for a household or property. This limitation is a barrier to expanding electricity service in marginal areas of cities and in loosely organized individual, communal or cooperative ownership arrangements in rural areas that lack clear legal status.

The obligation to serve inside a concession area of a distribution company varies, depending on the location of the point of service. If this point of service is located within 100 meters of an existing electrical facility of the distribution company, the company has to provide the service without any condition. If the point of service is located more than 100 meters from an existing facility, the distribution company can request the user to finance the additional facilities required. The company has a maximum term of one year to complete the facilities and provide the service.

Requests for service that require additional electrical facilities of a distribution company are those that cause most of the problems in electricity supply for productive uses in rural areas. As indicated previously, the responsibility for investment in the electrical system for productive uses, on the part of the distribution company and the user, should be analyzed case by case.

Regarding tariffs, as indicated in the section on tariffs above, the basic tariffs to the regulated distribution market are determined by considering cost-based efficient model companies. The tariff schedules applied to final users of each distribution company are derived from these basic tariffs using demand, loss and distribution factors which depend on the incidence of the different users load characteristics with respect to the total load of the distribution company (the cost-causation principle).

The Peruvian tariff schedule system does not follow the traditional classification by type of use: residential, commercial, industrial and other uses. Instead, the tariff schedule system is based on three fundamental parameters (related to cost-causation): voltage level, level of demand and (partial) time of day⁴⁸. Another important characteristic of the tariff schedule system is the

⁴⁸ Sophisticated time-of-use tariffs have not been established. These type of tariffs required special measurement equipment and communication systems for their correct application (a smart grid). The time of day application of the Peruvian electricity tariffs refers to the different schedules applied to demands on-peak and off-peak periods.

existence of tariff options for certain types of users.⁴⁹ The regulator and the distribution companies are obliged to inform the public of the characteristics of the different tariff options and recommend to the user the best alternative given the characteristics of a particular demand.

Very large loads are usually connected directly to the extra-high (500, 220 kV) or very-high (138, 60 kV) voltage levels of the electrical grid and do not use the distribution networks at lower voltage levels (33, 22.9, 13.2 and 10 kV medium voltage primary distribution and 220 V low voltage secondary distribution).

At medium voltage (MT – “*Media Tensión*”) the tariff system offers three different options: MT2, MT3 and MT4. At low voltage (BT – “*Baja Tensión*”) the tariff system offers five different options: BT2, BT3, BT4, BT5 and BT6.

Tariff options BT2 and MT2 are applied to loads where the energy and the power demand requirement vary between peak and off-peak hours. Users of these tariffs need to install measuring equipment capable of registering energy and power demands during peak and off-peak hours (four measurements).

Tariff options BT3 and MT3 are applied to loads with an energy consumed that varies during peak and off-peak hours while there is only one “representative” power demand rating. A user of these tariffs is qualified as present during peak hours if the peak power demand is greater than or equal to 0.5 of the “representative” power capacity rating, during peak hours; otherwise the user is qualified as present during off-peak hours. The classification is done monthly and is done automatically. These tariff options require the installation of measuring equipment, capable of registering energy consumed during peak and off-peak hours and power demand (three measurements).

Tariff options BT4 and MT4 are applied to loads for which the total energy consumed and one peak power demand are registered (two measurements). The peak power demand presence has to be selected as on peak or off-peak, and is fixed during a period of three months to a year. This classification can be changed after each fixed period.

Tariff option BT5 applies only to users fed at low voltage with peak demand up to 20 kW, or in the case a power limiter is installed up to 20 kW. Peak power demand requirement is not measured but calculated from the expected power demands of installed equipment. A single (total) measurement is made of energy consumed.

Tariff option BT6 applies only to fixed installations (like neon signs, telephone booths, traffic lights and similar) for which the power demand characterizes the load. A single peak power demand is measured.

⁴⁹ For example, the same tariff option could be requested by a low voltage user for a residential household or by a different user for a commercial premise.

Energy Sector Management Assistance Program
1818 H Street, NW
Washington, DC 20433 USA
Tel: 1.202.458.2321
Fax: 1.202.522.3018
Internet: www.esmap.org
E-mail: esmap@worldbank.org





Energy Unit
Sustainable Development Department
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