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THE BOTTOM LINE

Rural electrification programs can be more effective in stimulating economic growth, social development, and sustainable utility operations when they promote productive uses of electricity, as shown by a decade of experience in Peru. To obtain the desired benefits, rural electrification programs need to encourage and support installation and reliable operation of electrical equipment that makes production more efficient and profitable.

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Promoting Productive Uses of Electricity in Rural Electrification Programs: Experience from Peru

Why is this issue important?

Rural electrification programs can often multiply their effect by promoting productive uses of grid-based electricity beyond basic household uses

Most countries place a high priority on electrification, recognizing the many benefits it can bring. These benefits include improved lighting; higher educational attainments of children; improved productivity in businesses and agriculture; improved health through reduced use of kerosene lamps; more access to entertainment and information through radio, television and computers; and increased social activity and safety through public lighting (IEG 2008). Today, electrification is often combined with investments in other areas, such as roads, water supply, education, training, technical assistance, and access to credit.

This brief focuses on the important benefits that can result from the use of grid-based electricity for productive uses, over and above basic household uses of electricity.[1] It considers how the adoption of electrical equipment can increase the productivity of micro-, small, and medium-sized businesses, including those based in the home. It also shows how promotion of productive uses can increase the financial viability of investments in electricity generation and distribution, especially in rural areas.

"Any use of electricity that generates income for the user is a productive use of electricity." That definition comes from NRECA International, Ltd. (no date). The German development agency, GIZ, uses a similar definition: "Productive uses of electricity are those that increase income or productivity (that is, they add value…)" (EUEI PDF and GIZ 2011). The range of production processes is wide, from artisanal activities to large-scale commercial and industrial processing of agricultural products (box 1).

Box 1. Examples of productive uses of electricity

Agriculture

- Pumps (groundwater, surface water)
- Modern irrigation (sprinkler, drip)
- Processing centers for coffee, cereals, root crops, fruit
- Grain and rice mills
- Crop drying

Animal husbandry

- Centers for processing and storing dairy products and meat
- Heated shelters, feed mixing and processing

Metalworking and carpentry

- Soldering equipment, saws, lathes, and sanders

Tourism, bakery, restaurants, crafts

- Lights, fans, ovens, mixers, cookstoves
- Sewing machines

Source: Finucane, Bogach, and Garcia (2012).

[1] Off-grid electricity from mini-grids and stand-alone systems is not considered here because of limited power. Biomass co-generation is also not considered.

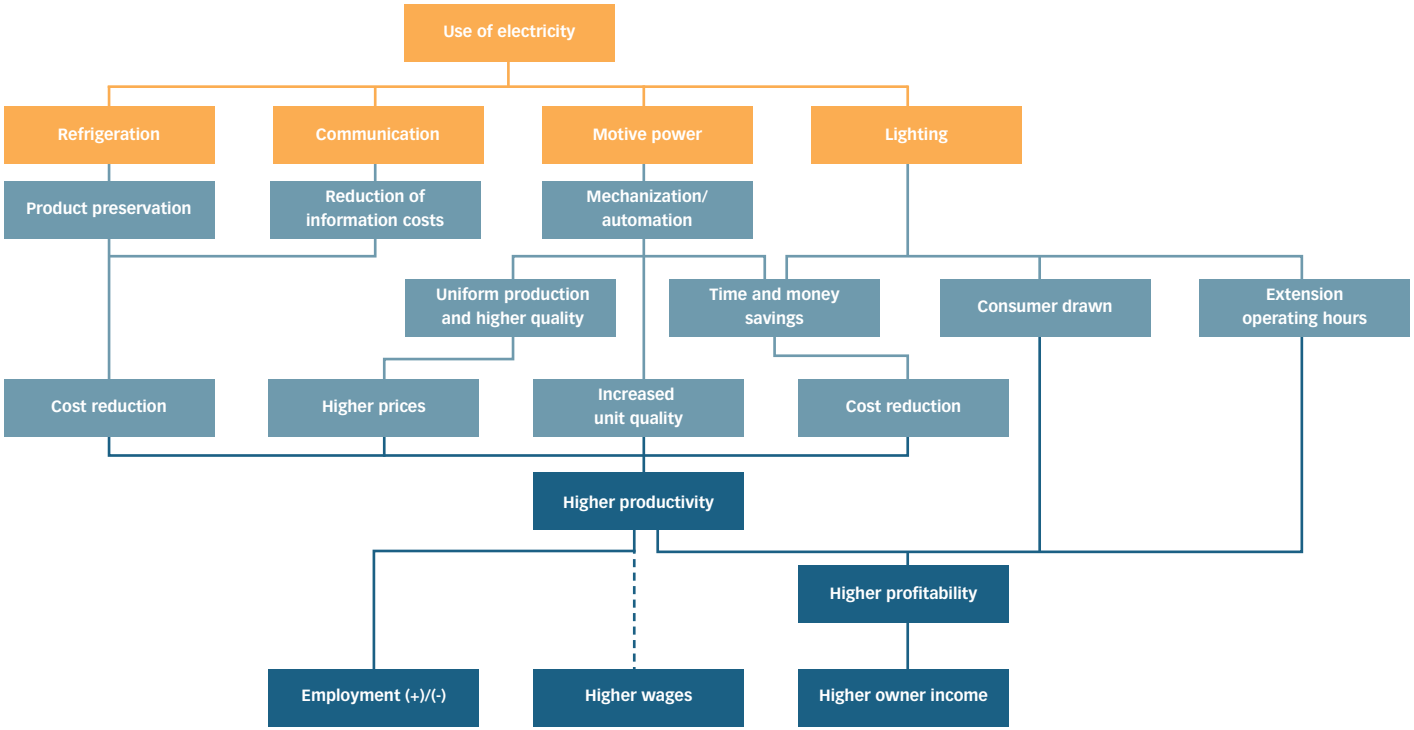
Productive uses of electricity are those that increase income or productivity—that is, they add value.

The simplest productive use of electricity is the extension of working hours of restaurants, shops, clinics, schools, and artisanal businesses thanks to electric lights. Other common uses include the provision of cooling and refrigeration, heat, and motive power for agriculture, small industry, or commerce.

In Peru, which is the focus of this brief, common examples include electric motors to grind grains and to process coffee, as well as electric pumps to irrigate the land and improve growing conditions and yields. In Indonesia, a survey of businesses showed that most productive units were family owned and operated, had less than 20 employees, were based at home or nearby, and used electricity mainly for lighting and motive power (Fishbein 2003).

Applying electrical equipment to production increases productivity and income by (a) extending product life through electrical equipment for drying, refrigeration, freezing, and packaging; (b) raising output, standardizing product quality and cutting costs; (c) replacing less-efficient equipment (e.g., diesel-powered motors); (d) expanding access to information about markets and technologies; and (e) creating jobs. These gains translate into higher incomes and help catalyze economic growth in a community, thus contributing to both increased household well-being and shared prosperity (figure 1).

Figure 1. Main pathways from productive uses of electricity to income generation



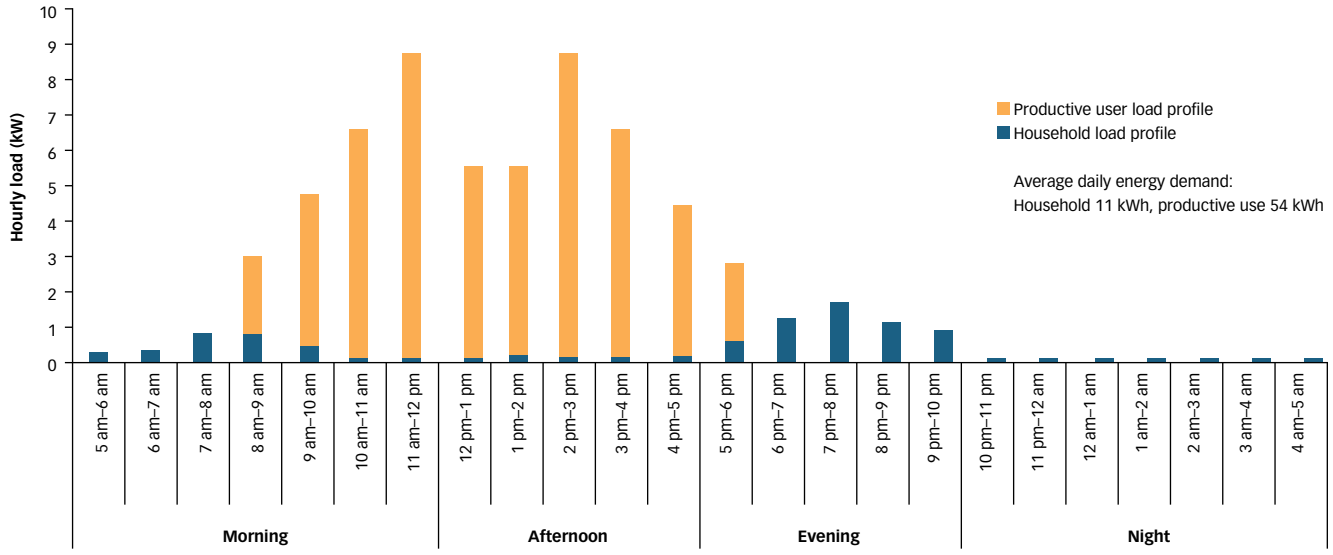
Source: GIZ, BMZ, ESMAP, AEI (2013).

When demand for electricity for productive uses is added to demand for household applications, not only do electricity system revenues increase but also the load curve changes, enabling more efficient operation.

Productive uses of energy can assist women, in particular, to earn income and improve their quality of life, through the use of lighting to extend opportunities for cottage industries in the home and electrical equipment in activities such as baking and ceramics. Electrical equipment helps women save time and labor and creates opportunities for education, socializing, and communication. Benefits for women such as increased cash incomes, community development, enhanced lighting for education, improved health services, lower indoor air pollution, and reduced labor burdens have been cited if not always documented. Increased income and fulfillment of social needs in turn allows greater use of modern energy, with further development benefits (White 2002; Cabraal, Barnes, and Agarwaal 2005).

Increased use of electricity for productive purposes can also improve the efficiency and financial sustainability of rural electric systems and utility operations. When demand for electricity for productive uses is added to demand for household applications, not only do revenues increase but also the load curve changes, enabling electricity systems to operate at more efficient levels. The demand profiles in electrified communities with a low level of productive activities often follow a classic pattern of morning and evening peaks of demand, mainly for lighting, with low demand during the day. Daytime use of electricity in businesses can maximize the use of the power infrastructure at times when it is otherwise underused. Figure 2 provides a dramatic example from an Indian village.

Figure 2. Daily load curve in the village of Naurangabad, India, with and without productive uses



Source: Rammelt (2015).

Why doesn't the adoption of electrical equipment for production occur spontaneously?

Demand, supply, and policy constraints must often be overcome before electrical equipment is integrated into production

Promotional efforts are often needed to encourage the adoption of electrical equipment for production and to overcome demand constraints, supply constraints, and policy constraints.

In spite of the potential benefits identified above, international experience shows that promotional efforts are often needed to encourage the adoption of electrical equipment for production (Finucane, Bogach, and Garcia 2012). A major evaluation of World Bank-assisted rural electrification projects concluded that simply providing an electricity connection did not lead to adoption of electrical equipment in businesses or significant development impacts (IEG 2008). The U.S. National Rural Electric Cooperative, with many years of experience worldwide, recognizes that increasing the productive uses of electricity is a long-standing challenge (NRECA International, Ltd. ND).

The reasons why adoption of electrical equipment requires promotion relate to (a) the nature of rural producers and the markets for their products (demand constraints); (b) the characteristics of rural electricity supply (supply constraints); and (c) tariff and regulatory issues (public policy constraints).

Demand constraints include:

- **Limited market opportunities.** The local market may not be able to absorb the expected increase in production from use of electrical equipment.
- **Limited access to information.** Producers may lack knowledge about business opportunities or technology options (electrical equipment types, sizes, brands, local availability), or how to connect to the grid. In a survey on productive uses in Indonesia, this was the main barrier identified.
- **Lack of technical and management skills.** Adopting a new technology may require know-how that rural producers lack. They may not have the skills to present a business plan to financing institutions. In rural areas, qualified technicians may not be available to maintain equipment.
- **High investment costs and limited financing.** Producers may face high upfront costs for grid connection and new equipment. Credit to finance those costs may be scarce in some rural areas.

Supply constraints include:

- **Unreliable electricity service.** An unreliable grid poses threats to equipment from voltage fluctuations and interruptions and can prevent realizing a return on investment in electrical equipment. For example, ice cream factories in semi-rural areas in Sri Lanka and Bangladesh grew quickly but continued using small-scale generators due to the unreliability of the grid (IEG 2008).
- **Physical limitations of rural grids.** Most rural distribution systems use single-phase circuits (two-wire configurations with a neutral conductor or single-wire earth return). Such lines can accommodate small-scale applications such as sewing machines and refrigerators. However, the motors needed for many productive uses can create problems on such systems. Motors have high starting currents (often six to ten times their running currents) that can cause a voltage depression on start-up. As a result, many utilities limit the size of the motors that can be run on rural circuits.
- **Minimal service by rural utilities.** Utilities serving rural areas often provide minimal service, focusing on connections, billing, and collection. Many have no staff to help rural producers select electrical equipment or design connections and facilities.
- **Low distribution company revenues and viability in rural areas.** Utilities often incur high costs but earn low revenues in rural areas owing to a combination of low levels of demand, the lack of cost-reflective tariffs and the absence of compensating subsidies. The result is poor quality and minimal service.

Public policy constraints include:

- **Tariff issues.** Rural tariffs may not fully cover costs, discouraging utilities from promoting demand. Tariff structures may discourage productive uses of electricity. In Peru, for example, users with demand of less than 100 kWh per month are entitled to a graduated cross-subsidy. If they increase consumption, they may lose all or part of that subsidy.
- **Electrification targets and system designs that focus on access and ignore motorized uses.** When programs focus only on numbers of connections, system designs often use least-cost single-phase or single-wire earth return distribution lines. As noted above, such lines often limit the use of motors that are essential for common applications such as grinding, milling, pumping, and sawing.

- **Lack of evidence linking productive uses of electricity to socioeconomic development.** Data on the results of promoting productive uses of electrical power has focused on increases in demand for electricity and producers' output. There is a lack of data and evidence-based conclusions on the broader effects—on income generation, health, and education—of expanding the productive use of electricity.
- **Electrification seen as an end in itself.** Rural electrification must be seen not as an end, but as a means of promoting rural development and the well-being of rural populations.
- **Lack of coordination with other development efforts.** Too often, electrification is not coordinated with efforts in other sectors, such as health, education, agricultural extension, or small-industry development programs.

Target areas and communities were selected based on criteria that included a surplus of electricity supply, 24-hour electricity service, adequate physical infrastructure, availability of complementary support services and programs, and, most importantly, the presence of small enterprises with potential to increase electricity consumption.

Can those constraints be overcome?

Peru has achieved good results by promoting productive uses of electricity

Over the last decade, Peru has made a concerted effort to increase rural electricity coverage, introducing the Rural Electrification Law of 2006 and establishing, in 2007, the General Directorate of Rural Electrification (DGER) within the Ministry of Energy and Mines. From 2007 to 2015, electricity coverage increased from 29 to 78 percent in rural areas and from 74 to 93 percent nationally (Ministry of Energy and Mines 2016).

The DGER's National Plan for Rural Electrification 2016–25 recognizes that the promotion of productive uses of power fosters economic and social development. The plan aims to exploit that potential through capacity building and education of rural producers in coordination with other government agencies in value chains such as coffee, cocoa and grain processing, bakeries, livestock and dairy production.

Peru's rural electrification efforts have included two World Bank-assisted Rural Electrification Projects implemented by the DGER (known as FONER I and II) that have led the way in establishing the importance of productive uses of electricity. FONER I was carried out between 2006 and 2013; FONER II closed in August 2017. Together, the two projects provided electricity access to more than 597,100 rural residents, increasing national rural electrification coverage by 8.2 percent. Through the FONER projects, distribution companies received capital cost subsidies to establish 124,300 new connections through grid extension, while an additional 18,900 households, small businesses, and public buildings obtained regulated electricity service from individual household solar photovoltaic systems owned and maintained by distribution companies. The two projects also helped more than 25,000 family businesses adopt electrical equipment that increased their productivity. The Bank's Energy Sector Management Assistance Program (ESMAP) provided technical assistance to support the projects. DGER's productive uses activities were designed using previous experience in Indonesia (box 2).

Box 2. Promotion of productive uses of electricity in Indonesia

Two World Bank–assisted rural electrification projects in Indonesia (RE I & II) pioneered the application of business development services for productive uses of electricity. Implemented by the national utility, PLN, the projects reached out to small businesses through nongovernmental organizations that addressed lack of information, tariff barriers, and service quality. Impact studies showed that 66,000 enterprises adopted electrical equipment under the RE 1 project, and more than 20,000 jobs were created. "Outsourcing" to NGOs was an effective way to reach individual producers, although the program did not take hold as hoped within PLN.

Source: Fishbein (2003).

Promotion of productive uses under Peru's FONER I and II projects was carried out through a series of activities in specific geographical areas selected for the presence of productive activities and the willingness of the distribution company to participate (Finucane, Bogach, and Garcia 2012). For each activity, the DGER first signed a memorandum of understanding with the distribution company. It then signed a contract with a competitively selected local NGO to assess the market for productive uses of electricity and carry out promotional activities to increase them, in collaboration with the distribution company and other local development efforts. Key elements of the approach are described below.

Selection of the communities. Target areas and communities were selected based on criteria that included a surplus of electricity supply, 24-hour electricity service, adequate physical infrastructure, availability of complementary support services and programs, and,

The activities targeted were chiefly small-scale operations in agriculture (e.g., coffee, cacao, grains, cereals, fruits, livestock, dairy); and off-farm activities (e.g., artisanal mining, textiles, carpentry, metal working, bakeries, ceramics, transportation, and distribution). Throughout the country, a total of 600 interventions increased electricity demand by 22.3 GWh per year, exceeding the target of 19.5 GWh.

Figure 4. Power-assisted brick making

most importantly, the presence of small enterprises with potential to increase electricity consumption.

Memorandum of understanding with distribution companies. Distribution companies were selected based on their interest in promoting productive uses. The DGER signed an agreement with each company, establishing its role and responsibilities.

Time-limited contracts with NGOs. The project team in the DGER competitively procured the services of an NGO for promotional activities in each area. The NGOS were key actors and change makers, given their links with the communities, field experience, and motivation for social development. They tailored their approaches to the communities and their own skill sets, using innovative methods like live theater performances to attract attention. The contracts had two phases. Phase 1 consisted of about three months for surveys, assessments, coordination with other programs and sectors, and identification of opportunities. The program then negotiated with the NGO performance targets for Phase 2 based on the analysis of Phase 1. Phase 2 consisted of about nine months of capacity building of individual producers and cooperatives and implementation of business plans.

About a third of the producers that benefited from the productive uses promotion were women. This came about naturally, as women entrepreneurs are active in bakeries, dairy production, ceramics, and textiles and are represented in most other types of productive activities in Peru.

Figure 3. Coffee processing with the aid of electricity

Business development services. The NGOs helped small enterprises address constraints using business development techniques that included: (a) deployment of strong field-based teams; (b) analysis of market opportunities for electricity based on productive chains; (c) assistance in preparing business plans and obtaining credit from financial institutions; (d) targeting of low-risk agriculture-based businesses; (e) integration with other projects, sectors, and government programs; and (f) coordination with distribution companies on how to provide adequate connections.

Collaboration with other actors and programs. The success of the small NGO teams depended on active collaboration with other actors such as other government programs and agencies, municipalities and local associations, and finance organizations that provided credit for equipment and electricity infrastructure.[2] An institutional platform was created for the project.

Activities targeted. While the activities targeted varied by region, they were chiefly small-scale operations in agriculture (e.g., coffee, cacao, grains, cereals, fruits, livestock, dairy); and off-farm activities (e.g., artisanal mining, textiles, carpentry, metal working, bakeries, ceramics, transportation, and distribution) (figures 3 and 4). In Cuzco, the main productive activities included grain milling, coffee processing, agricultural processing, and milk products. 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.

Leadership within the project team. Essential to the success of the entire effort was an effective productive-uses coordinator on the FONER team who maintained close contact among the parties and supervised the activities of the NGOs and distribution companies.

What does the work in Peru show us?

Promotion of productive uses of electricity in rural areas worked and benefited producers

Under FONER I and II, the DGER carried out seventeen contracts with ten NGOs working together with eleven distribution companies in eighteen Peruvian provinces, benefiting more than 25,000 family productive units. The productive uses program was active in all three major geographical regions in Peru—the dry, flat, coastal desert plains, the highland areas of the Andes, and the Amazonian rainforest. The NGOs developed a business plan for each value chain identified. Throughout the country, a total of 600 interventions under both projects increased electricity demand by 22.3 GWh per year, exceeding the projects' combined targets of 19.5 GWh.

An impact evaluation of the productive uses component of the FONER I Project estimated that its promotional activities increased the average electricity consumption of the participating producers from 56 to 240 kWh per month, an increase of more than 300

[2] Partners include INAI (Instituto Nacional de Innovación 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), Ministry of Agriculture, and local universities and technical institutes.

Peru's success could be replicated where similar conditions exist. These conditions include: (a) broad-based economic growth that reaches into rural areas; (b) strong NGOs that are active in rural development efforts; (c) adequate infrastructure and availability of financing for rural productive investments; and, (d) willingness of distribution companies to make productive connections.

percent. Participating producers reported a number of benefits: more productive hours during the day (56 percent); higher levels of production (39 percent); better product quality (40 percent); and higher market prices (39 percent). A comparison between producers that benefited from the productive uses interventions and those that did not estimated that the producers under the project had higher net gains of about S/. 130 per month, a project-related increase of 18 percent (Prisma, Macroconsult, and Instituto Cuanto 2016).

About a third of the producers that benefited from the productive uses promotion were women. This came about naturally, as women entrepreneurs are active in bakeries, dairy production, ceramics, and textiles and are represented in most other types of productive activities in Peru. For example, FONER I assisted an association of women in adapting its electrical installations to the requirements of idle productive machinery to increase production of bakery products, especially cookies, made from kiwicha (amaranth seed), a high-nutrition traditional crop native to Peru, and to more effectively brand, label, and market the goods.

The incorporation of productive uses into the National Rural Electrification Plan and the availability of funds for capacity building from Peru's Rural Electrification Fund provide a foundation for the DGER and the electricity distribution companies to continue promotion of productive uses after FONER II closes.

DGER held an international forum on Peru's productive uses promotion experience in Lima in November 2016. The 200 attendees included participants from Argentina, Bolivia, Colombia, Germany (GIZ), Haiti, and the United States (NRECA). Conclusions from the forum are reflected in this brief.

Could Peru's experience be replicated?

Yes, where supportive conditions exist

FONER's success could be replicated where similar conditions exist. These conditions include: (a) broad-based economic growth that reaches into rural areas; (b) strong NGOs that are active in rural development efforts; (c) adequate infrastructure and availability of financing for rural productive investments; and, (d) willingness of distribution companies to make productive connections. Lessons from Peru are summarized below.

Rural electrification authorities must lead the effort to promote productive uses of electrical power by integrating productive uses into efforts to extend the rural grid. They must organize business development services to actual and potential producers; ensure that distribution companies address the demands and constraints of productive users; modify rural distribution systems to foster productive uses; and adapt regulatory practices to cover rural marketing costs and the costs of infrastructure.

Distribution companies must support the promotion of productive uses by providing quality service in rural areas, responding to requests for connections for productive uses, and sharing in the cost of those connections, based on regulations.

Change agents are needed. Rural electrification programs need to contract NGOs or similar agents of change to interact with individual producers as distribution companies cannot be expected to lead the work of promoting productive uses with individual rural producers. The structure of the NGO contracts was one key to success in Peru, especially their results-based and phased approach. Also key was the flexibility given to NGOs to apply their particular strengths.

While opportunities may be easy to identify, constraints need to be addressed. In the FONER projects, finding opportunities for adoption of electrical equipment by existing producers was relatively easy. Peer-replication worked well, once first adopters set a strong example. Financing was accessible after solid business plans were prepared. The degree to which markets would absorb increased production was not known ahead of time, but this potential constraint proved less serious than expected.

The potential of monitoring and reporting needs to be fully exploited. Monitoring beneficiaries for 1–2 years after adoption of electrical equipment would increase knowledge of impacts. To assess broader impacts, it would be useful to introduce additional indicators such as increased production and income and employment generation.

Change agents are needed. Distribution companies cannot be expected to lead the work of promoting productive uses with individual rural producers. The structure of the NGO contracts was one key to success in Peru.

What can we conclude?

Promoting productive uses of electricity can enhance producers' results while simultaneously improving the viability of electricity distribution

The promotion of productive uses of electricity can significantly improve productivity in rural areas. Experiences in World Bank-assisted projects in Peru and Indonesia have shown that such promotion can have a significant effect on: (a) adoption of electrical equipment in rural areas (66,000 enterprises adopted equipment through Indonesia's RE I and 25,000 through Peru's FONER I and II); (b) electricity use (an estimated 300 percent increase annually per participating producer in Peru's FONER I); (c) income and employment in rural enterprises (an increase in monthly income of 18 percent by participating producers through RE I in Peru and an additional 20,000 jobs through RE I in Indonesia).

Rural electrification programs need to actively promote productive uses of electricity. Between 2000 and 2014, however, only 16 of 278 World Bank electricity-sector projects (about 6 percent) included indicators in their results frameworks for tracking productive uses and increased income associated with electricity access (IEG 2015). Fewer projects included active promotion of productive uses.

Standards and regulations for rural electrification need to be adapted to support productive uses. Designs of rural electrification systems must support productive uses of electricity (such as three-phase electric motors), not just lights and a few appliances. The costs of providing adequate levels of service in rural areas need to be reflected in rural tariffs. Rural tariffs also need to encourage productive uses, including lower tariffs for larger-scale demand or off-peak electricity consumption.

NGOs have proven to be successful agents of change in programs to promote productive uses of electricity. They can work directly with producers and coordinate among stakeholders, including other government programs, as a natural extension of their development activities. Other change agents could be small business development centers, microfinance institutions, programs that provide credit to small and medium-sized enterprises, small business accelerators, and chambers of commerce.

Collaboration with other actors and availability of complementary infrastructure increase probability of success and impact. Promotion of productive uses depends on collaboration with actors outside the electricity sector such as agricultural and rural development programs, municipalities, and local associations and finance organizations. Success is more likely in places that have achieved a certain level of development and where complementary infrastructure (transport, water supply, and ICT services) and services (e.g., availability of credit) already exist (Fishbein 2003). Credit and concessional loans programs allowed local entrepreneurs to explore possibilities for electrification in India and Sri Lanka; while knowledge and training on how to use new-found electrical and motive power increased profitability for households under the Nepal Home Employment and Lighting Package (IEG 2008).

Assessment of the broad impacts of promoting productive uses needs to be strengthened. More evidence is needed that links adoption of electrical equipment to increased economic activity and well-being. Monitoring of electrification programs has focused on sector outputs (connections, kWh sales) rather than outcomes (income creation, employment). Impact evaluations and other research could investigate and measure the channels through which electricity increases economic activity, raises incomes, and improves livelihoods at levels beyond the firm and the household level (GIZ, BMZ, ESMAP, and AEI 2013). Research could test whether a given intervention created desirable effects such as provision of new higher-value goods, more-efficient processing of local raw materials, and transfer of production from urban to rural areas—or whether it simply reallocated incomes among different producers (EIUI PDF and GIZ 2011).

The demonstrated benefits to rural producers and electrical utilities already justify the inclusion of strong efforts to promote productive uses in electrification programs. If rural people are to be fully integrated into modern economies, rural electricity systems must facilitate a broad range of productive uses beyond providing power for lighting and basic household appliances.

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