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Profits and Productivity: Stimulating Electricity Demand in Low-Income Settings

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Review

This policy brief has not undergone a formal review process. It is intended to inform a discussion on emerging opportunities in stimulating rural electricity demand.

Summary

As electricity companies in low- and middle-income countries move deeper into rural regions, the cost of new connections generally increases while the electricity demanded by these new customers remains lower than urban and peri-urban customers. This is a challenging dynamic for utilities looking to sustain their financial health as well as for governments tasked with engineering viable strategies for achieving universal electrification. Off-grid platforms like solar home systems and minigrids have entered this market, developing innovative approaches to serving these populations that promise to scale up to help meet the needs of the one billion people around the world still lacking electricity access. The creative partnerships and complementary services these off-grid providers are pursuing provide important lessons for larger utilities. Yet the primary driver for new electricity connections—the grid—will continue to play an important role in closing the access gap, especially in places where serving commercial, industrial, and other productive loads is a priority. Countries with national utility companies facing massive debt, stagnant revenue, and overcapacity must develop strategies for maintaining fiscal health, ideally in a manner that facilitates rural income growth and development.

This brief provides a snapshot of the relevant demand-stimulating lessons learned in the off-grid space as well as those that have been pursued by governments and utilities in the past order to help answer the critical questions:

What is preventing rural customers from increasing their electricity demand? How can governments, utilities, NGOs, and companies come together to foster the greater use of energy services?

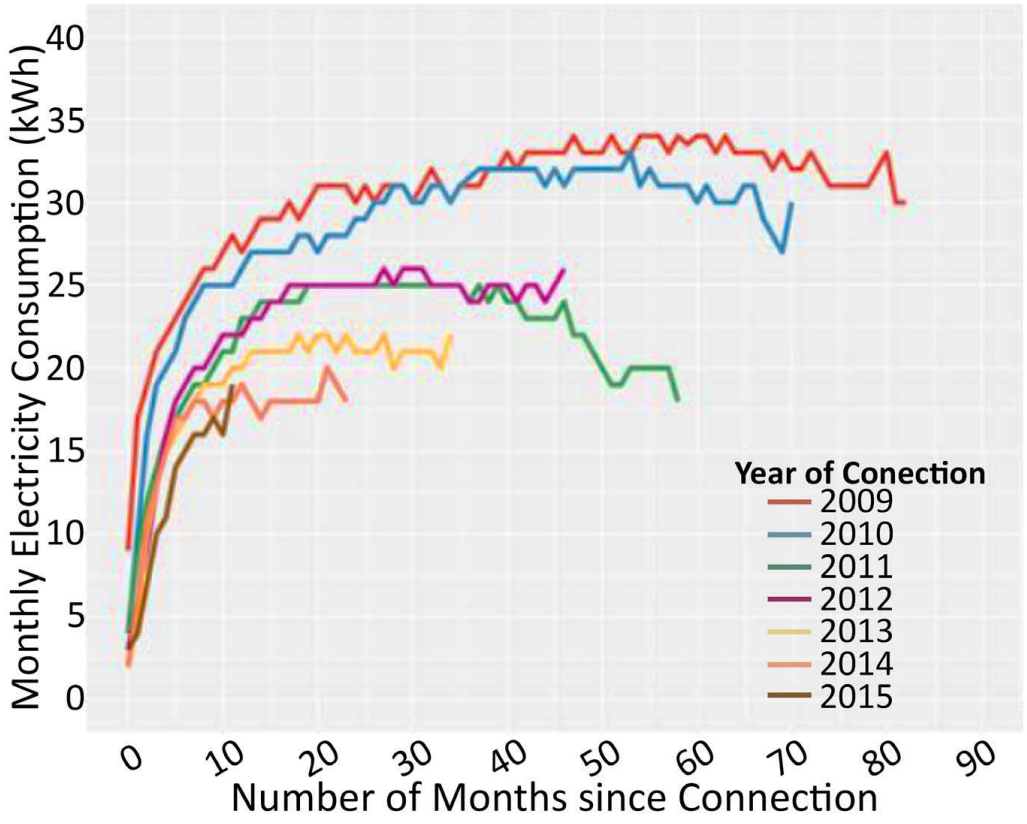
INTRODUCTION

Utility companies in sub-Saharan Africa are drowning in debt. All but 2 of the 39 utility companies in the region are loss-making ventures and cumulative budget deficits are estimated at $20 billion annually (Babungi and Skierka 2019). Many utilities, driven by ambitious government mandates, are expanding their systems rapidly. While distributed solar companies—predominantly solar home system providers and minigrid developers—are scaling in some places, upwards of 94% of the roughly 100 million new connections achieved annually around the world are delivered via the main grid. However, many utilities are finding that once connected, these hard-to-reach households generate extremely limited or, in some cases, no new demand (IEA 2017).

Concurrently, the focus of governments and the international community in strengthening the power sector has led to the development of significant amounts of new generation capacity. Many countries now face or will soon be facing overcapacity situations. In short, utility companies in many low-income countries are driving the grid deeper into more rural, lower-consuming communities and taking on significant power purchase commitments and massive loans from multilateral development banks to do it.

This is proving a dangerous recipe for operating utility companies. Kenya and its distribution utility, Kenya Power and Light Company (KPLC), illustrate the challenge. Kenya's access rate has increased remarkably from 8% in 2000 to 73% today, and its current plans aim to deliver universal access by 2022 (Cozzi et al. 2018). Over the last three years, KPLC has doubled its number of customers, adding an average of more than one million new connections annually. However, most of these expensive new connections generate little revenue. Anecdotally, estimates are that more than one million customers are using no power at all. Mounting debts to pay for expanded infrastructure, coupled with stagnant sales is forcing short-term borrowing to maintain solvency. Payments to generators are being delayed, adding costly penalties and undermining the utility's credibility as an off-taker (Alushula 2018).

Figure 1: Monthly Electricity Consumption after Connection



Source: Taneja, J. "Growth in Electricity Consumption in Kenya and the Implications for Energy System Planning." Presented at the 2018 Sustainable Energy Transition Initiative Conference, Durham, North Carolina, May 17, 2018.

These trends—expanding utility debt, poorer customers consuming smaller amounts of power, and excess capacity—represent a rising challenge that many countries and utilities must find ways of addressing.

Over the long-term, it appears certain that declining technology costs and uptake of key connectivity platforms, including mobile money, mean that off-grid models like solar home systems and minigrids may be the preferred method for delivering electricity access to those currently without. But in the near term, utilities remain the backbone for providing electricity to residential, commercial, and industrial enterprises and their deteriorating health in many countries calls for careful consideration of policies and programs that can help to bolster rural demand.

This problem is not new. Countries that have successfully achieved universal electrification in the past have often also incorporated strategies to help support a healthy state utility. A part of maintaining the financial health of the public utility has been building a base of customers with high electricity demand, which can be challenging as electrification projects move into rural areas where incomes are lower and there are fewer productive loads (Haanyika 2006). Large countries such as the United States and China have proactively addressed low rural demand through strong government intervention. In the 1940s–1950s the U.S. aggressively targeted farmers with information about how electrical equipment could improve their lives, offering demonstrations and financing for equipment and appliances (Kline 2000). China focused on electrifying agricultural processes through micro-hydro minigrids, increasing demand in tandem with economic productivity (Bhattacharyya and Ohiare 2012). More recently, Laos has targeted lower electricity tariffs at the rural poor, as well as irrigation and industrial customers, with the aim of increasing demand while supporting economic development (World Bank 2012).

This policy brief reviews these and other programs designed to support financially viable rural electrification systems and provides a snapshot of the relevant demand-stimulating lessons learned more recently in the off-grid space. We will examine the key barriers to growing rural demand, approaches, and programs that governments and broader stakeholders may consider for addressing them and highlight important areas for further inquiry.

BARRIERS TO GROWING DEMAND

The key barriers to increasing rural electricity demand cut across social, technical, and economic dimensions:

(1) **Insufficient demand for equipment**. Areas with small markets may not offer enough demand for energy-intensive industries, such as brick-making or paper-making. Increasing electricity demand is much easier in areas that have conducive infrastructure (e.g., roads, access to markets) and economic opportunities (e.g., secondary agricultural processing) (Usmani and Fetter 2019).

(2) **Weak supply chains and lack of awareness**. Where there may be demand for such products, rural markets often have little access to equipment and appliances to direct towards those productive end uses (McCall and Santana 2018). Without exposure to these technologies, households and enterprises may be unaware of the potential uses of electricity.

(3) **Lack of financing**. When customers do have access to appliances and are in circumstances where they could deploy them productively, they often encounter high upfront costs and no access to credit financing (Fishbein 2003; McCall and Santana 2018).

(4) **Willingness to pay and awareness of operating costs**. After an energy-intensive device is purchased, high electricity costs can inhibit regular usage of the equipment or appliance (McCall and Santana 2018). While solar home systems can operate small appliances with nearly zero operating costs, grids and minigrids charge a tariff that can be expensive for rural customers (Fishbein 2003; Cook 2013). Further complicating the matter, willingness to pay can differ widely across energy services. Therefore, knowledge of the cost of power and the consumption level of devices influences peoples' willingness to use appliances they already own.

(5) **Reliability**. Electricity service reliability is also a key predictor of electricity use. Utilities that increase the number hours of electricity service see higher rates of customers opting to connect and higher demand for electricity (Agrawal et al. 2019). This is due in great part to the fact that some appliances and equipment require continuous service to be viable. For instance, until electricity reliability is sufficiently high,

refrigerators are unable to keep food adequately cooled and become useless. Irregular electricity can also damage appliances or otherwise raise costs of obtaining protective equipment. At the firm level, energy-intensive industries suffer when electricity service is unreliable, forcing businesses to curtail production or self-generate more costly power. Both outcomes undermine firm competitiveness, which inhibits job creation and damages the broader economy (Adenikinju 2003; Alam 2013; Ado et al. 2005; Allcott et al. 2016).

APPROACHES FOR GROWING DEMAND

Cross-sector policy development

The primary means of addressing these challenges is to integrate the needs of multiple sectors into electrification plans, and vice versa (Odarno et al. 2016). Evidence suggests that linking electricity use to other development programs improves program outcomes. For instance, much of China's success in developing rural demand came from linkages between electrification expansion and agricultural intensification (Bhattacharyya and Ohiare 2012). In Vietnam, initial electrification focused on productive and agricultural uses of electricity, and even the Fifth Power Development Master Plan (2000–2010) gave priority for grid expansion to areas with the potential to enhance agricultural productivity and economic development (World Bank 2011).

Targeting programs to high impact areas

The latest research suggests that the economic potential of electricity, and increases in electricity demand, occur in contexts where other infrastructure and economic factors facilitate this demand (Usmani and Fetter 2019; Morrissey 2019; Jeuland et al. 2019). Contextual factors include local industry, proximity to markets, and proximity to quality roads. By targeting programs to these areas, a program increases its likelihood to impact the local economy and stimulate local electricity demand. However, aiming to achieve maximum impact with electrification investments must be balanced with equity concerns. Targeting more isolated, lower-income regions that score low on the aforementioned contextual factors represents a greater challenge from the perspective of growing electricity demand, but it would contribute to other important goals.

Identifying relevant equipment and appliances

Governments are in a position to support expanded availability of electric-powered technologies that can improve economic growth and rural demand (McCall and Santana 2018). One means to do this, either directly or through supporting a third party, is to create and make available databases of electricity end-use equipment that may be relevant to different customers or business sectors (Odarno et al. 2016). Such databases can aid cross-sectoral policy making and inform private capital flows aiming to build productive equipment distribution channels. In Senegal, a top down approach was used, bringing together a group of experts on different areas of productive use to recommend which electric equipment should be made available and what policies were needed to support those supply chains (Odarno et al. 2016). Another approach could use field surveys or equipment distributer sales data to identify which technologies are already being used in some markets, in order to promote their use in other areas with similar features.

Bulk purchasing programs and supply chain support

To address the high upfront cost of appliances and equipment in the U.S. in the 1930s and 1940s, a government agency called the Electric Home and Farm Authority was created in conjunction with rural electrification cooperatives in order to support the purchase of home appliances. The agency used bulk purchasing from appliance makers to lower costs and made appliances available for purchase with the help of loans through local cooperatives. Such programs also address issues of access to appliances, which can be limited by end user access to rural markets and underdeveloped supply chains. Supply chains can also be supported through market research that maps the current supply chain networks, appliance pricing, and market size estimates (E4A 2017).

Roadshows and customer education

Evidence suggests that households and enterprises in areas where electricity access is relatively new are often not aware of the potential of electricity services, or aware of the services that electricity can provide (Peters et al. 2009). In the U.S.

example above, the Rural Electrification Administration organized appliance roadshows to increase awareness of these technologies, displaying the latest appliances and educating end users in how they could benefit from them (McCall and Santana 2018). Although some governments are still involved in information campaigns, like India's 2014 Total Sanitation campaign, NGOs and social enterprises have been taking the lead in sharing information about appliances (see, for example, DharmaLife's Lighting Up Young Minds campaign) (Hammer and Spears 2016).

This is important because evidence suggests that knowledge about appliances and other new technologies is a major driver to purchase (Pattanayak et al. 2016; Filippini et al. 2019). Households in India that read information brochures or attended improved cook stove demonstrations were found to purchase such devices at a significantly higher rate (Pattanayak et al. 2016).

Business development programs

Rather than focusing on productive equipment identification through a top-down approach, another way to address low rural demand is to actively promote and grow local economies through business development programs that focus on building the capacity of enterprises to use energy productively. These programs have been successfully implemented in Indonesia and Peru, and some evidence exists to link these programs to increased demand (Finucane et al. 2002; Fishbein 2003). For instance, Indonesia's rural electrification program in the 1990s focused on outreach to small businesses through NGOs offering small business consulting services. Surveys suggested that enterprises that were customers of the national utility had limited knowledge of the costs of electricity access and technical aspects of relevant electrical equipment. In order to address this issue and increase power usage, the utility contracted NGOs to work with small enterprises to provide guidance on how to incorporate electricity into their business. The utility assisted 66,000 enterprises, which led to the creation of over 20,000 jobs (Fishbein 2003).

Case Study: Peru's Business Development Program

In 2006, the World Bank supported a rural electrification program in Peru modeled on the Indonesian program that included a pilot program to increase productive end uses of electricity in rural areas. The program, run as a partnership between the distribution utility and NGOs, assessed potential uses of electricity in the market and offered business development services reflecting those opportunities. The results from the three pilot projects, covering 4,760 microenterprises, estimated an increase in electricity use of 1,863 MWh/year (Finucane et al. 2002).

Financing for equipment and appliances

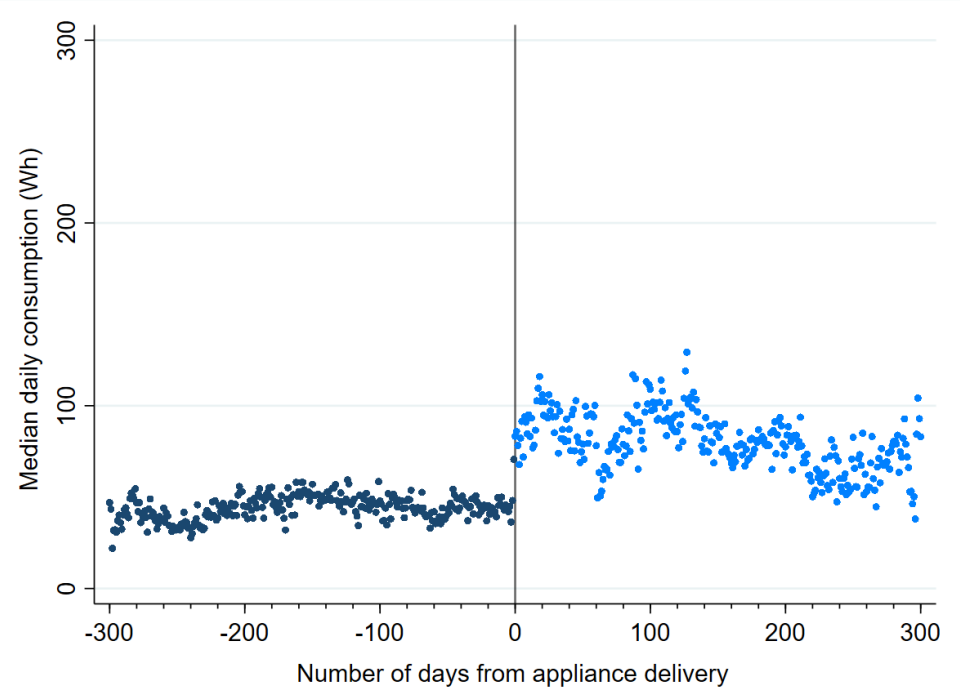
A complementary approach to addressing high upfront costs of equipment is to provide financing to end users for equipment and appliances, which can be paid back over time (McCall and Santana 2018). Appliance-specific financing was successfully implemented in Colombia and other Latin American countries and is increasingly being introduced to the off-grid space through organizations such as Brightlife (Ghalib et al. 2011; Attanasio et al 2015; Garone et al; 2019). This financing is able to extend its reach through mobile money systems and digital financial services, as in Uganda, where mobile phone penetration is at a higher rate than energy access (55% vs. >20%) (UOMA 2019).

In a pilot project funded by the Rockefeller Foundation and implemented by CrossBoundary in partnership with the Duke University Energy Access Project, appliances purchased through a financing scheme have been found to roughly double household electricity consumption in communities served by minigrids in rural communities in East Africa, although the demand increase appears to settle closer to 50% after several months of appliance use (see Fig. 2). These types of programs have the added benefit of establishing credit for households who previously may have had no access to credit.

Case Study: Colombia's Tarjeta Somos Program

In 2009, the public utility of Colombia, Empresas Públicas de Medellín (EPM), implemented the Tarjeta Somos program, which offered a credit card for customers to purchase appliances and home improvements. Financed by the Inter-American Development Bank, the program aimed to provide access to credit for low-income populations outside the formal banking system (Garone et al. 2019). The program was successful in increasing the number of home improvements and purchases of durable goods, such as washing machines (Azevedo et al. 2019). Card holders ended up being 10% more likely to own a washing machine (Azevedo et al. 2019, p. 17).

Figure 2: Impact of appliances on electricity consumption



OPPORTUNITIES FOR LOW-INCOME COUNTRIES

Integrating electricity and agricultural development

Rural economic development depends in great measure on improving the efficiency, quality, and quantity of agricultural outputs (Ade Freeman et al. 2004). Globally, agriculture and food supply chains accounts for nearly a third of the world's energy consumption. With many informal rural jobs tied to agriculture, using energy more productively in this sector could not only boost rural power demand but also have major impacts on rural income generation as well (REEEP 2017). Electrification of irrigation drives improved crop yields, and the electrification of agricultural processing and storage can increase locally procured agricultural products and drive revenue creation (Powering Agriculture 2016).

The mechanization of food processing such as milling cereals, has increased agricultural incomes in a pilot study in Mali by $0.32/day (Porcaro and Takada 2005). Many grid-connected areas have not tapped into electricity's agricultural potential. This is in part because poor electricity reliability and high equipment costs limit the incorporation of power into the production and processing of low-margin crops, such as cotton (Machado Mendes and Paglietti 2015). This is a missed opportunity for capturing local revenues. Prospective pilot programs could integrate agricultural uses into their work. One option would be to incorporate demonstrations of electrified agricultural equipment (whether irrigation, or light processing like mechanized milling) into information campaigns. Another possibility might be to pilot lower tariffs in conjunction with subsidizing electrified agricultural equipment.

Finally, mobile technology can address information issues as well as financing barriers. Startups already exist to connect farmers to improved agricultural information, and the increasing access to mobile money also offers an opportunity to market mechanized agricultural equipment directly to farmers. A pilot that connects pay-as-you-go financing for pumps and refrigeration through mobile money and mobile services targeted at farmers may increase their uptake, and increase rural demand. In all cases, impact evaluation of these pilot interventions is critical to determining the costs and benefits of expanding such programs.

Private-public partnership for appliance financing

In order to address the challenge of high appliance costs and low access to appliance markets utility companies could become partners in an effort to sell appliances with financing to customers. Given utilities' consumer data and distribution

capability, they would be a valuable partner in identifying pilot communities and reaching rural customers with additional consumer goods.

This could take the form of a private-public partnership that would connect rural customers to appliances and appliance financing, promoting the uptake of energy-consuming devices with high upfront costs. Utilities could offer their customer data and distribution network, and partner with financing organizations and appliance partners to supply the products. One way to think of this is as an on-grid version of the Mini-grid Innovation Lab approach mentioned above, which is piloting appliance financing to households living under new minigrids in East Africa (Khan 2018). To ensure replicability and clarify the relative importance of the many variables in play, such an intervention should be designed carefully, and its impacts evaluated.

Another approach could be to strengthen supply chains for these appliances could be done through mapping where customers have grid access, where relevant nodes of the supply chain exist, and creating a geospatial model to provide market intelligence to potential new market entrants (E4A 2017, p. 13).

Appliance information campaigns

An appliance promotion campaign—either run through the utility or a third-party organization—could increase consumer awareness and demonstrate how specific appliances and equipment could support households and businesses in specific locations. This could be implemented in tandem with the opportunity above. Such information campaigns could be integrated with different geospatial models and willingness to pay for electricity data to target those communities with the optimal demand and income profiles or potential opportunity for productive end uses. Agricultural end uses in particular offer an opportunity. Many farmers or secondary agricultural processes could benefit from electric equipment, but limited information about their operations and maintenance costs make such purchases risky. Demonstrations in market areas or in denser populated farming communities could improve trust in the appliances, promoting purchases and increasing rural electricity demand. This campaign could also take advantage of the high mobile phone and social media use in many low-income countries to disseminate information to consumers (Aker 2011).

The efficacy of the information campaign can vary by the channel through which information is shared. It would be critical to measure and test the effectiveness and impact of different channels and innovative approaches, such as the targeted distribution of appliances to key influencers in communities who could then disseminate information to other consumers through formal and informal networks. Likewise, women and men use different appliances, and so information campaigns must target both the purchaser and the beneficiary to maximize interest in the product (Khalid and Sunikka-Blank 2017; Sunikka-Blank et al. 2019). It is crucial to be mindful of which channels are being used to share information, such as women's groups or town halls.

Additional work around understanding willingness to pay (WTP) for particular energy services could also be valuable on a number of fronts, including for developing more effective appliance campaigns. Anecdotally, some off-grid power providers believe a rural households' WTP for phone charging may frequently be on the order of $20/kWh or more, while WTP for boiling water, operating a refrigerator, and other services is closer to $0.10/kWh or less. Measuring service-based or application-based differentials in WTP could be a breakthrough for accelerating access to appliances and equipment with higher relative WTP.

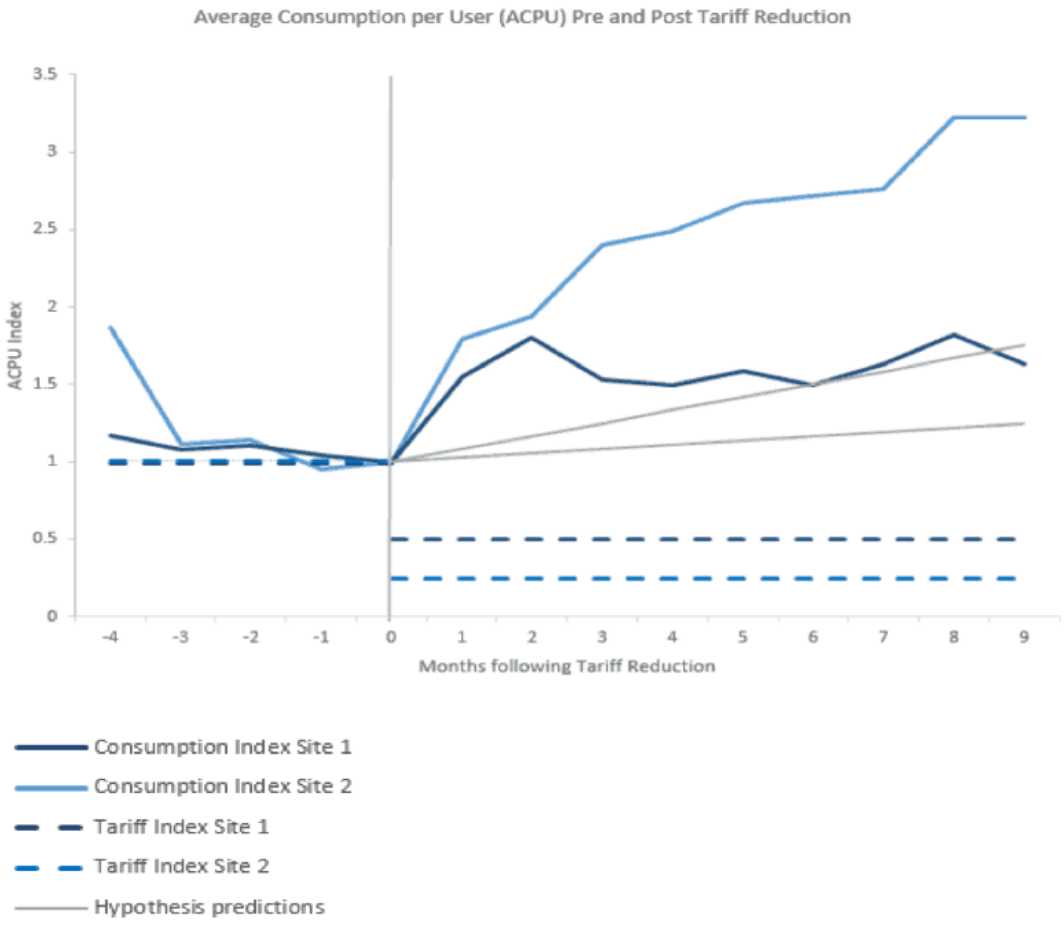
Prioritizing the reliability of target zones of potential development

Given the increasing evidence that economic development and electrification go hand-in-hand in areas with facilitating infrastructure (roads, market access) and economic opportunity (secondary agricultural processing, nonfarming activities), piloting some of the aforementioned programs or promoting reliability in these areas could improve their impact. It is important to note that this brings up equity concerns about who should receive limited resources. However, using these priority areas for impact evaluation through academic partners could offer important evidence on the relationship between electricity access, other key enabling factors, and productivity growth. Satellite imagery and machine learning tools being developed at Duke and elsewhere can be applied to identify areas of potential high impact.

Trial tariff interventions

The impact of price on electricity demand varies across income levels. Interventions could be conducted to test the impact of different tariff rates on rural electricity demand. When electricity prices are changed, how much does it impact the amount of electricity that the average rural customer uses and the uptake of appliances and equipment? Some preliminary evidence suggests that lowering tariffs may still allow companies to make similar revenues, as the perception of lower costs encourages customers to use more power. This was the case in the tariff intervention introduced by the Mini-Grid Innovation Lab, which lowered tariffs in two minigrids by 50% and 75% and found that consumers responded by significantly increasing consumption.

Figure 3: Consumption on a minigrid before and after tariff reduction



Source: Davies et al. 2019

As illustrated in Figure 3 above, for every dollar saved by consumers through the tariff subsidy, they increased their spend on electricity by $0.93, suggesting that customers are very sensitive to price, and that reductions in tariffs may still allow for similar cost recovery (Davies et al. 2019). It should be noted that this example comes from a minigrid case study, but minigrid customers have a similar profile to other rural customers, being remotely located, having less experience with electricity, and being comparably poorer than urban and peri-urban customers. Therefore, piloting tariff reductions in rural areas may improve demand use and improve revenues over the long-term.

Duke University, in partnership with the Ethiopian government and the Ethiopian Development Research Institute, is currently evaluating the impact of tariff reforms being implemented there in order to understand how businesses and consumers react to changes in tariffs through efficiency improvements and changes in consumption or production.

CONCLUSION

As governments and companies increase their efforts to electrify those without access, the challenge of low rural demand will persist. Governments and utilities need rural customers to take advantage of this new energy source in order to stay financially healthy, and in order to deliver on the promise of electricity to improve lives and economies. Low demand can be caused by a number of factors: little access to appliances, lower incomes to purchase electricity, less experience with the technologies that can take advantage of electricity, and less access to banking institutions that can enable purchase of electrical equipment on credit. In addressing these barriers, lessons can be learned from experiences of other countries and from the experiences of the off-grid sector. Utilities and governments may benefit from partnering with private sector organizations, NGOs, and financial institutions to help deliver the information, hardware, and capital that is needed to unlock electricity's rural potential.

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