



CLOSING THE CIRCUIT

STIMULATING END-USE DEMAND FOR RURAL ELECTRIFICATION

BY MARGARET MCCALL AND SCARLETT SANTANA



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SUGGESTED CITATION

McCall, Margaret and Scarlett Santana. *Closing the Circuit: Stimulating End-Use Demand for Rural Electrification*. Rocky Mountain Institute, October 2018, <http://www.rmi.org/insight/closing-the-circuit/>

EDITORIAL/DESIGN

Editorial Director: Cindie Baker
Editor: David Labrador and Peter Bronski
Creative Director: Romy Purshouse
Design: Laine Nickl

Images courtesy of iStock unless otherwise noted.

ACKNOWLEDGMENTS

The authors thank the following individuals and organizations for offering their insights and perspectives on this work:

Okenwa Anayo Nas, Nayo Tropical Technologies
Vivien Barnier, Inensus
Samuel Booth, National Renewable Energy Laboratory
Amanda DelCore, Factor[e] Ventures
Nicole DeMarsh, Open Capital Advisors
Olya Irzak, Zola Energy
Paulina Jaramillo, Carnegie Mellon University
Umang Maheshwari, Smart Power India
Crystal Mugimba, Open Capital Advisors
Jay Patel, Village Energy

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RMI receives generous support for the SEED program from the Rockefeller Foundation, Virgin Unite, the Global Environment Facility, United Nations Development Program, Schneider Electric, and individual supporters.

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EXECUTIVE SUMMARY



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EXECUTIVE SUMMARY

Electrification's ultimate measure of success in developing nations—and its real contribution—is to both meet basic humanitarian needs *and* underpin economic development. But most electrification programs focus on expanding supply with limited investment devoted to enabling end uses that drive productivity improvements and meet critical needs. For example, from 2000 to 2008, supply expansion represented almost half of the nearly \$4 billion the World Bank approved for investment in energy access, whereas investment in productive use represented 0.7%.¹ In Africa, all investment in productive use financed technical assistance (TA); no such financing was directed to implement productive use investment projects.¹

Electricity is a system solution that matches supply to demand, so both must be addressed. For example, providing power without access to financing for equipment that can use that power to increase productivity means that the customer cannot fully

realize the benefit. The supplier, in turn, has a system with low capacity utilization which leads to higher per-unit energy cost, which in turn reduces customer demand and benefits. Increasing end use improves capacity utilization and so improves system cost recovery and profitability, shortening payback periods and decreasing the subsidy burden.

Furthermore, targets used to evaluate the success of electrification programs often focus on the number of connections made and megawatts (MW) installed rather than the use of that power. Yet building new generation, extending that supply's reach through expanded transmission and distribution, and growing access to supply by connecting customers risk being a “bridge to nowhere.” Although building supply is necessary, failing to directly address demand-side barriers and needs reduces the benefits of electrification, slows down economic development, and drives up the cost of power.

The current focus on increasing supply to the exclusion of supporting demand also flies in the face of historically successful and rapid electrification programs in the United States, Europe, and elsewhere in the world. Identifying and committing demand before building systems and providing low-cost loans for equipment were critical components of the United States' rural electrification program in the 1930s, for example. These actions ensured that (a) rural electricity systems had enough demand to make systems financially viable, (b) electricity costs were affordable, and (c) electricity met human needs.

In this report, we make the case for a greatly increased focus on supporting demand, outline the key barriers hampering increased use of electricity, and provide a succinct set of recommendations on actions that can be taken to complement the current focus on supply-side solutions.

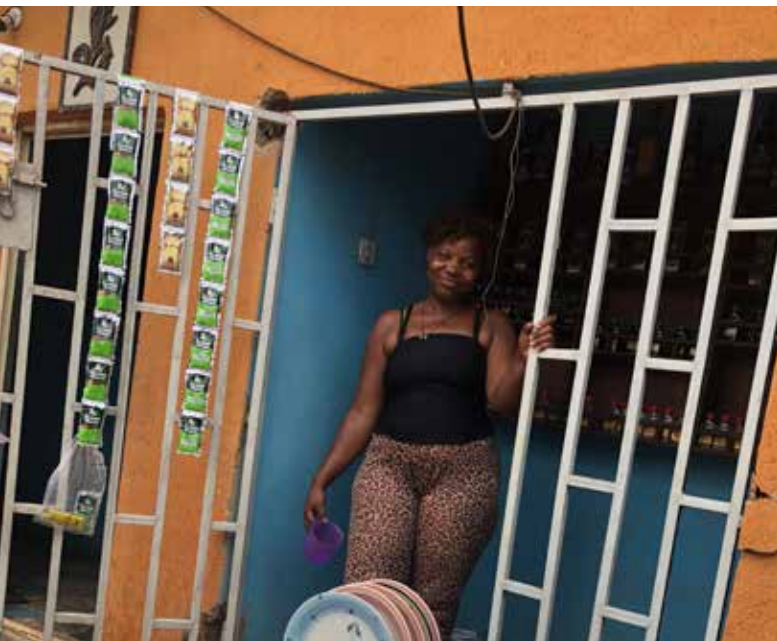


PHOTO: RMI SITE VISIT

¹The other half funded efforts to promote energy efficiency, access policy, and cooking and biomass energy.

01

INTRODUCTION



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INTRODUCTION

Electrification's goal is not providing electricity as an end itself but rather in enabling the activities that use that power. To enable these activities, electricity service needs to be affordable and reliable. Adding more load on a system is one way of lowering per-unit electricity costs by spreading fixed costs (capital expenditures and overhead) over more consumption (i.e., across a greater number of kilowatt-hours [kWh]).ⁱⁱ Without sufficient capacity utilization to justify the size of a system, electricity becomes expensive and developers cannot enable access to electricity. Stimulating end-use consumption increases capacity utilization and so improves system cost recovery and profitability, shortening payback periods and decreasing the subsidy burden.

Three World Bank-affiliated reports—*Beyond Connections: Energy Access Redefined*,² *Promoting*

Productive Uses of Electricity in Rural Electrification Programs: Experience from Peru,³ and *Maximizing the Productive Uses of Electricity to Increase the Impact of Rural Electrification Programs*⁴—illustrate an ongoing shift in how electrification success is measured, through a greater emphasis on end use and the services that electricity enables. *Beyond Connections: Energy Access Redefined* describes a multitiered definition of energy access, which accounts for level of service. The World Bank is now using this definition to measure progress in access to electricity, but this definition still only accounts for the supply of electricity.

Both building more supply-side generation capacity and extending the grid to add more total connections have been the focus of much development strategy and investment. But this focus has been disproportionate. For example, overall, electricity supply is still receiving



PHOTO: RMI SITE VISIT

ⁱⁱ There are other ways to reduce system costs, including sizing systems to meet demand, which can include building the system through modular increments. Similarly, ensuring a large enough critical mass of demand to build a larger system leads to economies of scale and lower costs.

50 times more financing than access to productivity-enhancing equipment in Africa.⁵ Above and beyond the end-use demand stimulation focus of this report, this can serve as a call to action for a more holistic approach to rural electrification in sub-Saharan Africa.ⁱⁱⁱ

For example, from 2000 to 2008, investment in supply expansion represented almost half of the total investment the World Bank approved for energy access, whereas investment in productive use represented 0.7%.^{iv} In Africa, all investment in productive use financed technical assistance (TA), and no financing was directing toward implementing productive use projects.⁶

Targets used to evaluate the success of electrification programs generally capture performance against number of connections made and megawatts (MW) installed. But although universal access and adequate power supply are key measures of electrification's success, these factors alone do not guarantee that communities will be able to benefit from power now and on an ongoing basis.

Building megawatts of new generation supply, extending that supply's reach through transmission and distribution expansion, and growing access to supply via the number of customer connections risk being a "bridge to nowhere." The situation is akin to running fiber internet to a community of homes but not ensuring those homes can afford computers and the monthly service plan. Although building supply is necessary, assuming that providing supply will generate demand fails to address the demand-side barriers end users face.

End use depends on end users obtaining appliances and equipment to use electricity. End-use demand stimulation includes providing financing and equipment



ⁱⁱⁱ See the upcoming RMI paper *Delivering on the Promise of Electrification: The Case for a Whole-Systems Approach in Sub-Saharan Africa*, to be published in winter 2018.

^{iv} The other half funded efforts to promote energy efficiency, access policy, and cooking and biomass energy.

that will enable the use of electricity. It also means creating a compelling business case for an end user to invest in equipment. This paper explores what it takes to enable access to equipment for productive use served by minigrids to explore a key component to achieve sustainable and viable electricity service in rural sub-Saharan Africa (SSA).

Development partners, as a major source of capital flows for electrification programs, have an opportunity to support end use as a core part of their electrification efforts. This paper addresses the importance of end-use stimulation for rural electrification, outlines the key barriers hampering increased use of electricity, and provides a succinct set of recommendations on actions to address these barriers. The paper is structured as follows:

- **Section 2** provides a compelling case for considering end use in electrification efforts by pulling on historical and present-day lessons of successes as well as the impacts of failing to consider end use
- **Section 3** describes the key barriers and challenges preventing end use
- **Section 4** describes the high-level solutions that development partners should pursue to address the barriers and challenges preventing end use



PHOTO: RMI SITE VISIT

02

LESSONS FROM THE FIELD HIGHLIGHT THE IMPORTANCE OF END USE



LESSONS FROM THE FIELD HIGHLIGHT THE IMPORTANCE OF END USE

This section highlights the importance of considering end-use stimulation to achieve sustainable access. It shows examples of countries and systems that have used end-use stimulation to ensure that end users receive energy services, systems recover costs, and electrification is sustainable. It also shows the impact to systems where end use is not considered.

2.1. HISTORICAL SUCCESS WITH END USE IN THE UNITED STATES

In the 1930s, only 10% of people in the rural United States had access to electricity compared to 90% in urban areas. By 1956, the rural electrification rate reached 96% due to a combination of supply expansion paired with end-use stimulation.⁷ Rural electricity cooperatives, in addition to stringing power lines and sourcing power generation, provided financing for appliances and equipment such as electric washing machines, refrigerators, water heaters, electric ranges, and milking machines.

The government financed grid extension with low-interest government loans to lower the levelized cost of service and ensure electricity affordability. In return, farmers wanting power paid a membership fee to the cooperative and committed to use a minimum amount of electricity per month.⁸ This minimum consumption ensured that the electricity system had sufficient capacity utilization to recover costs. To ensure that end users could use power, the government set up the Electric Home and Farm Authority (EHFA) to support appliance purchases. The EHFA provided financing for farmers to purchase home appliances and equipment and carried out bulk purchasing programs to negotiate large purchases directly with appliance makers, achieving lower purchase costs and making appliances and equipment affordable for end users. The EHFA also made the appliances and equipment available for purchase at local power companies and cooperatives

and carried out roadshows to increase end-user awareness.⁹

The focus on both demand and supply was key to ensure *sustainable* electricity access. A pathway to appliances and equipment ensured that end users received electricity services and freed up labor that could be applied to income-generating activities. The focus on demand also ensured that cooperatives and local power companies could recover costs and attracted significant investment—four times the size of concessional debt provided by the government. The focus on demand helped create the sustainable rural electric cooperatives underpinning rural economic development in the United States.



PHOTO: RMI SITE VISIT

2.2. MODERN-DAY SUCCESSES AND CHALLENGES WITH END USE IN SUB-SAHARAN AFRICA

There are significant opportunities in SSA to invest in end use. Only 4% of arable land is irrigated, yet irrigated crops yield double or more the production of rain-fed crops,¹⁰ and horticultural crops grown in the off-season by using irrigation can sell for significantly higher prices.¹¹ Carpenters and tailors that switch to electric appliances and equipment achieve a 20%–70% increase in revenues and a 50%–200% increase in productivity.¹² Entrepreneurs living in communities lacking mills, rice hullers, and welding shops travel long distances to the nearest town equipped with these machines and the electricity to power them and pay to use these appliances.¹³

This section provides anecdotal evidence of cases where building supply and providing access to equipment has led to sustainable business models in rural electrification. However, further analysis is needed to assess how consumers make decisions related to electricity consumption and which barriers have the largest impact on consumption. Section 3 addresses some of these barriers and issues, and Appendix C presents data needed to better understand these issues.

END-USE SUCCESSES

There are examples of end-use stimulation programs in SSA that target productive use and recover program costs. In 2016, JUMEME Rural Power Supply Ltd. (JUMEME) developed a solar-powered minigrid in the Mwanza region of Tanzania. Customers could not afford the purchase costs of appliances and equipment, so consumption and capacity utilization were low. JUMEME provided financing for end users to afford appliances. The pilot program targeted 12 businesses, and all have finished or are soon to finish repaying their loans. Additionally, JUMEME identified a new business opportunity, running its own fish freezing and delivery system to connect fishermen with local

markets. This new business line provides base load, improves capacity utilization, and provides an additional revenue stream. It also supplies the local community with new jobs.¹⁴

End-use stimulation efforts at a 300 kilowatt (kW) hydroplant in Tanzania financed mill, oil-seed pressing, and carpentry equipment within the surrounding community. This investment led to a 58% increase in consumption from businesses and drove down milling costs by 50%. The project reached breakeven less than two years after project initiation.¹⁵ Rockefeller Foundation is currently supporting pilot projects, including appliance financing, to test the efficacy of various end-use stimulation levers. It is too early to determine whether these productive-use programs will achieve system commercial viability. However, these examples suggest that there is demand for productive-use programs, and that these programs increase load and can be commercially viable investments in SSA.

END-USE CHALLENGES

Despite successes outlined above, end-use stimulation remains outside the scope of most electrification efforts in SSA. Accurately estimating demand before commissioning a project is difficult, and there is no foolproof way to do so. But, using demand data from other minigrids to predict demand¹⁶ and developing concrete plans to engage customers and stimulate end use help identify current and latent loads and provide a better picture of demand levels necessary to ensure a critical mass before defining system size. Failing to plan for end-use stimulation often leads to poor capacity utilization and inability to recover costs.

Generally, developers size systems assuming load will grow because they assume that availability of supply represents the main constraint.¹⁷ However, these assumptions fail to acknowledge other constraints that prevent load growth. Developers should size systems for existing load or proactively stimulate the demand that they are forecasting for.

In Uganda, one minigrid was built to serve 350 customers, yet only 60 connected. Six of the customers were commercial (small shops, restaurants, and bars) and none were productive (grain mills, welders, or carpenters).¹⁸ Without a focus on generating enough demand to match the supply, developers increased prices to \$2/kWh to recover costs, and larger customers disconnected. As the capacity utilization of the system fell, the cost burden on the remaining users rose, causing a downward spiral in demand and damaging the cost recovery of the system.^{v,19}

In Sierra Leone, several similar examples exist where developers overestimated demand and did not pursue end-use stimulation. In one town, none of the grain mills were connected to the minigrid, and there were no resources secured or plans established for supplying millers with soft-start motors that the grid could serve.^{vi} Welders and mechanics often just used their old diesel generators. As a result, capacity utilization was under 50%, and the unit cost based on operational expenses alone was over \$1/kWh, threatening the long-term financial viability of the system and making it unappealing for an operator to take over.²⁰

Box 1: Overcapacity on the Grid

Similar examples also occur on the grid. Some countries in West and East Africa lack integrated resource planning that addresses how to stimulate end use to complement investments in supply.¹ As a result, these countries are expected to develop significant capacity imbalances that may cost governments billions in take-or-pay

contract payments. For example, in Uganda, rural distribution companies struggle for profitability—more than half of rural concession operators are not yet financially viable. Average usage among rural operators stands at 185 kWh/customer/year, significantly below the sub-Saharan African average of 483 kWh per capita.²

Sources:

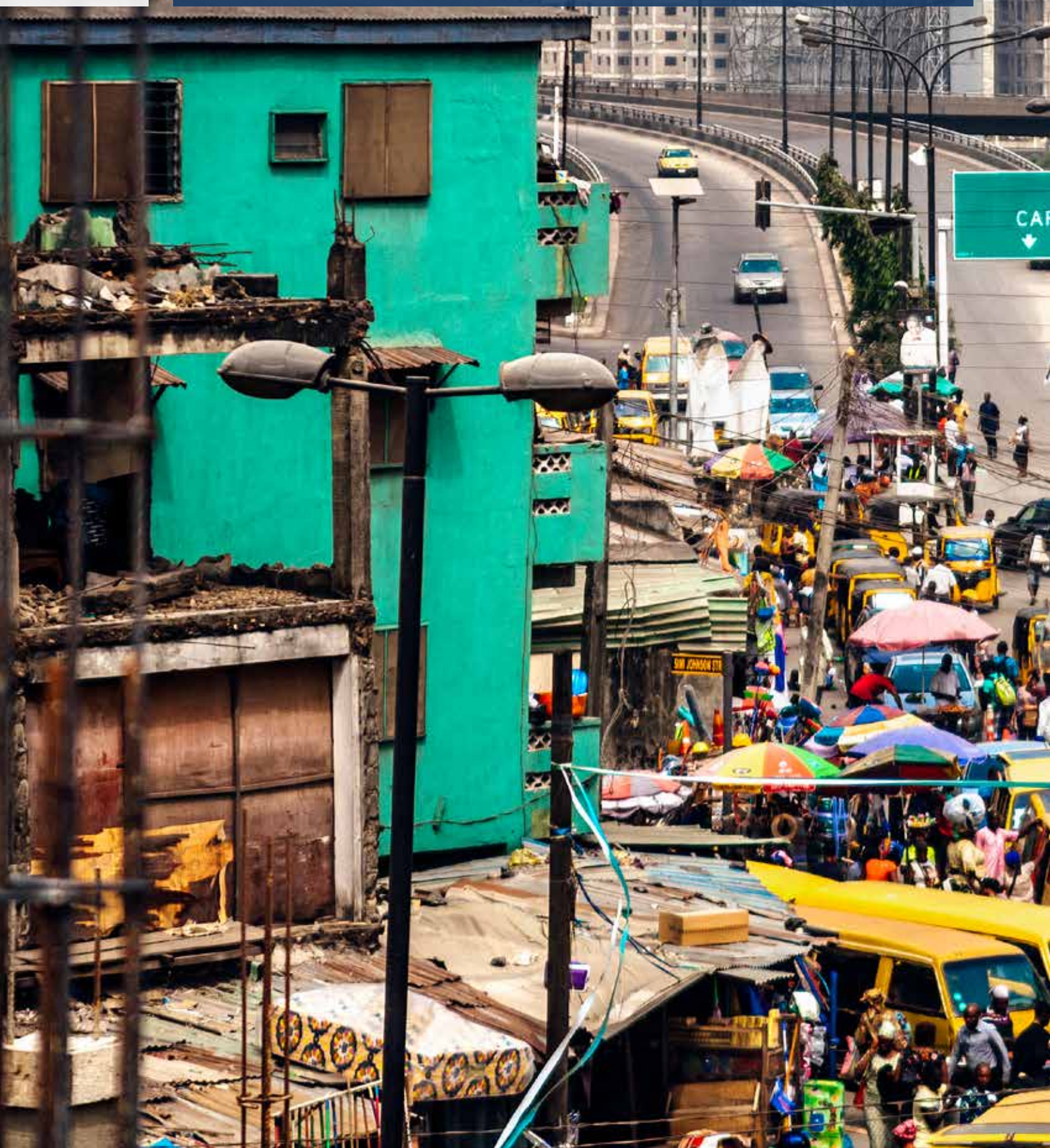
¹ RMI research on the risks of generation overcapacity in sub-Saharan Africa

² Average usage of rural operators in Uganda: RMI field research; sub-Saharan African average usage: World Bank World Development Indicators. Electric power consumption for sub-Saharan Africa (excluding high income countries).

^vAs some customers exit, a smaller pool of customers remains to pay for the infrastructure. This leads to higher average unit costs, which, when tariffs are cost reflective, leads to higher tariffs and incents more customers to disconnect.

^{vi}Soft start motors require less electricity to start up and to run, leading to lower operational expenses and smaller spikes in consumption. This in turn allows a smaller supply system to be installed, requiring lower capital costs and enabling higher capacity utilization.

KEY BARRIERS AND CHALLENGES PREVENTING END USE



KEY BARRIERS AND CHALLENGES PREVENTING END USE

Electricity demand fails to grow organically in some rural areas of SSA due to barriers that constrain the demand and supply for the equipment needed to use electricity. On the demand side, end users often cannot afford equipment and power due to high costs. On the supply side, end users cannot easily access equipment because equipment that meets consumer needs are not always present in remote locations. Underlying all this, electrification strategies and programs do not include demand as a key component, and therefore, financing does not flow to address these barriers.

EQUIPMENT COSTS ARE HIGH

The cost of an irrigation pump may range from hundreds of dollars for a small surface-water pump to tens of thousands of dollars if a borehole is needed.²¹ This represents from 13% to >300% of the average annual income of a farming household in SSA.²² Additionally, efficient, high-quality equipment is often more expensive up front than less-efficient equipment.

Access to financing that meets end-user needs is rare in rural SSA. A study in Kenya found that low-income customers were unwilling to take out loans for non-emergency purchases because repayment periods were too short, and penalties were easily triggered.²³ From 2004 to 2011, micro-finance interest rates were 28%–35%.²⁴ These high rates may prevent consumers from being able to afford to repay loans. Compared to the United States where the government subsidized consumer acquisitions of home appliances (see Section 2.1), rural consumers in SSA face a tougher hurdle to purchase equipment.

Many potential end users do not have credit histories, and financial institutions do not know how to assess creditworthiness using unconventional methods. Assessing creditworthiness is particularly important for low-income rural markets because repossessing



PHOTO: RMI SITE VISIT

equipment may not be socially acceptable when a customer defaults.²⁵ As a result, many financiers prefer not to serve low-income rural markets.

ELECTRICITY COSTS ARE HIGH

Even if consumers could afford equipment, they may not be able to afford the electricity to use it.^{vii} Minigrid electricity currently costs upward of \$0.50/kWh in SSA, depending on design, utilization, size, and other characteristics.^{viii} An end user consuming 30 kWh per month would incur a monthly bill ranging from \$13 to \$110, which represents 6%–44% of the average monthly income of a farming household in SSA.²⁶ The threshold above which electricity becomes unaffordable is 6% of a household's income.²⁷ⁱ High tariffs may make investments in equipment financially unviable, discouraging investment and displacing potential productive use.

EQUIPMENT IS NOT AVAILABLE IN REMOTE LOCATIONS

End users in remote locations cannot simply go to a store and purchase equipment. Stores can be many miles away, and transportation costs to get the equipment home can be high. Additionally, end users may lack access to the *right* equipment (i.e., access to efficient and high-quality equipment that meets consumer needs in cost, efficiency, durability, and power draw).²⁸ Product offerings must match what end users need and can afford and what the generation and network capacity can support. It is difficult for equipment suppliers to identify the equipment that can meet both end-user and grid needs. Additionally, it is more expensive for suppliers to serve markets in remote locations

outside of urban centers. Higher costs combined with uncertainty about demand size and ability to pay mean that equipment suppliers often prefer not to serve low-income rural markets.

STRATEGIES AND PROGRAMS DO NOT ADDRESS DEMAND AS A KEY COMPONENT OF ELECTRIFICATION

Addressing the aforementioned barriers requires financing. However, most strategies and programs fail to consider electricity demand as a key component of electrification and do not dedicate financing toward addressing barriers that prevent end use. Instead, electrification targets drive focus and funding toward MW installed and number of new connections made.



PHOTO: RMI SITE VISIT

^{vii} This is a fundamental issue extending beyond minigrids. Nineteen countries in sub-Saharan Africa have grid tariffs that exceed \$0.20/kWh. Due to the poor quality of service, particularly in rural areas, consumers generally face even higher total energy costs. For instance, when costs for running gensets are accounted for, consumers in rural Nigeria pay around 53¢/kWh.

^{viii} Minigrid costs are poised to fall dramatically—RMI's forthcoming report, *Minigrids in the Money: Six Ways to Reduce Minigrid Costs by 60% for Rural Electrification*, identifies a pathway to reaching \$0.25/kWh by 2020.



ACTIONS TO ADDRESS KEY BARRIERS AND CHALLENGES

Effective end-use stimulation requires end users to obtain and use equipment. Enabling access to equipment requires developing financing mechanisms to make equipment affordable and sizing minigrid systems correctly so that power costs fall. It also requires stimulating private-sector sales of equipment through incentive programs and demonstration projects to prove the business case. These efforts require financing. For development capital to fund these efforts, electrification strategies and programs need to support demand as a key component. This section describes and builds on these insights and provides the high-level structure of one example of an end-use stimulation program.

4.1 DEVELOP FINANCING MECHANISMS TO OVERCOME THE FIRST-COST BARRIER

Development partners can develop financing mechanisms to help end users overcome the first-cost barrier of purchasing equipment. Providing pay-as-you-go financing was a critical factor in the wide-scale adoption of solar home systems in SSA.²⁹ The use of concessional finance can also help lower financing costs and reduce the total cost of equipment.

Development partners can also help increase access to credit for equipment by financing training for financial institutions or equipment suppliers to assess nontraditional measures of credit. Nontraditional measures of creditworthiness include historical electricity bill payments,³⁰ responsiveness to SMS messages,³¹ and working with co-ops that know potential customers and can speak to their creditworthiness.

Training can help financiers, equipment suppliers, and customers understand the business case for investing in equipment. Making an informed decision requires understanding how to develop business plans and payback plans that compare the size of the cost of the equipment to new revenue flows and the timing of cash flows to determine how to address potential liquidity gaps.

REDUCE ELECTRICITY COSTS

Electricity costs can be reduced by supporting high-capacity utilization of minigrids. Sizing systems to meet but not dwarf demand increases capacity utilization and lowers costs for everyone in an energy system. (Box 2 provides further detail on the relationship between capacity utilization and electricity costs.) This in turn means signing up load before final design and having mechanisms to stimulate and meet latent demand. Signing up load before final design of the system through customer agreements that establish amount and quality of power helps guarantee a level of demand to the developer that allows for more-accurate system sizing.

Access to energy-efficient and soft-start appliances^{ix} that consume lower levels of electricity can also reduce peak load and operational costs and lead to lower electricity costs. Total cost of installation and operations is often lower if customers use efficient and soft-start equipment. For instance, super-efficient appliances can drive down the total cost of a solar home system and appliances by 50%.³² Soft-start motors also improve the capacity utilization of power systems by reducing the current surge of motors during start-up, allowing for smaller systems. For example, a 750 watt (W) motor can demand more than 5,000 W at start-up, driving up peak and lowering capacity utilization.

^{ix}Soft-start motors require less electricity to start up and to run, leading to lower operational expenses and smaller spikes in consumption. This in turn reduces the required size of the installed capacity of the system (grid or minigrid).



Box 2: Key Factors in Integrated Design of Minigrids and Productive-Use Equipment

1. To size minigrids appropriately, it is ideal to have an accurate understanding of the peak load and timing of large loads that will be on the system. Contracting with large customers ahead of time can bring certainty to expected load.
2. **End-use stimulation on a minigrid can effectively reduce the levelized cost to serve**, even when accounting for equipment cost. But developers need to understand the size of load, time of use, and seasonality—small and highly seasonal productive loads may actually increase levelized cost to serve. Figures 1 to 4 show an indicative example of the relationship between end-use stimulation and minigrid electricity costs. Figures 1 to 3 show the impact of adding a productive load that occurs in the daytime to a residential load. Figure 4 shows the reduction in minigrid electricity costs resulting from adding the productive load.
3. **Maximizing generation capacity utilization** reduces the levelized cost to serve:
 - Adding **daytime loads** (e.g., grain mills) is key to increase the percentage of solar utilization. Soft-start motors are important to mitigate instantaneous peak on the system.
 - **Flexible loads** (e.g., variable-drive pumps) can be useful to take advantage of excess solar.
4. Adding more kWh on the system allows for the spreading of fixed minigrid costs over more consumption (e.g., predevelopment costs, fixed operating costs), which can form a high percentage of the overall cost to serve.

FIGURE 1
LOAD PROFILE: BASELINE (NO END-USE STIMULATION)

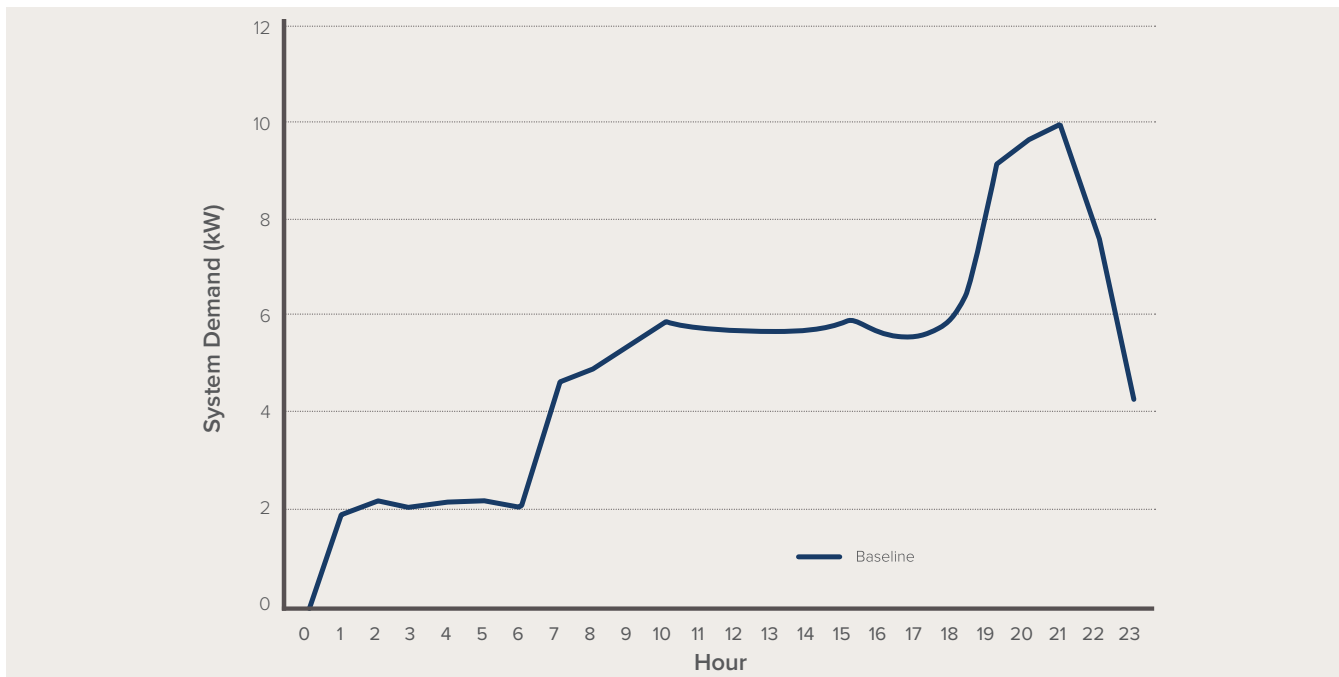


FIGURE 2
LOAD PROFILE: BASELINE + WATER PUMP

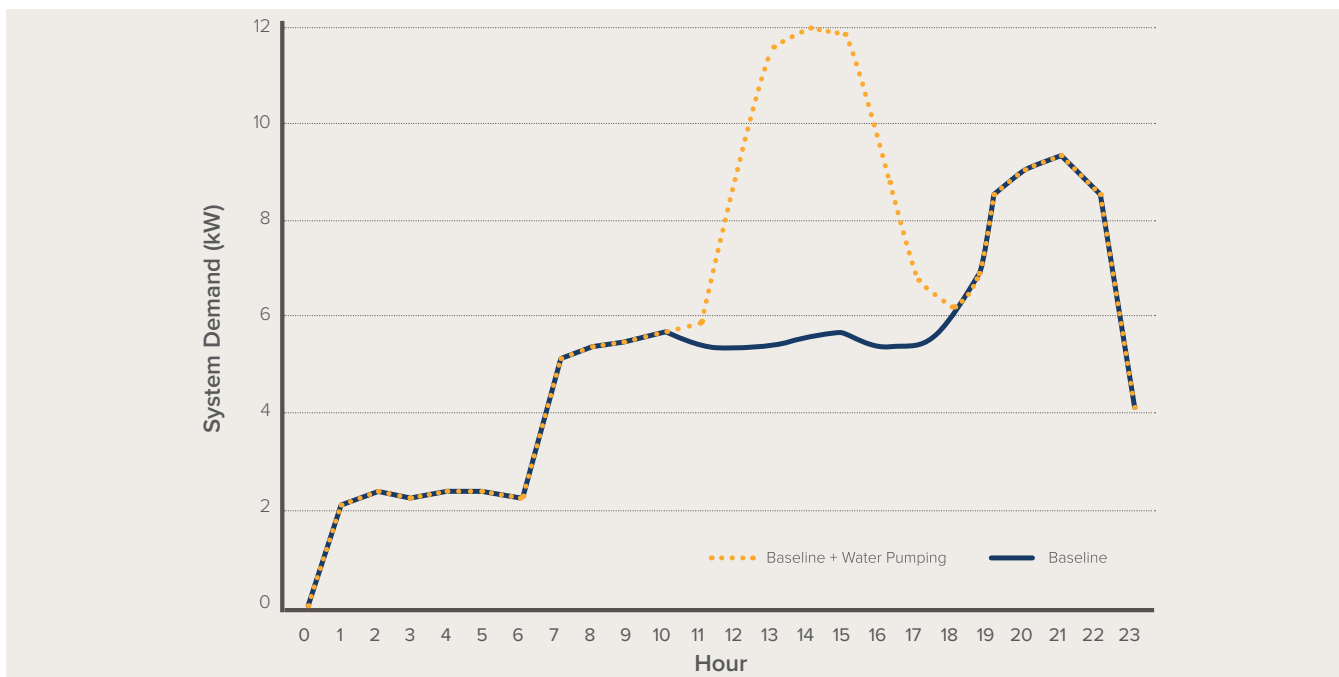


FIGURE 3

LOAD PROFILE: BASELINE + GRAIN MILL

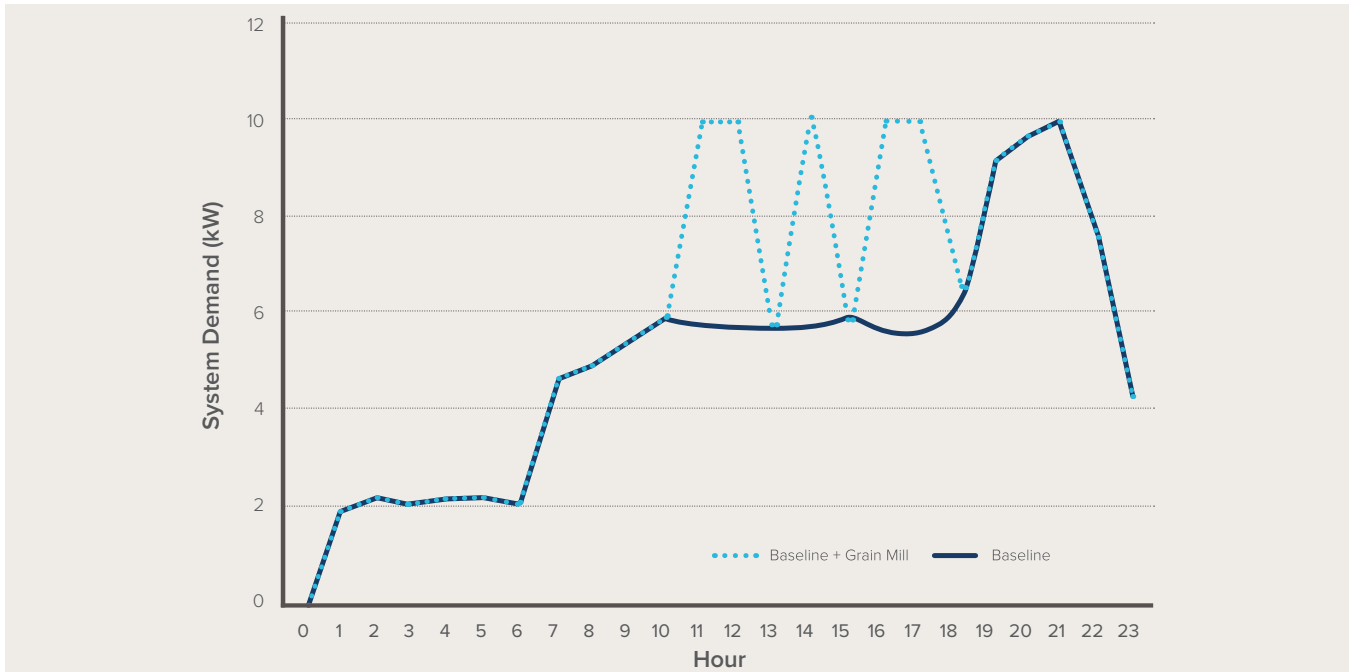
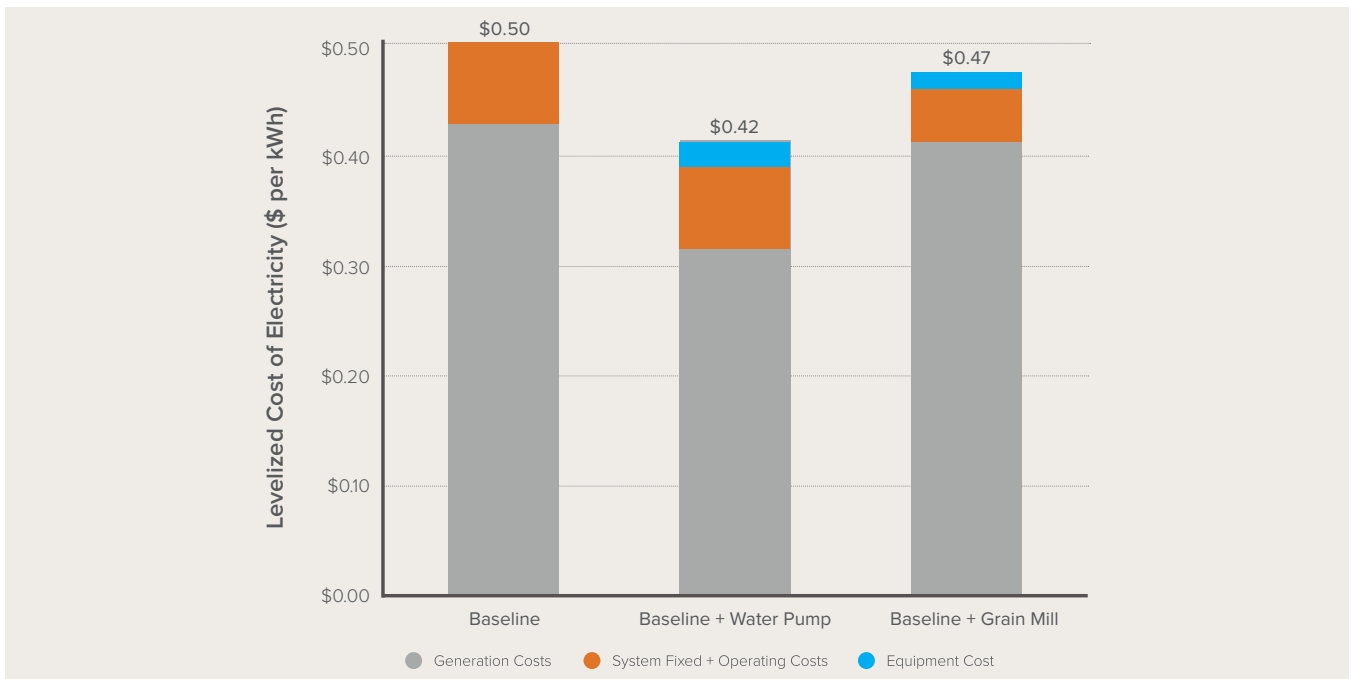


FIGURE 4

IMPACT OF END-USE STIMULATION ON LEVELIZED COSTS



PROVIDE INCENTIVES TO STIMULATE PRIVATE-SECTOR SALES OF EQUIPMENT

Effective end-use stimulation requires access to and understanding of cost-effective, productivity-enhancing equipment. To support this, development partners and governments should stimulate the development of competitive markets for that equipment. To do so, they should consider a host of levers ranging from customer education via roadshows, to financial guarantees to equipment sellers, to supporting bulk purchasing leverage, to effective dissemination of what is working and what is not. Examples follow:

- **Customer education via roadshows**—Present equipment and educate potential end users on using equipment and how to make tradeoffs of cost, durability, power draw, and efficiency to understand and identify cost-effective equipment that meet consumer needs.
- **Financial guarantees to equipment sellers**—Mitigate a portion of the off-taker and default risk equipment suppliers face by providing partial risk guarantees. A portion of the loan provided to equipment suppliers can convert to a grant if end users do not purchase the equipment or default on their loans. A portion of the loan should remain payable to ensure that the supplier is incented to sell equipment and recover payments.
- **Bulk purchasing programs**—Provide bargaining power and access to global supply chains to obtain equipment that meet consumer preferences. Bulk purchasing programs can also leverage economies of scale to lower equipment costs. End-user preferences should dictate what the purchasing agency buys between multiple rounds so that customer uptake informs purchases in later rounds. Resources

and examples of bulk purchasing programs can guide efforts in this area. For example, CLASP^x developed the Off-Grid Appliance Data Platform, which informed the Smart Power India Initiative in launching a pilot to deploy energy-efficient, off-grid appliances in minigrid sites across India.³³

- **Dissemination of lessons learned**—Share lessons learned about what levers are effective in stimulating demand and those that are not. Showcase the success of the market for equipment, presenting information about profitability, investment returns, and default rates.

UPDATE ELECTRIFICATION PROGRAMS AND STRATEGIES SO THAT DEMAND CONSIDERATIONS ARE A KEY COMPONENT

Including end-use targets—in addition to supply targets—in national strategies and policies changes incentive mechanisms to refocus efforts on unlocking a wider set of barriers that cover supply- as well as demand-side challenges. Examples of indicators that capture end use beyond supply-side metrics include disaggregated consumption per capita for different population segments, service levels (level of energy service, power quality, and reliability), and cost of service.

End-use stimulation should be a core part of electrification programs. This includes designing and procuring productive-use components as a core part of developing minigrids to ensure end use is pursued as a goal. Where competitive procurement is used to electrify off-grid areas, scoring applicants partly based on their plans to stimulate productive use can help drive a more-sustainable system. Developers should describe how they plan to stimulate end use, ensuring that their financial plan covers both costs for building supply and stimulating end use.

^xCLASP website: <https://clasp.ngo/who-we-are>

4.2 COMPONENTS OF END-USE STIMULATION PROGRAM DESIGN

This section provides an illustrative example of how the main insights of this paper can be used to design the key aspects of an end-use stimulation program. The program described here targets agricultural productive use. Programs targeting other segments would require participation from other stakeholders. Similarly, other designs and structures may be successful at driving demand.

End-use stimulation programs should address the barriers that prevent end use. They should provide the financing and training required to allow for demand of equipment to meet supply. On the demand side, the program should facilitate levers needed to drive end use—access to credit and training to identify the business case and develop business plans. On the supply side, the program should facilitate levers to prove the commercial viability of supplying equipment. Supporting all this, the program should create an enabling policy framework and collect data to test the success of levers used.

The key components of a program include:

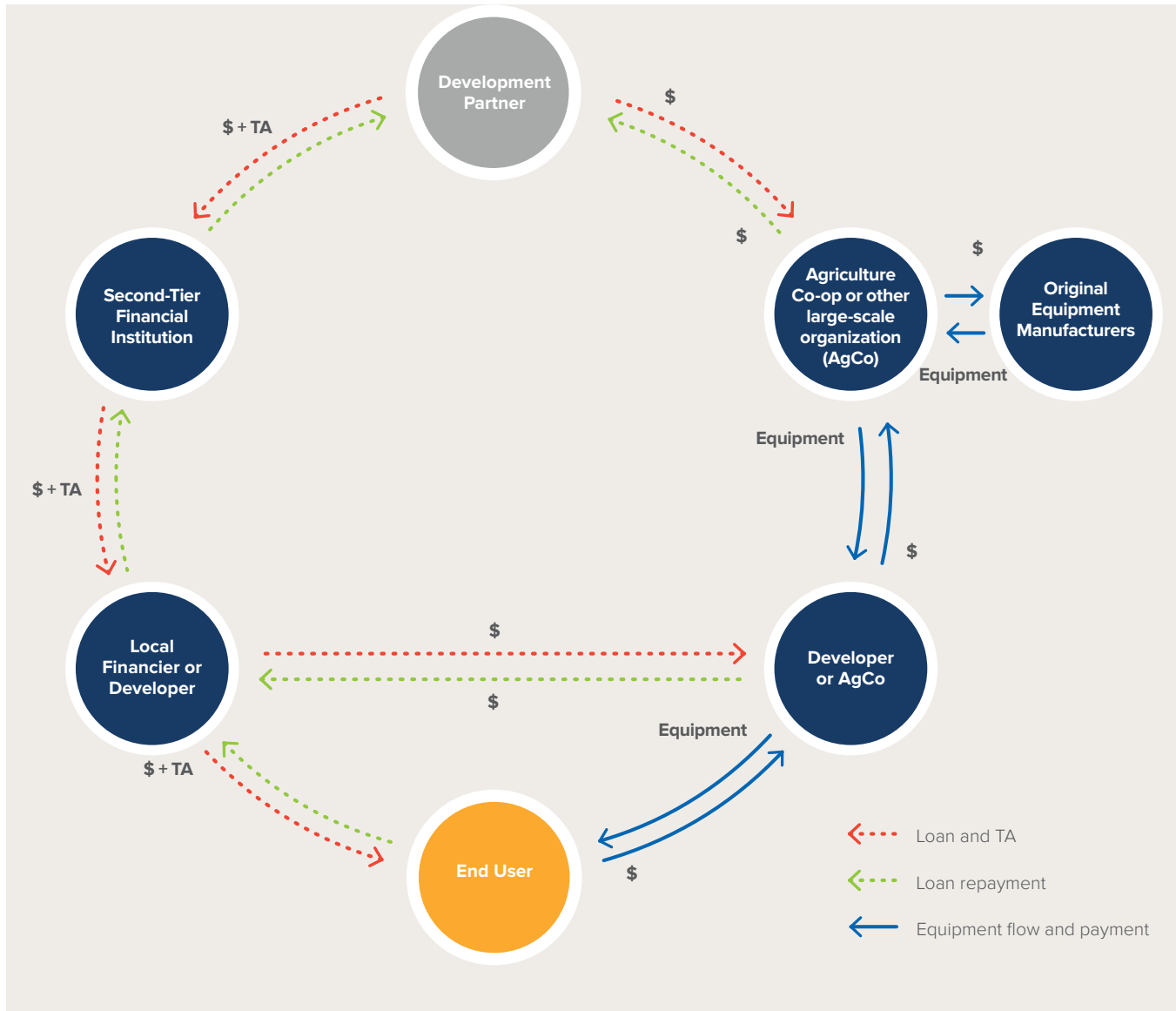
- **Component 1: Financing and Training for Equipment Investments**—Provides financing for end-user investments in equipment. In addition to financing equipment, this component would finance training destined for local financial institutions or equipment suppliers to assess untraditional measures of creditworthiness and the business case for investments, and develop business plans with end users.
- **Component 2: Testing Commercial Viability of Supply Market**—Provides TA to rural electrification agencies (REA) or other large organizations to map end use and identify which equipment meets end-user and grid needs. The component also provides financing to agricultural co-ops

(AgCos) or other large institutions to carry out bulk purchasing programs to lower unit costs of equipment and provides delivery and supply equipment to end users.

- **Component 3: Enabling Policy Framework**—Provides TA to support governments at the national level to modify policy frameworks to include targets beyond connections and MW installed to capture energy services end users receive.
- **Component 4: Data Collection and Dissemination and Monitoring and Verification**—Collects data and captures performance on the efficacy of levers used in the program to drive end use and inform future efforts. Component 4 also disseminates results of Component 2 to attract the private sector to participate in the market. Appendix B presents an initial list of questions to test and data to collect. However, new questions and data needs may surface during implementation that the program would need to consider.

On the demand side (left side of Figure 5), development partner capital flows provide financing and training to second-tier banks that funnel financing and training through local financial institutions to end users. This training would be twofold: (1) including training for local financiers to assess creditworthiness using untraditional forms of creditworthiness and assessing the business case for equipment investments, and (2) teaching end users to develop business plans for their equipment investments. In communities lacking local financiers, developers can fulfill the role of the local financier and equipment supplier. However, including local financiers allows for decoupling electricity payments from loan repayments. This in turn helps identify the drivers of default, when they occur. The end user would repay its loan to the local financier or developer.

FIGURE 5
CAPITAL FLOWS OF AN END-USE STIMULATION PROGRAM



On the supply side (right side of Figure 5), development partners provide financing to AgCos or other large institutions to carry out bulk purchasing programs and distribute equipment. The AgCos can sell the equipment directly to the end user or partner with a developer that would sell the equipment to the end user. If the developer supplies equipment to

the end user, the developer can obtain concessional finance from local financiers to finance the purchase of equipment from AgCos. Development partners could also finance TA to help the REA assess user and grid needs and identify which equipment AgCos should purchase. The REA should also consult with developers in this process to understand grid needs.



CONCLUSION

The goal of electrification should be enabling end users to use power. To enable end users to use power, electricity service needs to be affordable and reliable. Without sufficient capacity utilization that spreads out system fixed costs over enough consumption to justify system size, electricity becomes expensive. Increasing end use in turn increases capacity utilization of systems and therefore lowers electricity costs, improves system cost recovery and profitability, shortens payback periods, and decreases the subsidy burden. As such, enabling capacity utilization and providing access to people go hand in hand in improving peoples lives.

Enabling capacity utilization requires end users to obtain and use equipment. Development partners' greatest impact lies in providing the financing and training needed to enable end users to identify and afford energy-efficient and productivity-enhancing equipment that create a compelling business case for an end user to invest in. It also means stimulating private-sector sales of equipment through incentive programs and demonstration projects to prove the business case and ensure that equipment is available for end users. These efforts require financing and reframing sector strategies and programs to consider demand as a key part of providing electricity access.

AP

APPENDIXES



APPENDIXES

The appendixes include the following sections:

- **Appendix A: Replacing existing diesel-run appliances represents a low-risk way to start end-use stimulation**—presents two examples showing the business case of switching to electrically powered equipment. The examples include switching from a diesel-powered mill to an electric mill and from manual carpentry tools to electrically powered carpentry tools.
- **Appendix B: Data Collection Guidelines and Further Questions**—presents initial data requirements and questions that need to be tested to better understand end-use stimulation.

Appendix A: Replacing Existing Diesel-Run Appliances Represents a Low-Risk Way to Start End-Use Stimulation

Electrification of equipment can be a cost-effective choice for many businesses. Substituting existing diesel-run appliances reduces the risk of investment because the business plan does not need to estimate additional revenue from higher productivity. The business plan can assume that productivity remains the same whether the appliance is powered by a diesel generator or it is powered by electricity, and therefore, revenue streams remain the same.

Figure A-1 assesses the financial viability of switching from a diesel-based mill to an electric mill and switching from manual carpentry tools to electrically powered carpentry tools when selling prices remain fixed. Because selling prices remain fixed, these examples show that the electric mill investment increases unit profit by reducing unit cost and is financially viable, whereas the investment in electrically powered carpentry tools decreases unit profit by increasing unit cost. The investment in electric carpentry tools could be financially viable if the surrounding market can absorb the additional output from the greater productivity of the electric tools, as is shown in Figure A-2.

The analysis included in Figures A-1 and A-2 does not include financing costs. Including financing costs can significantly reduce the net profit of the investment during the repayment period. For instance, a 36-month loan with a 12% interest rate for the electric mill would require monthly payments of \$49.82, which would consume almost all the net profit during the repayment period. However, the investment would still be financially viable, with a net present value of \$412 using a 12% discount rate and a 10-year lifetime for the appliance. Net profits are assumed to remain constant during the lifetime of the investment.

FIGURE A-1

ILLUSTRATIVE EXAMPLES OF ELECTRIFYING A GENERATOR-POWERED BUSINESS VS. A MANUAL BUSINESS: UNIT PROFIT IF PRICES REMAIN FIXED

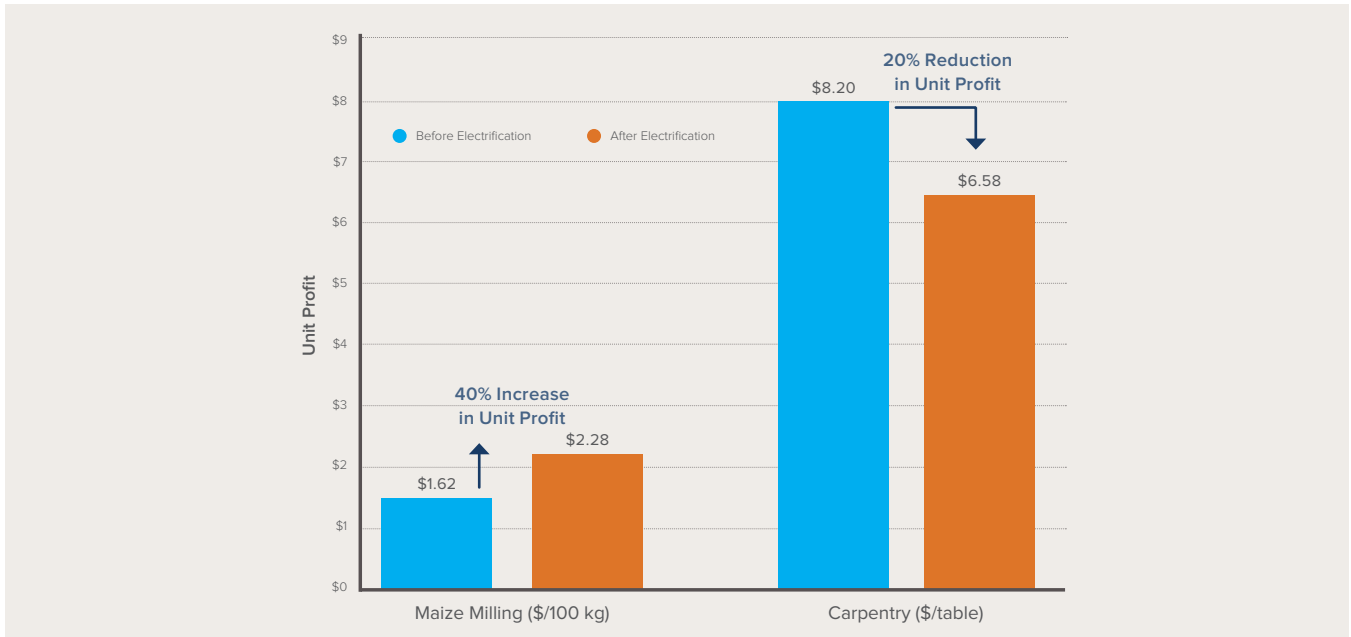


FIGURE A-2

ILLUSTRATIVE EXAMPLES OF ELECTRIFYING A GENERATOR-POWERED BUSINESS VS. A MANUAL BUSINESS: MONTHLY PROFIT IF THE SURROUNDING MARKET CAN ABSORB ADDITIONAL OUTPUT

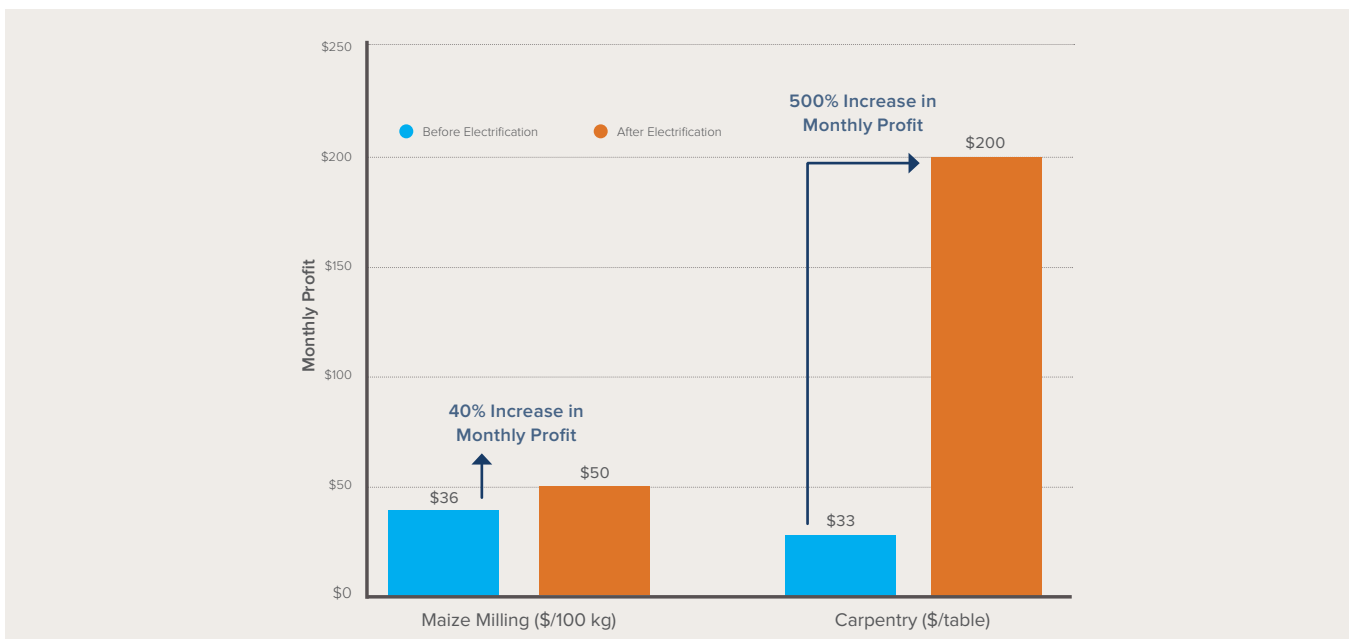


TABLE A-1

ASSUMPTIONS UNDERLYING ANALYSIS OF REPLACING EXISTING DIESEL-RUN APPLIANCES

VARIABLE	ASSUMPTIONS FOR GENERATOR-POWERED MILL	ASSUMPTIONS FOR ELECTRIC MILLS	ASSUMPTIONS FOR MANUAL CARPENTRY TOOLS	ASSUMPTIONS FOR ELECTRIC CARPENTRY TOOLS
Exchange Rate	3,600 Uganda Shillings (USh) per USD			
Purchase Cost	\$1,000	\$1,500	\$100	\$150
Monthly Production	2,200 kg of maize		4 tables (Makes 1 table per week)	30 tables (Makes 7.5 tables per week)
Monthly Revenue	\$61 Selling Price: 100 USh per kg; \$0.03 per kg		\$96 (sales remain the same) \$720 (sales increase to absorb full production)	
Operational Expenses	Transportation costs to purchase diesel: 32,000 USh per month; \$9 per month Diesel: Diesel price-3,000 USh per L; \$0.83 per L Diesel usage-20 L per month	Transportation costs: \$0 Electricity costs: \$11 per month Electricity tariff: \$0.50/kWh Mill grinds maize at 75 kg/hr with a 0.75 kW motor; assume the mill runs for 29 hours per month	Materials and transport costs: \$15 per table Electricity costs: \$0	Materials and transport costs: \$15 per table Electricity costs \$1.84 per table: Electricity tariff: \$0.50/kWh Circular saw draws 460 W; assume table requires 8 hours to produce

Sources for Maize Mill Calculations: Pre-electrification based on fieldwork in Uganda in Atura; post-electrification based on specifications of FS31 Grain Mill BOSS Pro Farina; source: GIZ solar catalog; Mill Price = 5,000 euros, removing cost for PV controls and 900W of PV panels.

Sources for Carpentry Tools Calculations: Assume DeWalt 18V Max Lithium Ion 6-Tool Kit, Model number DCK691M3; source: GIZ solar catalog.

Appendix B: Data Collection Guidelines and Further Questions

End-use stimulation is still in early stages. Questions remain around which barriers have the largest impact on consumer decision-making (e.g., equipment costs versus power costs) and which levers are most effective to drive end use. Current pilots do not include controlled experiments necessary to test these questions. Answering these questions and learning how to design effective end-use stimulation programs require collecting data on a set of indicators that capture the impact of levers on end use.

This section presents a list of questions that end-use stimulation programs should answer and data to collect to answer those questions. This list is not meant to be exhaustive—as the implementation of more end-use pilot projects progress, more questions and data needs will become apparent.

QUESTIONS TO ANSWER

- **End-use financing:**

- What are the most-effective and scalable mechanisms for appliance financing?
- Which entity should provide financing—a developer, a bank, or a co-op?
- What ownership and collateralization options are most needed for scale?
- What financing terms meet customer needs?



PHOTO: RMI SITE VISIT

- **End-use availability and education:**

- How can appliances with the right balance of cost, efficiency, and durability be made available to customers and grid/minigrid operators?

- **End-use targeting:**

- When going beyond electrifying existing diesel-based equipment, which appliances/equipment will be most beneficial for a given community?
- Is it higher impact to target individuals or to partner with larger-scale, government-led development efforts?

- **Tariff innovation:**

- To what extent can innovative tariff schemes incent demand that is profitable for the customer and the grid/minigrid operator?
- Is the limiting barrier for consumers the inability to afford the loan to pay for the appliance, or is it the tariff and electricity payments?

- **Maintenance:**

- What is the most effective model for maintaining end-use equipment?

DATA REQUIREMENTS

Data should be collected to create a baseline and measure success in increasing end use. Data requirements can be grouped in three broad categories based on the metrics captured:

- **To measure growth in consumption**—monthly consumption (kWh/customer), monthly electricity spend (\$/customer), metering scheme (prepaid or



postpaid), tariff scheme, load profile (daily and per customer, if possible), purchase date of electrical appliances

- **To measure effectiveness of specific end-use stimulation efforts**—end-use appliances marketed to customers, educational methods used and frequency, number of customers targeted versus total number of customers, number of customers expressing interest in equipment, number of customers purchasing equipment, financing parameters (purchase payment, length of loan, monthly payment, collateral, coupled versus decoupled appliance financing), default rates, equipment downtime, and business revenue and costs (including electricity costs)

- **Qualitative data to assess barriers to participation**—for various customer groups (e.g., people who were uninterested in end-use equipment, people who were interested but ineligible, and people who obtained end-use equipment), conduct surveys to assess the relative importance of the following barriers to effective participation and opportunities to increase effectiveness: awareness of appliances and pilot, appliance availability, ability to understand and scope out business case for appliance ownership, purchase cost, ongoing cost/revenue, availability and ease in obtaining appliance maintenance



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