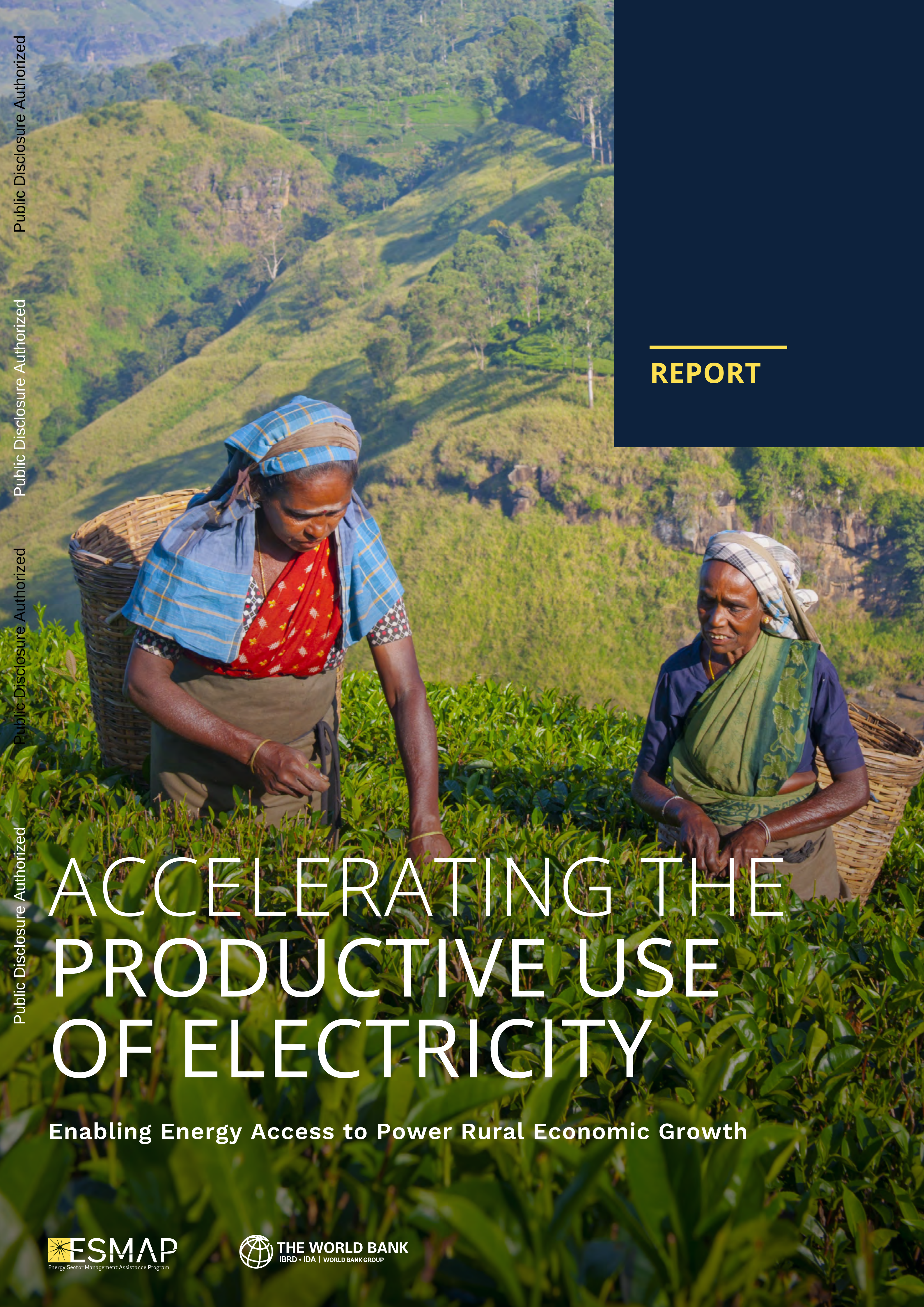

REPORT

ACCELERATING THE PRODUCTIVE USE OF ELECTRICITY

Enabling Energy Access to Power Rural Economic Growth

ESMAP
Energy Sector Management Assistance Program

THE WORLD BANK
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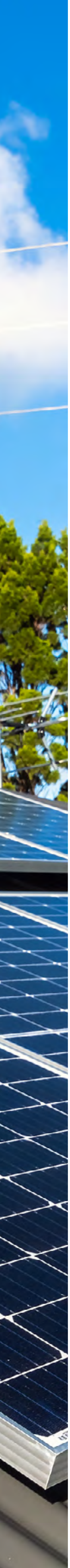
FOREWORD



Productive uses of electricity are expected to boost economic development if the potential of expanded access to energy in rural areas is to be realized. Ensuring that wider access leads to higher incomes for businesses, farmers, and households can multiply community benefits and make energy services more affordable, thus ensuring that the transition to clean energy will be equitable and sustainable. To date, however, expanded access to electricity has not always been accompanied by increases in productive uses. Dedicated actions are required to promote income generation as remote, poor, and fragile communities gain access to modern forms of energy.

Actions to stimulate productive uses are needed to respond to overlapping crises. Especially in the agricultural sector, climate change is threatening rural incomes, a danger compounded by the Covid pandemic's effects on growth, poverty, health, education, and national budgets. At the same time, Russia's war on Ukraine has disrupted supply chains, raised the prices of essential inputs, and cut food production.

The good news is that developments in renewable energy technologies, energy efficient appliances, and digitalization have opened new opportunities for economic growth in rural communities. Some examples: Solar-powered irrigation can increase output and reduce costs without the use of diesel pumps. Solar cold storage for fish can reduce spoilage without diesel generators. Distributed rural renewable energy systems are resilient in the face of climate change and exogenous shocks and are cost-competitive with fossil fuel alternatives. Solar mini-grids can power appliances for industries and commercial businesses. More-efficient appliances are available for productive use. Local expertise in renewable energy development, operation, and maintenance can be boosted beyond already substantial levels. Digitalization improves planning and operational efficiency while providing opportunities for financial inclusion and equitable economic growth.

This report brings together ESMAP's knowledge on cost-effective ways to increase rural productive uses in rural areas, drawing from decades of experience and reviews of successful cases across countries. The basic suggestions are to make productive uses a strategic priority; to work collaboratively; and to take a holistic, multidisciplinary approach that deals with rural realities from the ground up.

The report proposes an ecosystem approach. Key building blocks for increasing productive uses discussed in the report are planning, policies and regulations, technology and innovation, access to finance, market and business development. Depending on the context, each building block is a potential entry point for interventions that aim to enable and promote increases in productive uses. With digitalization, data analytics, and modern communications, the building blocks can be recalibrated and adjusted in real time in response to results and events.

New thinking on practical approaches will be a constant requirement. The uniqueness of each rural community and the need for local ownership will demand adaptions as efforts are brought to scale. The limited market opportunities of many communities will require concerted efforts by governments, private companies, development agencies, and local communities. The path is clear; the potential rewards are great. It is time to move forward.

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AI	artificial intelligence
AMPERE	Accessing Markets through Private Sector Enterprises for Refugees Energy
B2B	business to business
BDS	business development services
CAPI	Computer Assisted Personal Interview
CAS	complex adaptive system
CLASP	Collaborative Labeling and Appliance Standards Program
DGRE	Directorate General of Rural Electrification
DRD	Department of Rural Development
EELA	Energy Efficient Lighting and Appliances (project)
EnDev	Energising Development
ESMAP	Energy Sector Management Assistance Program
FAO	Food and Agriculture Organization
FONER	Proyecto Mejoramiento de la Electrificación Rural
GEP	Global Electrification Platform
GIS	geographic information system
GIZ	Gesellschaft für Internationale Zusammenarbeit (Germany)
GOGLA	Global Off-Grid Lighting Association
GPC	village cotton producer cooperative
GPRBA	Global Partnership for Results-Based Approaches
GWh	gigawatt hour
IDCOL	Infrastructure Development Company Limited
IFC	International Finance Corporation
IFPRI	International Food Policy Research Institute
KVa	kilovolt amps
kW	kilowatt
kWh	kilowatt hour
kWp	kilowatt peak
LCOE	levelized cost of electricity

LED	light-emitting diode
LSMS-ISA	Living Standards Measurement Study–Integrated Surveys on Agriculture
M&E	monitoring and evaluation
MFP	Multipurpose Functional Platform
MSMEs	micro, small, and medium-size enterprises
NEP	National Electrification Plan
NGO	nongovernmental organization
NRECA	National Rural Electric Cooperative Association (United States)
OBA	output-based aid
OGS	off-grid solar
PAEGC	Powering Agriculture: An Energy Grand Challenge
PAYGO	pay as you go
PPP	public-private partnership
PV	photovoltaic
RBF	results-based financing
RBS	Rural Business Services
RE	rural electrification
RERED	Rural Electrification and Renewable Energy Development
SAGARPA	Secretaría de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentación
SDG	Sustainable Development Goal
SIDA	Swedish International Development Agency
SIIP	Sahel Irrigation Initiative Support Project
SIP	solar irrigation pump
SPAM	Spatial Production Allocation Model
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
USAID	US Agency for International Development
VAT	value added tax
VIDA	Village Data Analytics

Key Findings

- The productive use of electricity in rural communities can contribute to significant socio-economic development and increased welfare. The "virtuous cycle" of productive use of electricity assumes that early development creates higher incomes, leading to increased demand for electricity and further investment in improving electricity quality and availability. Electricity suppliers benefit from higher revenue and financial sustainability, and appliance dealers, credit services, and investors benefit from market growth.
- However, without targeted measures, the increase in productive uses has been slower than expected in many communities after electrification. This has limited development benefits, financial performance and the sustainability of electricity access. Moreover, in the absence of wide based productive uses, too often investments in increased access to electricity have disproportionately benefited higher-income groups.
- This report highlights the importance of actively promoting productive uses to MSMEs, including small farmers, as a way of accelerating development after communities gain access to electricity. An ecosystem approach is recommended to comprehensively stimulate productive use of electricity including five "building blocks": planning, policy and regulations, technology and innovation, access to finance, and business development support. Such interventions require multi-sectoral expertise and partnerships. Attention to productive uses is crucial in remote rural communities with weak market linkages, poverty, poor resource endowments, and fragile economic conditions.
- The report is based on a comprehensive review of programs that promote the productive use of electricity, including case studies from a geographically diverse sample of countries. It considers long-term trends affecting productive use opportunities, including climate change, energy-efficient technology, and digitalization, as well as more immediate impacts of crises like the Covid-19 pandemic and disruptions of food security and supply chains.

- The report provides a dynamic roadmap for accelerating the impacts of rural energy access, which is based a well-grounded, multidisciplinary and comprehensive approach that addresses the specific needs and complexities of rural communities. When well done, this roadmap responds rapidly to shifting circumstances and events, adjusts based on real-time results tracking, builds on partnerships that continuously incorporate local intelligence and expertise, scale depending on experience-based learning, and constantly maintain poverty reduction as a mission-critical objective.
- Additionally, the report offers recommendations for grid-operators, mini-grids and off-grid solar based on the experiences of successful and indeed unsuccessful programs. Enterprises in all these supply sectors should prioritize the growth of sales to their productive use customers. Grid and mini-grid operators should actively market to MSMEs, ensure that they are delivering stable, reliable, and affordable services, support appliance purchases through partnerships with credit and appliance providers and consider incentives for connection charges, tariff rebates, and off-peak discounts. Mini-grid and off-grid solar require business models that can be tailored to fit the needs and opportunities of individual communities and their ecosystems. Depending on the existing planning, policy, and regulatory frameworks, and financing environment adjustments may be required to incentivize quality, availability, and affordability of the electricity services for MSMEs. Financial support should be considered to advance decarbonization of the value chains and ensure food security.

Executive summary

The productive use of electricity in rural communities generates revenue for the users and can contribute to significant socio-economic development. Over time, the productive use of electricity is linked with productivity and income growth, the emergence of new enterprises, and increases in household purchases of time- and drudgery-saving appliances, all of which boost welfare—and electricity consumption. Welfare is further bolstered as households benefit from the improvements in health and education made possible by electricity, creating a virtuous circle.

In many settings, increases in productive uses have not advanced as quickly as expected. Their failure to do so limits both development benefits and the financial performance of service providers and investors. Early assumptions that wider access to electricity access would spontaneously produce rapid improvements in productivity have been supplanted by the realization of the need to focus explicitly on developing productive use specific interventions. This need is particularly great in remote rural communities with weak market linkages, poor resource endowments, and fragile economic conditions, where productive uses typically lag dramatically. Because the gains of achieving least-cost rural electrification have accrued disproportionately to higher-income groups, poverty reduction should be considered as a mission-critical objective in the design and operation of rural electrification investments.

Opportunities to expand productive uses are affected by long-term trends in climate change, renewable energy, energy-efficient technology developments, and digitalization. More immediate crises, including Covid-19 pandemic, Russia's war on Ukraine and disruptions of food security and supply chains, affect livelihoods and market functioning throughout the economy, all the way down to rural communities. Fortunately, technological developments in renewable energy generation, decentralized electrification, communications, remote sensing and data analytics, financial technology, and, woven throughout, digitalization open opportunities for more resilient productive use interventions.

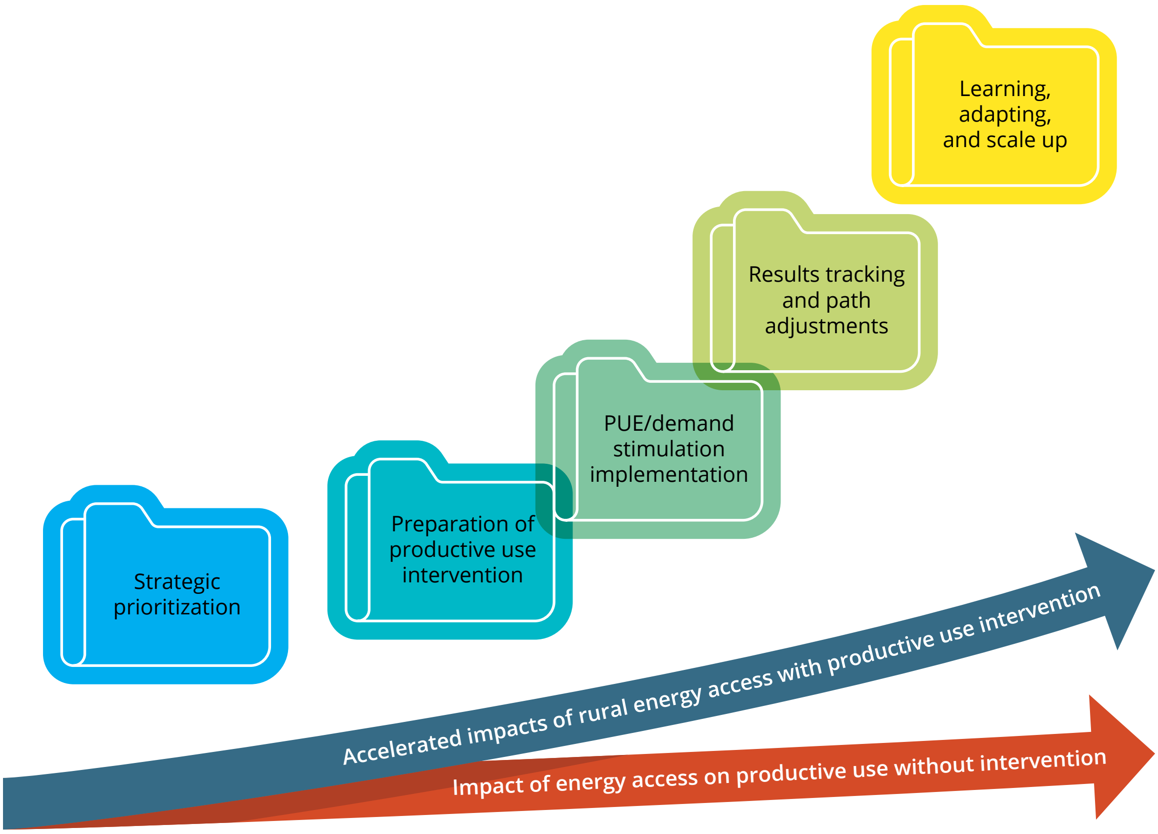
Promotion of rural productive use of electricity is a multifaceted, multi-partner, holistic effort grounded in rural realities, including the fact that men and women often use and benefit from electricity differently. Rural communities are complex systems with a dense array of circumstances and dynamically layered and interacting agents, relationships, elements, and unanticipated events.

A dynamic roadmap is one solution to low productive use amidst this complexity. This report can serve as a guide to policy makers and practitioners seeking context-specific solutions as they chart viable paths. The effort must grow out of adaptive designs that are responsive to changing circumstances and based on real-time data. It also requires partnerships that incorporate deep local knowledge and multisector expertise, cooperation, and investments.

The graphic ES1 shows overlapping stages of a dynamic roadmap for developing projects to accelerate impacts of rural energy access through productive use of electricity, highlighting (i) strategic prioritization of productive uses; (ii) holistic preparation and appraisal including ground up and top down information gathering; (iii) active promotion; (iv) real time results tracking with dynamic adjustments; and, (v) learning-based and opportunistic scaling. The context is characterized by uncertainty and interplay of cultural, natural, social, political and economic forces.

FIGURE ES.1

Overlapping stages in developing productive use of electricity projects



This report is based on a comprehensive review of programs that promote the productive use of electricity—programs that move beyond the goal of extending grid electricity or promoting decentralized renewable energy supply technologies. The case studies in annex A reveal best practices and uncover lessons for energy access programs. They describe electrification technologies, including grid, mini-grid, and off-grid renewable energy, in a geographically diverse sample of countries.

Value propositions

For micro, small, and medium-size enterprises (MSMEs), raising incomes is a driving value proposition behind expanding productive uses. For programs designed with poverty reduction as a mission, the added-value proposition is broad socioeconomic development across communities: higher incomes, greater productivity, and more jobs—all ingredients of the resilient community well-being that is expected from productive-use interventions.

For electricity suppliers, the value of more productive uses comes from higher revenues thanks to new productive-use customers, whose spending on electricity rises with their incomes. Payments from productive-use customers can make grid or mini-grid operators more financially sustainable. For off-grid solar suppliers—as well as appliance dealers and credit services and their investors—more productive use grows markets. For some electricity suppliers, the value proposition will include contributing to the socioeconomic development of the rural communities in which they operate.

For development, the rationale for actively stimulating the adoption of productive uses as rapidly as possible is to accelerate and expand near- and medium-term socioeconomic benefits. Shortening the cycle between the introduction of electricity and the adoption of productive uses can boost total benefits over time. Promoting productive uses as part of a development mission enhances the prospects that these increases can be achieved in ways that contribute to widely shared and sustainable benefits for the rural communities. If done in partnership with other sectors—most notably agriculture, water, manufacturing, transport, and social development—the development of productive uses can have positive ripple effects through value chains. (Annex C provides a detailed treatment of the benefits of productive uses of electricity.)

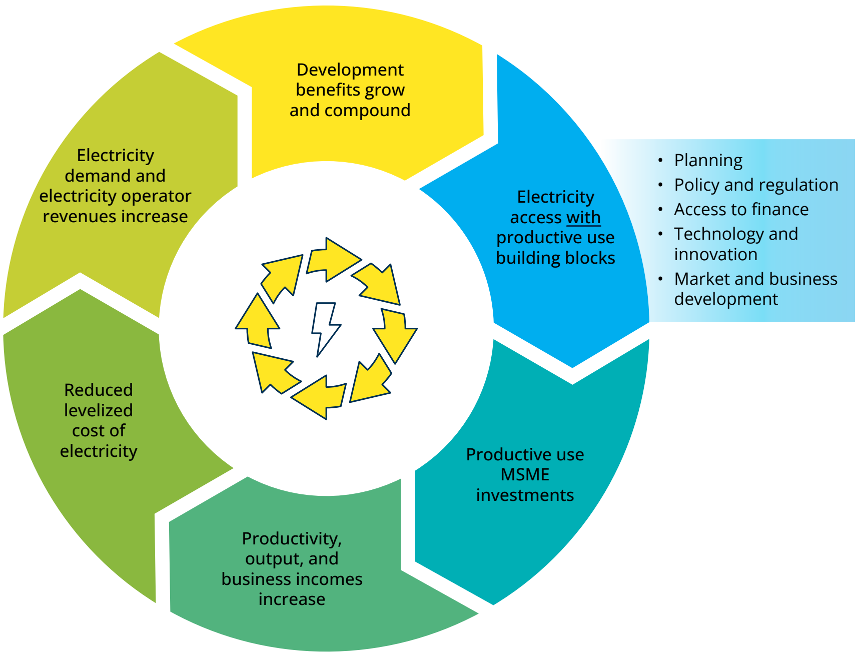
Creating a virtuous cycle of development

The virtuous cycle of the productive use of electricity begins soon after or even before a community gains access to electricity (figure ES.2). The main technologies used to promote energy access are the main grid; mini- or micro-grids; and individual systems for homes, farms, and small businesses. People tend to adopt productive uses slowly after receiving access to electricity. This cycle can be shortened through dedicated programs.

The virtuous cycle ideal assumes that the early development of productive uses creates higher incomes. Households, farms, and businesses with higher income over time purchase more appliances and more machinery, increasing both their incomes and demand for electricity. The higher demand for electricity increases the financial viability of energy service providers, which allows them to invest further in improving local electricity quality and availability. The benefits of productive use programs grow with each repetition of the cycle.

FIGURE ES.2

Virtuous cycles of development spurred by productive-use programs



Recommendations

This report presents recommendations for designing interventions to develop the productive use of electricity in rural communities, drawn from programs that have done so. Given the diverse and complex contexts, these recommendations should be taken as suggestions rather than requirements.

A core recommendation is to establish that productive uses development is a mission-critical task, as important as, for instance, increasing household access. Augmenting productive uses relies first on setting the growth of productive uses as a mission driving each step in the development cycle, from design through implementation and evaluation. Other requirements include the following:

- Conducive frameworks
- Understanding and engagement with the community
- Practical partnerships and competencies across a wide front
- Affordable and high-quality products and services
- Active marketing and promotion
- Dedicated and adequate resources
- Flexibility and adaptability, from design through implementation
- Curiosity and drive to find viable paths.

These requirements apply differently to operators of the main grid, mini-grids, and off-grid installations.

Grid operators

Productive uses sustain the development mandate of electric utilities and can contribute to their financial viability. Grid expansion to support more access for more households is often a political target, especially in communities where such expansion is not economically viable. The promotion of productive uses should be an integral element of this development mandate, ideally under the purview of programs to integrate efforts to expand household access to electricity with the government's multisector regional development strategies.

The reliability and affordability of grid services to MSMEs are critical to their adoption by productive users. Achieving the goals of reliability and affordability may require regulatory reforms—related to governance, tariffs and connection charges, and financial and operational performance, for example —as well as changes in utility practices and technical designs.

Experience has shown that active marketing of electricity services to MSME customers can spur increases in productive uses. Active marketing is different from the typical customer services that handle connection applications and upgrade requests, customer queries, and complaints. Active marketing should include outreach to build awareness of productive-use opportunities. It should provide support to help MSMEs resolve technical, financial, and market concerns, as in the United States in the 1930s and 1940s, Ireland in the 1940s and 1950s, Indonesia and South Africa in the 1990s, and Peru in the 2000s. Depending on a grid operator's capabilities and business model, the marketing may be outsourced or handled in-house. It may take the form of a time-limited campaign targeting early adopters and innovators or be a permanent feature of an operator's business.

Grid operators can also spur productive-use sales by supporting access to affordable appliances through on-bill financing and partnerships with appliance and credit suppliers. This customer-centered approach may require supply-side incentives (such as lower connection charges, bulk and seasonal tariff rebates, off-peak time-of-use discounts, faster responses to outages, and support for dealing with administrative challenges, such as applying for a connection) as well as demand-side incentives (related to the availability and affordability of productive-use appliances, access to finance, public awareness, and skills development).

Mini-grids

Demand from productive loads can enhance the sustainability of private and community mini-grids in remote communities. The uptake of productive uses directly benefits mini-grid developers through higher sales, better use of assets, and greater efficiency of generation operations (increasing daytime loads for solar hybrid installations, for example). Load forecasting based on potential loads, particularly productive-use demand, is typically used in sizing generation investments and ranking mini-grid site selections. Improved data analytics have underpinned mini-grid electrification programs in Myanmar and Nigeria. Identifying potentially viable communities for mini-grid development will depend on information from detailed rural appraisals, reliable data analytics, careful attention to the possibilities of developing MSME market linkages, and active marketing to MSMEs.

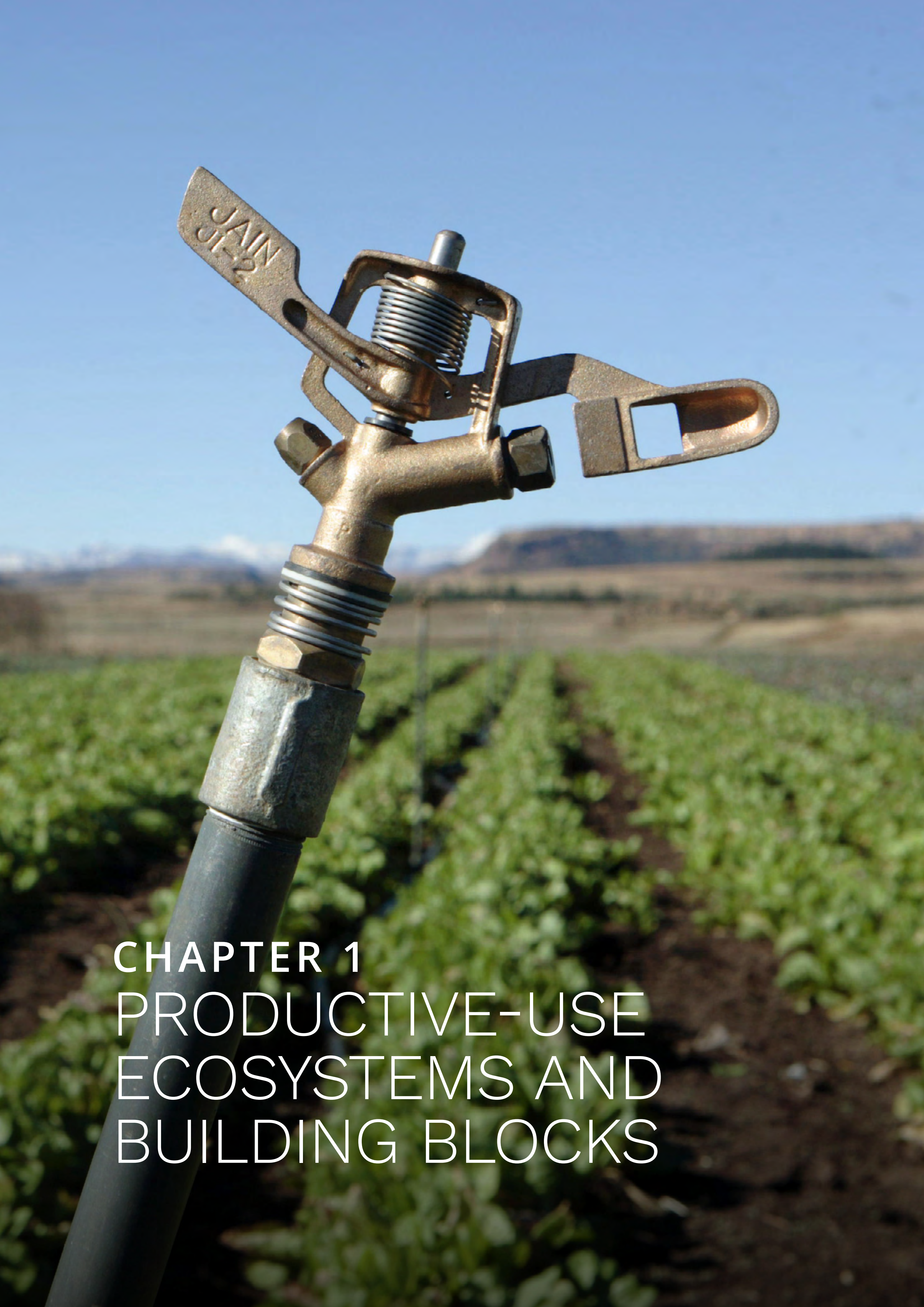
Competitiveness is critical to a mini-grid operator's viability. To be competitive with diesel, mini-grid operations may need to offer preferential productive-use connection charges, tariff rebates, off-peak discounts (for solar-powered mini-grids), and other incentives. Mini-grid owners can partner with appliance and credit providers to facilitate the purchase of the equipment needed for increased productive uses. Digitalization and related advances, such as pay-as-you-go payment and transaction technologies, have reduced the costs of these partnerships.

Financial support may be warranted to help mini-grid owners and investors bear some of the market entry costs and risks and help bring efficient electrical appliances to rural communities for use in productive activities. These efforts could include initial awareness raising and marketing. Continuing support could be provided to some mini-grid operators beyond the initial technology adoption phase, in order to advance decarbonization, ensure food security, or promote the use of renewable energy. It will almost certainly be necessary to sustain mini-grid services for productive-use customers on an equitable basis in poor, remote communities that are otherwise not economical to supply. In some cases, market entry or operating support may require policy and regulatory adjustments.

Off-grid solar

Developments in solar energy technology continue to improve prospects for productive uses in remote communities where grid and mini-grid services are not the least-cost electrification option. As with grid and mini-grid investments, increasing productive uses of distributed off-grid solar requires an ecosystem approach. Depending on the findings of assessments of the planning, policy, and regulatory frameworks, it may be necessary to seek specific adjustments to incentivize quality, availability, affordability, and adoption of solar technology options.

In the marketing of off-grid solar, emphasis should be placed on providing productive-use customers who are unfamiliar with the technology with information on their options; promoting the use of quality-certified appliances; and facilitating access to finance, including by leveraging pay-as-you-go technologies as well as market linkages. Such efforts have been made for solar irrigation in Bangladesh, Niger, and Togo; cold storage in Rwanda; and agri-processing in Mexico, to cite just a few examples. Productive uses leveraging solar energy are linked with agriculture and water; they can be promoted with ever-greater confidence given the development of quality-certified energy-efficient products. Collaborations between actors in the energy and agricultural sectors will be critical, both in planning and in practice.



CHAPTER 1

PRODUCTIVE-USE ECOSYSTEMS AND BUILDING BLOCKS

Electricity is an infrastructural commodity underpinning economic development, including through income- and employment-generating activities. Productive uses involve inputs of electricity in any income-generating activity that produces goods or services. Productive uses are defined as having an economic benefit and a direct impact on income. Almost all active energy access projects funded by the World Bank now include productive-use interventions.

Productive use occurs in a complex adaptive system with many layers of interacting agents and circumstances. This perspective highlights the interplay of multiple actors, networks, and power relationships. It stresses the role of formal and informal connections and co-dependencies. Conceptualizing productive use as an activity within a complex system is becoming more common among practitioners (see, for example, IRENA and SELCO Foundation 2022). Viewed through an ecosystem lens, lackluster uptake of productive use of electricity is partly a social problem involving issues of equity that call for holistic, collaborative approaches. Low uptake emerges from the complex, layered interactions of rural communities; the influence of histories and cultures; and the impacts of uncertainty, change, and time.

The report analyses five building blocks to promote the use of electricity for productive use: planning, regulation, finance, technology, and support for market and business development. The most useful visualization of this ecosystem places micro, small, and medium-size enterprises (MSMEs) (broadly defined to include smallholders, household-based income-generating activities and other productive users), at the center, with the five building blocks as potential entry points for actions to boost productive-use incomes (figure 1.1).

FIGURE 1.1

Building blocks of productive-use development

Actions to increase productive uses can be taken at the level of any of the building blocks and then linked to broader, well-defined objectives for addressing cross-cutting concerns. Projects can be designed opportunistically to achieve urgent ends within a project cycle, but the longer-term strategic vision is to strengthen the resilience and sustainability of the entire productive use of energy ecosystem.

The five building blocks suggest that advancing the productive use of electricity goes well beyond physical expansion of grid electricity or the introduction of decentralized renewable energy technologies. Four of the building blocks—planning, policies and regulations, technology, and finance—have received significant attention from officials, donors, academics, investors, and others. Market development for rural productive use of electricity has received much less attention and support. This relative neglect must end. Support for this market and business development includes awareness raising, market linkages, skills development, and facilitation of access to technology and finance. It also involves easing of supply-side constraints linked to engineering and regulatory designs, governance, service quality, and affordability.

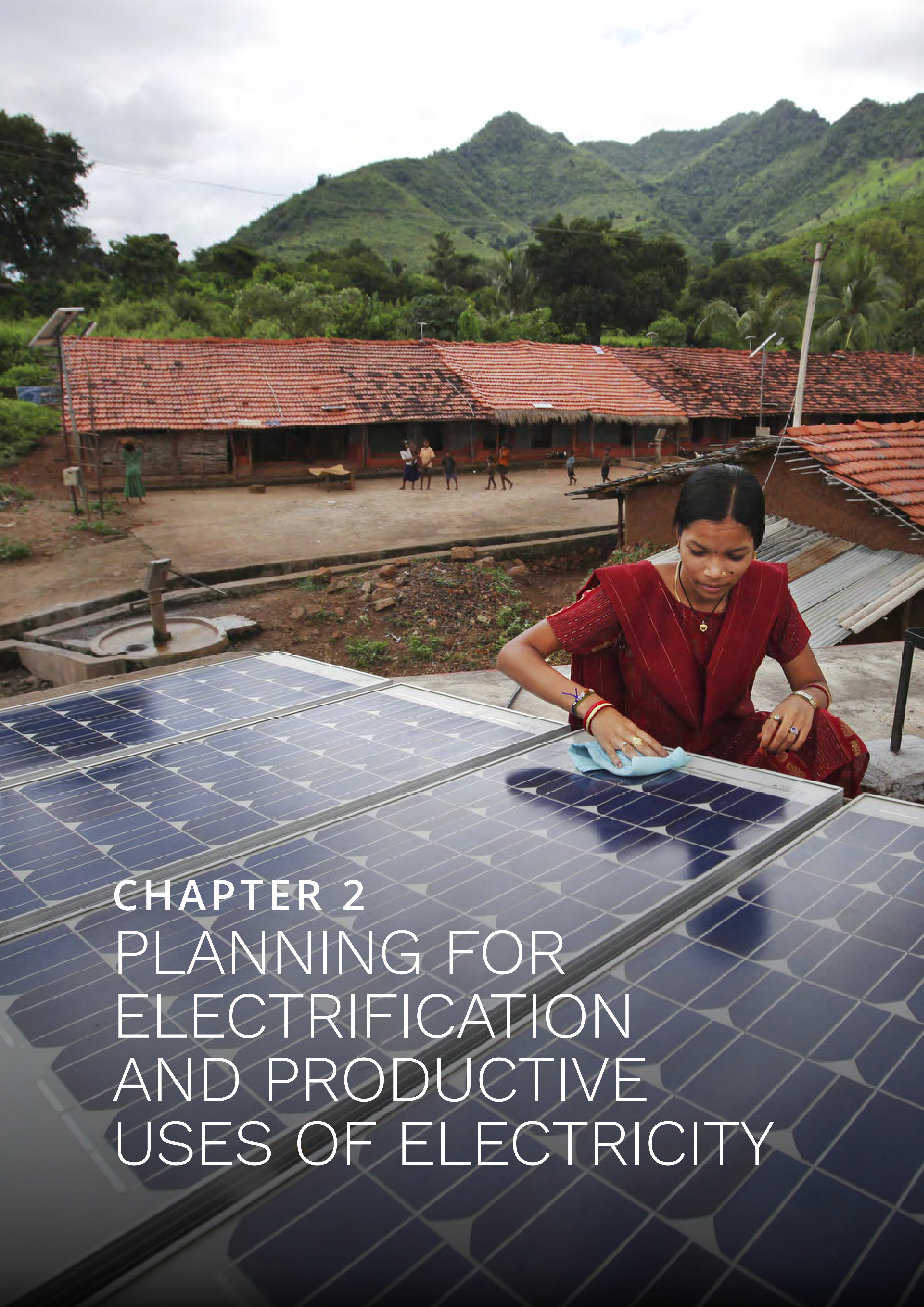
An MSME–centric ecosystem approach to promoting the productive use of electricity emphasizes actions that involve multiple partnerships and stakeholders. Their interactions help enterprises reach their full potential. Energy service suppliers, appliance and credit sellers, mobile phone operators, credit business, and others are necessary enabling actors as well as collateral beneficiaries of the productive use of electricity development. But the first-order focus is the MSMEs themselves.

Ample evidence shows that electricity adoption—from the grid, mini-grid, or solar home systems— is associated with improved business and household incomes over the long term (Barnes 2014). In Bangladesh, both farm and nonfarm income grew by close to 25 percent after households adopted grid electricity; in India, the increase was nearly 70 percent. In India, solar irrigation systems with electric pumps improved crop yields (Naik and others 2021). In Nepal, electricity-powered micro-hydro power raised income by 11 percent (Barnes, Samad and Banerjee 2014).

There is also ample evidence of the often unexpectedly slow uptake of energy for productive uses in the absence of dedicated efforts to stimulate demand from income generating users (Bernard 2012). At the same time, there are examples of dedicated efforts that accelerated uptake. In Kenya, for example, support for solar water pumps increased crop yields for households by as much as $800 per year (Crane, Zukerman, and Thrift 2020), and solar-powered cooling reduced losses and improved sales, leading to a 150% impovement in key dairy performance indicators such as milk quality and production, and farmer's income (Savanna Circuit Tech & UK Government, n.d). In Mali, mills for grinding and machines for de-husking saved women six hours of drudgery per day (Sovacool and others 2013), freeing up their time for other productive activities.

Stimulation of the productive use of electricity increases revenues of electricity service providers. A report by Oxfam describes a virtuous cycle of higher nonpeak electricity demand and lower costs per kilowatt hour (KWh), making electricity more affordable while increasing demand (Morrissey 2018). Larger-scale promotion of productive uses for grid electrification has been successful in Indonesia and Peru (Finucane, Besnard, and Golumbeanu 2021; Finucane, Bogach, and Garcia 2012). In Peru, adoption of electricity by commercial enterprises raised their average electricity consumption from 56 KWh to 240 KWh per month (a 330 percent increase) (Prisma, Macroconsult, and Instituto Cuanto 2016). Improving productive uses can reduce mini-grids' cost of service per unit of electricity (ESMAP 2019). For solar-powered mini-grid systems modelled by the World Bank's Energy Sector Management Assistance Program (ESMAP), productive uses reduce the levelized cost of electricity (LCOE). Typical load factors for mini-grids are about 20 percent, so for most of the day, system capacity goes largely unused. Conservative assumptions estimate the additional productive-use load from commercial business and activities at a load factor of up to 40 percent. This additional load reduced the LCOE from $0.55/KWh to $0.42/KWh in 2018 (a 24 percent reduction) and from $0.38/KWh to $0.28/KWh in 2021 (a 26 percent reduction).

Productive use programs aim to accelerate the accrual of the gains from rural electrification, allowing them to compound over time and accelerating the virtuous cycle of development impacts. The next chapters expand on the building blocks used to design productive-use programs.



CHAPTER 2
PLANNING FOR ELECTRIFICATION AND PRODUCTIVE USES OF ELECTRICITY

If efforts to expand energy access and reduce poverty reduction are to succeed, electrification plans must include productive use of energy. Universal household access to electricity, a pillar of Sustainable Development Goal (SDG) 7, is now a standard aim of planners across countries, often coupled with the aim of realizing broad economic opportunities through productive uses. Planners have identified cost-optimal technology mixes to supply households, but stimulating demand for the productive use of electricity has proved difficult.

An important outcome of an integrated planning process is clear guidance to policy makers and regulators on the broad mission of rural electrification. This guidance may stipulate that 100 percent of rural households are to have access to electricity by a given date through a combination of grid, mini-grid, and off-grid solar electricity. Such guidance will promote productive electricity use only if it specifies that expanded access must contribute to this goal and clarifies the roles of the public sector, private sector, communities, and other stakeholders in achieving it.

Rural household electrification programs typically proceed from more developed areas to poorer ones, with lower electricity demand. Planning for productive uses becomes more challenging as this process reaches remoter, poorer communities with weak and fragmented markets. When they encounter the complexities of rural communities, planners and outside investors are hampered by scant information and insufficient understanding. They also draw on limited experiences with planning for and promoting the productive use of electricity to MSMEs in deep rural areas. Distance, poverty, and uneven socioeconomic conditions make it time-consuming and difficult to find and implement solutions. These constraints raise entry costs for investors, contributing to underinvestment in resources that could develop productive-use markets in these communities.

Advances in digitalization help planners harness data and tools to improve remote resource assessments and least-cost engineering designs, as well as to engage in integrated and dynamic planning using top-down and bottom-up methods. In addition, more experience is now available with accelerating rural MSME development across sectors, including renewable energy projects. Constraints should also be addressed by community level appraisals. The interest in poverty reduction and productive uses create opportunities for partnerships and cross-sector cooperation that can make electrification planning better and more practical.

GIS–linked data and analysis tools

Geospatial planning tools are used to map and visualize potential consumers for grid extensions, mini-grids, and off-grid solutions. These aids bolster planning for broad rural electrification and for individual investments. Infrastructure costs, funding needs, and technology options can all be calculated for scenarios that factor in terrain and distances from existing infrastructure. Mapping technologies can be used to forecast electricity loads, taking into account population densities, resource endowments, complementary infrastructure, and other factors. The falling costs of digitalization, technology, and communication facilitate more integrated and data-intensive scenario-building exercises for planning purposes. Now more than ever, project planners and investors have vast and growing amounts of digitized data on transportation, communications, water, health facilities, schools, markets, and business opportunities to inform their demand-side calculations, stakeholder mapping, project siting, financing, and monitoring and evaluation. These data come from a range of mostly public sources, including the following:

- Geospatial imaging tools, including remote sensing, geospatial datasets, and geospatial data-modeling tools that provide information on geography (land cover, topography, water sources); demography (population density); and infrastructure (road, cellular tower, or electric transformer proximity)
- National household surveys, such as the Living Standard Measurement Study, which capture household income, expenditures, and consumption data; surveys such as the Multi-Tier Framework for energy access; and enterprise datasets
- Agricultural surveys of crops, areas, yields, irrigation requirements, and livestock
- Agriculture and water programs funded by the International Food Policy Research Institute (IFPRI) and the Food and Agriculture Organization (FAO) that show commodity market trends and opportunities for small-scale producers to access high-value markets.

In addition to publicly available data, private data can provide design insights for projects. These data include the following:

- Profiles of electricity service customers, including usage patterns (time, frequency, duration of use); payment patterns; and demographics collected from mini-grids, off-grid solar companies, and utilities
- Sales and other market data gathered by industry organizations such as the Global Distributors Collective, the Global Off-Grid Lighting Association (GOOGLA), and national renewable energy associations
- Off-grid solar and appliance sales data on volumes sold, type of sale (cash or installments), and unit size.

Public and private entities have developed geographic information systems (GIS) and other analytical tools to help plan and evaluate demand-side interventions for productive uses. Applications and web-based platforms can enable customized, least-cost electrification modeling; impact assessments; equipment performance/usage monitoring; credit scoring and payment tracking. Machine-learning approaches are being used to assess irrigation needs in the agriculture sector and the affordability of specific solutions for potential customers. Table 2.1 presents examples of such analytic platforms.

TABLE 2.1

Data analytics tools and digitalization techniques used to plan and evaluation interventions to increase productive use of electricity

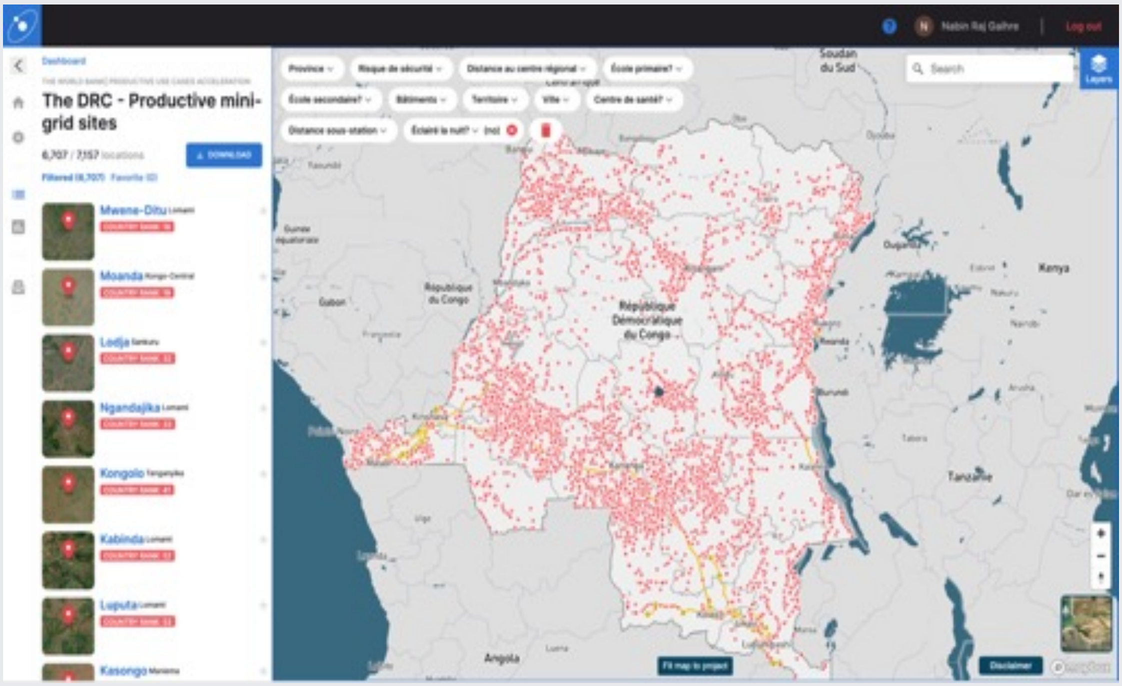
PROGRAM	DESCRIPTION
AgroDem	AgroDem is an open-source model that uses publicly available data to simulate climatic conditions, crop-yield distribution, and other agro-ecological features to generate estimates of the water and electricity required for irrigation. It can be applied to inform planning related to agriculture and other productive uses of electricity.
AtlasAI	AtlasAI offers hyperlocal data about the population of rural Sub-Saharan Africa, including data on demographics, agricultural productivity, wealth distribution, and other topics, in a raster (2 km x 2 km) format.
CAPI (Computer Assisted Personal Interview) program	CAPI enables practitioners to design surveys with a full range of applications. Users can also control the quality of data collected.
Fraym	Fraym offers hyperlocal subnational information (to 1 km x 1 km) about a population's characteristics and behaviors. It combines primary data, remote sensing data, and satellite imagery with machine learning models. Fraym has worked with USAID and the World Bank, among other institutions.
Global Electrification Platform (GEP)	The GEP is an interactive hub of open-source data created by ESMAP and partners. The web platform provides decision makers with high-quality geospatial information. Planners can use the least-cost electrification plans that are provided for 58 countries. The platform can be used as an electrification planning tool.
Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA)	Agriculture surveys have been integrated into national LSMS surveys. On the LSMS-ISA website, practitioners can find the LSMS-ISA dataset, sampling strategy, and survey questionnaire.
Nithio	In addition to its own investment activities, Nithio offers a standardized, AI–driven credit-risk assessment engine that combines proprietary geospatial population data with customer repayment data to forecast pay-as-you-go repayment rates and cashflows for solar home systems.
Odyssey	A one-stop-shop web platform for mini-grid developers and investors, Odyssey enables data collection from any technology component regardless of its manufacturer, providing analytical tools for assessing site and portfolio viability.
Spatial Production Allocation Model (SPAM)	Developed by the International Food Policy Research Institute (IFPRI), SPAM uses a cross-entropy approach to estimate crop distribution within disaggregated units. The model can be used to integrate agricultural production and energy needs into least-cost electrification planning. It can also be used to estimate crop yields. It has been used in Ethiopia to estimate least-cost options to meet the demand for energy for irrigation.
Village Data Analytics (VIDA)	A software application that combines GIS, survey data, and artificial intelligence (AI)–based algorithms to map villages where energy and productive-use appliances can potentially be deployed together. VIDA identifies off-grid villages using a unique clustering algorithm. It then identifies productive-use proxies such as agricultural activities, crops grown, access to roads, nearby public facilities, and distance to major markets (box 2.1). This information is made available to both energy providers/developers and productive-use companies. Companies can jointly identify areas with good potential for selling their products and energy services. Projects can see where potential-use cases might exist for certain appliances, and financiers and insurers have transparent information on their clients' sites. VIDA is widely used in Sub-Saharan Africa, where it has been deployed in more than 25 countries. Users include the World Bank Group, the US Agency for International Development (USAID), KfW, several governments, and mini-grid developers.

BOX 2.1

DATA-DRIVEN PRIORITIZATION OF PRODUCTIVE-USE INTERVENTIONS

The World Bank Group, in partnership with Vida Data Analytics (VIDA), is conducting several pilots to identify the potential of using geographic information system data to encourage co-investments in productive-use case appliances and mini-grids in villages. The objective is to analyze potential mini-grid sites and layer in productivity-related factors (crop growth, road and transport infrastructures, access to commerce, public facilities, irrigation availability and requirements, and so forth), in order to identify villages with substantial demand for both residential consumption and productive use (figure B2.1.1). Access to the platform and data is then provided to key stakeholders, including mini-grid developers, productive-use companies, and financiers. The stakeholders are matched and encouraged to co-invest in villages they deem attractive. The data inform roadshows in these villages to raise awareness on electrification and productive-use appliances. The project helps villagers access electricity, appliances for productive use, and financing.

FIGURE B2.1.1
VIDA's user interface visualization of the list of potential mini-grid sites and major crop-growing areas in the Democratic Republic of Congo



Source: World Bank and Village Data Analytics 2022.

Data analytics can also help identify potential investments or clusters of investments for energy service providers by identifying hydro, solar, and other local resources. In Rwanda, a project is estimating the solar potential of agriculture based on the value of agricultural supply chains (box 2.2).

BOX 2.2

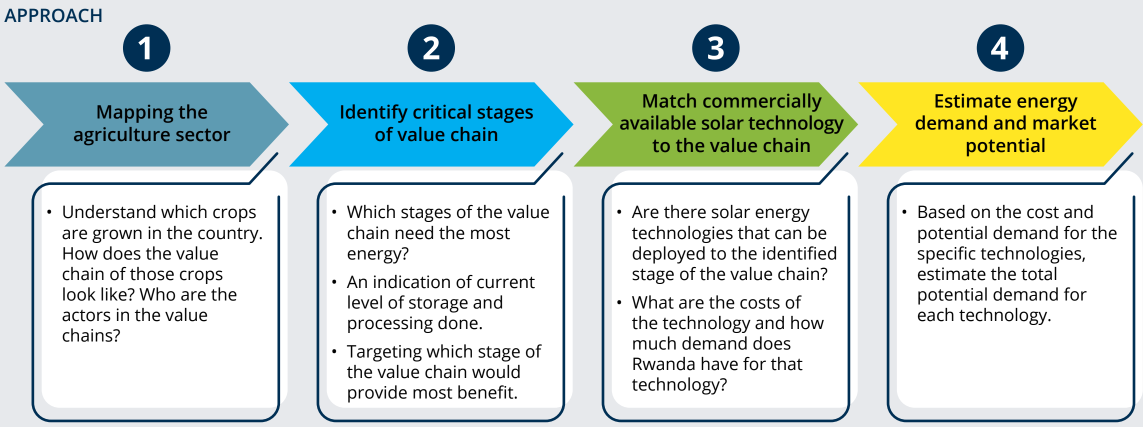
ESTIMATING SOLAR POTENTIAL FOR AGRICULTURE IN RWANDA

Electrification can shift value added upstream to micro, small, and medium-size enterprises and their communities, driving rural development. Value chains can be mapped to detect specific energy requirements at each stage and identify supply technologies to meet them.

In Rwanda, the World Bank, in collaboration with the FAO, has conducted such a value-chain assessment in a project called Re-energizing Agriculture in Rwanda through Solar Energy. Its methodology, described in box figure 2.2.1, could be used for various energy supply technologies and for value chains.

FIGURE B2.2.1

Methodology of project to nurture agriculture in Rwanda



Source: World Bank and FAO 2018.

Rural appraisals: Data and analysis

Remotely generated planning data rarely include sufficiently granular data on rural businesses and their demand profiles, business incomes, and gender disparities. As a result, demand for electricity for productive uses is sometimes misestimated, contributing to suboptimal technical designs and inadequate measures to stimulate productive-use demand. As earlier lessons on planning rural electrification in the United States and Ireland demonstrate (box 2.3), an in-depth understanding of the local context is required in the design of productive-use interventions.

BOX 2.3

EXPERIENCE WITH RURAL ELECTRIFICATION PLANNING IN THE UNITED STATES AND IRELAND

In the oft-cited success cases of the United States in the 1930s and in Ireland in the 1940s, planning and implementing electrification for rural development was an urgent political imperative. Commercial electrification efforts were slow and insufficient. During and after the Depression, governments mounted extensive, mission-driven rural electrification programs to stimulate growth and modernize rural life.

The programs were designed to meet the productive-use requirements of farmers and rural households. Based on assessments at many levels and in many communities, the programs built on—and built up—local capabilities. They relied on multiple measures, institutions, and collaborations that fit their contexts, including low-interest loans for energy distribution investments and appliance purchases, partnerships with appliance and equipment providers, measures to strengthen cooperatives and public sector agencies, awareness raising, and marketing campaigns to inform existing and potential productive users of the opportunities afforded by electrification.

Key lessons from these early experiences are that project design should emerge from a deep understanding of local capabilities and contexts and that productive use requirements should be integral to both the technical and commercial aspects of programs.

Source: Sablik 2020; Shiel 2003.

Ground-level assessments that map MSMEs' productive-use potential provide granular data and insights that enable more accurate scenario building. Geospatial and other remote planning tools should be complemented with primary data collection.

In-person engagements are vital throughout a project cycle, from the initial design to the adaptations that will inevitably be necessary. Participatory rural appraisals are needed to inform the design of community-level interventions. These appraisals illuminate the ecosystems, opportunities, and challenges of productive electricity use in rural communities. They should include surveys, stakeholder engagement, and consultations and focus groups using communication and data-gathering methods appropriate for the setting. The data gathered should include gender-disaggregated household and business demographics, incomes, expenditures, preferences, and energy needs. The surveys should also gather data on the competitive context (for example, suppliers, availability, prices, reliability, quality) in the energy markets in the communities.

Potential operational opportunities for promoting specific productive uses can be revealed and initially vetted through rural appraisals. Opportunities for the productive use of electricity may depend on how communities respond to government budgets, local and global markets, and weather and climate change. Farmers, for instance, may adopt electricity to increase productivity only if they have access to agricultural inputs, such as fertilizers or irrigation. A community-focused approach is necessary as part of any effort to identify energy needs and market opportunities (Lighting Global and IFC 2019; Verploegen 2017).

Multiple good-practice guidelines and methods are available for participative rural appraisals (Chambers 1994; D-Lab 2017; Orr, Donovan, and Stoian 2018). Experienced appraisers are often readily available to consult on rural energy, business, social, and community development, particularly in rural communities. Wandschneider and others (2012) provide guidelines and methods for appraisals of rural markets and agriculture value chains. ESMAP describes a process for productive uses and gender integration (World Bank n.d.) In many cases in may be difficult to gather complete information, and creativity and initiative will be needed to find viable methods (Duffield 2014; Cramer and others 2016).

The World Bank is increasingly adopting cross-sectoral approaches to electrification planning. A pilot in Nigeria to coordinate the location of mini-grids and investments in agri-processing aims to ensure the financial viability of both goals (box 2.4). In Ethiopia, ESMAP's Access to Distributed Electricity and Lighting in Ethiopia (ADELE) project identified productive loads from enterprises in horticulture, dairy, poultry, and industrial parks that could serve as anchor customers for mini-grids deployed under the project. In the Democratic Republic of Congo, the Access Governance and Reform for the Electricity and Water Sectors project (begun in 2022) aims to boost renewable electricity and improve water services for various productive sectors.

BOX 2.4

NIGERIA'S PILOT PROJECT ON MINI-GRID ASSESSMENT AND DEMAND MAPPING

Through the Empowering Rural Consumers program in Nigeria, ESMAP is gathering knowledge and evidence on approaches to integrate the productive use of electricity into large-scale electrification interventions. This pilot project assesses the potential of mini-grids to meet electricity demand in agri-business.

The project was designed to assess demand for agri-business for the purpose of understanding existing and potential electricity demand in targeted sites and evaluating options to supply it. The analysis relied on (a) extensive data collection and analytics on the potential of solar mini-grids; (b) GIS–based analysis of settlement clusters; and (c) agri-processing data, including type of agri-business, types of crops and value chains, equipment used, the timing of its use, and communities neighboring the clusters.

The conclusions suggest that sites near agricultural fields are good targets for mini-grid development, as agricultural loads compensate for the small size of these communities. Value chains of rice and cassava are good anchor loads. Electrifying these value chains may reduce electricity tariffs by 10–15 percent when the agricultural load exceeds 15 percent.

The pilot highlights the power of integrated planning anchored in data analytics to boost productive-use interventions, laying the groundwork for evaluating the impact of agri-business on demand stimulation.

Source: World Bank 2022; Integration Environment and Energy 2022.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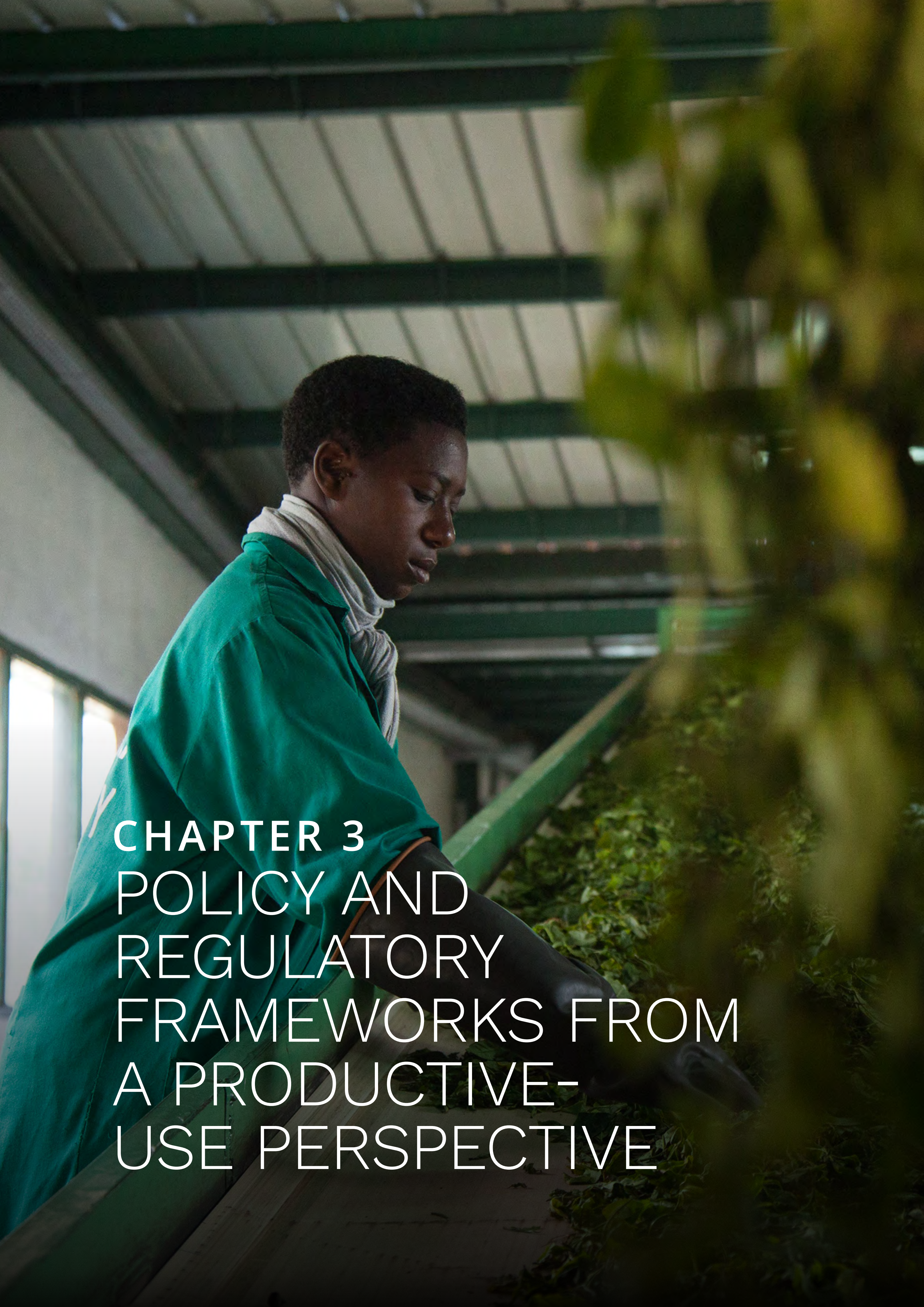
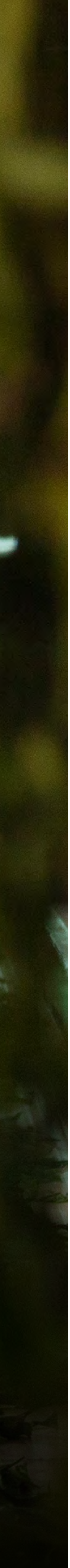


CHAPTER 3

POLICY AND REGULATORY FRAMEWORKS FROM A PRODUCTIVE-USE PERSPECTIVE



Policy and regulatory frameworks exert a great deal of influence over both the potential for and the uptake of the productive use of electricity. A systematic review conducted from a productive-use perspective should be sensitive to rural realities. Remote rural communities possess energy ecosystems, value chains, and markets, as discussed in chapter 2. Pre-electrification energy-services businesses (such as those devoted to battery charging or diesel supply) and their productive-use customers all function within a mix of existing formal rules, informal norms, and unchecked market and social forces. The landscape is crowded with incumbents (diesel motor dealers, battery suppliers, informal micro grids, appliance retailers) and entrants, such as solar equipment suppliers. Poverty, along with government and market failures, hinders the entry, competitiveness, and scaling of enterprises that could offer cleaner, cheaper, and more productive and resilient equipment. High initial costs and low affordability can make potentially beneficial investments unviable. These realities can be grasped only when a review of policies and regulations is paired with information and insights on actual practices.

Both formal policies and regulations and informal norms must be considered. Informal networks and market practices (including extralegal and illegal ones) help shape the suitability of a business environment in the eyes of investors. Engaging with stakeholders who work daily with supply-and-demand issues can be vital to finding policy and regulatory fixes that suit the context, strike the right balance, avoid both over- and under-regulation, and are workable in local contexts. Consultations must integrate women and vulnerable groups from the outset. Active stakeholders have practical knowledge of the market system, supply chains, and the ecosystem of social and market networks and political economies that help or hinder the productive use of electricity in their communities. Their market intelligence and insights, buttressed by solid qualitative information from on-the-ground sources, can be gathered and analyzed relatively quickly. Appropriate skills and trust are needed to gather this intelligence, as much of the cost and risk data may be proprietary or closely held, and competitors and other stakeholders may hesitate to share.

The major elements of an enabling policy and regulatory environment are presented below. They may already be present in a country or community. If they are not, or if they are present in ways that restrict welfare-increasing investments in productive energy use, they may warrant specific interventions.

Policy and regulatory frameworks

Institutions are key in productive-use development. A line ministry (agriculture or water) and its decisions on decarbonization can shift public resources in ways that favor the productive use of electricity. In Bangladesh for example, the government promoted decarbonization of irrigation and set targets for solar-pumped irrigation in rural off-grid areas. Finance ministries can advance market development for renewable energy and energy-efficient appliances through fiscal incentives (such as customs duty exemptions). They play a key role in shaping the business environment, including access to finance or subsidies for clean technologies. Regulators set requirements in the ecosystem, including business registrations, licenses, construction permits, access to credit, standards for appliances, and the quality of service provided by energy operators.

For MSMEs and other investors, clarity can save costs. Mapping institutional roles and rules and describing the actual practices gleaned from local information gathering will help investors identify opportunities and prepare their risk assessments. Investors who understand the frameworks will have fewer qualms about uncertainties and risks.

Appropriate policy and regulatory frameworks can support the productive use of electricity by facilitating high-quality equipment, affordable prices, and sustainable business models. Some framework conditions are necessary for its widespread adoption. They are not always directly related to productive uses but can be considered as foundational elements upon which productive uses are possible. Some of them include the following:

- A favorable business environment, including access to finance
- Overall energy sector policies and rural electrification planning
- Regulations covering user tariffs, connection costs, and quality of service for grids and mini-grids
- Off-grid solar product performance standards and labeling
- Regulatory assessments of key electric appliances for productive use, especially where public funds are to be used to accelerate the adoption of, say, energy-efficient appliances
- Fiscal incentives, import duties, and value-added taxes as needed to make solar and other energy efficient, renewables-based electricity systems competitive.

Tariff regulations, connection fees, and minimum service standards

Regulations covering tariffs, connection costs, and quality of service affect the adoption of electricity. Grid energy services, and often mini-grids above a defined size, are typically regulated, with tariff rates based on analyses of costs and acceptable returns, taking into account other concerns, such as lifeline services, minimum service levels, connections charges, and the need for continual adjustments.

Consumer tariffs and cost recovery for suppliers are a deeply researched and contentious field. Although cost-reflective tariffs can be a prerequisite for financial sustainability, affordability and competitiveness are no less important concerns for the productive use of electricity in rural communities, especially when the mission is to reduce poverty by increasing incomes. Tariffs and cost structuring for MSMEs (for example, initial connection charges) and competitive rates with respect to alternatives (for example, diesel gensets) will be major factors in determining the uptake of services from, for instance, a new mini-hydro grid.

High connection charges, cumbersome application procedures, and internal wiring cost often impede the adoption of electricity. Low-cost electrification technologies, optimized technical design, effective procurement practices and financing schemes, including subsidies and credit to customers are critical for making connection affordable.

Properly structured tariffs can provide incentives for MSMEs to convert to electricity. The tariffs should respond to MSME energy needs, service reliability, affordability, and the competitiveness of alternatives, such as diesel, while also taking into account the marginal costs of supply and available subsidies. For mini-grids, initial application of lower tariffs can provide incentives to businesses to connect. For solar-powered mini-grids, the use of time-of-day tariffs can shift demand to the day time and reduce peak demand.

The quality of electricity service makes it more likely that both households and businesses will adopt electricity, whether it involves the grid or decentralized clean energy sources (Blimpo and Cosgrove-Davies 2019; World Bank 2020). Regulations often set minimum standards for voltage and voltage drops, service interruptions, and response times that can be critical for MSMEs' business operations. Despite such well-intentioned regulations, the quality of service is poor in many remote communities. Advances in clean technology—including storage for intermittent solar and seasonal hydro and wind-based systems; smart controls; and applications for monitoring, troubleshooting, metering, and payments—hold out the promise of improving the reliability of grid and mini-grid electricity supply. Moreover, the market availability and uptake of high quality certified off-grid solar productive appliances are increasing. Thus, the market intelligence on existing service quality and how to improve can provide important incentives for electricity use and adoption by MSMEs and other investors.

Standards for equipment, appliances, and customer protection

Insufficient or untrusted information and the networks of suppliers of cheaper, lower-quality energy alternatives hinder the adoption of more efficient, cleaner technologies. Labeling, certifications, warranties, and brand building are steps enterprises take to differentiate their products. Performance standards can improve the uptake of affordable, good-quality appliances by MSMEs and households who might otherwise tend to purchase lower-quality, inefficient, undifferentiated products.

International efforts to qualify, certify, and brand products are continually adding ways to comply with regulations to promote high-quality appliances and electricity service. For more than a decade, Lighting Global has operated a quality-assurance program that developed test methods and quality standards for pico solar products and kits for solar home systems up to 350 Wp and worked with governments to encourage the adoption of harmonized policies to lower market barriers for quality-certified products and protect consumers. In January 2020, Lighting Global, in partnership with the Collaborative Labeling and Appliance Standards Program (CLASP), launched VeraSol, an independent quality-assurance program. VeraSol expanded its quality-assurance frameworks to include productive-use appliances. Other international efforts include Energy Efficient Lighting and Appliances, which supports market development for energy-efficient appliances in East and Southern Africa through market incentives, energy performance standards, capacity building, and market awareness. Chapter 5 discusses both VeraSol and Energy Efficient Lighting and Appliances.

Taxes, duties, and permitting requirements

Taxes and duties affect whether investments in the productive use of electricity are profitable. In many countries, regimes for supportive duties, value-added taxes, and general service taxes are in place for appliances and electricity system components. However, the application of these regimes by customs officials is often inconsistent, and appliances that have both business and nonbusiness uses are rarely exempted. Easily accessible material that defines applicable taxes, duties, and exemptions, along with intelligence on actual market and official practices, can help investors. Designing a viable intervention must be fully grounded in market intelligence that paints a full picture of the taxes and duties as applied.

The requirements for registering, licensing, qualifying, permitting, and operating a supply- or demand-side business vary greatly across settings. Informal requirements and related costs vary even more. Lists or analysis of formal requirements therefore need to be strengthened by market intelligence on the actual costs, procedures, and timing. Official information is useful, but businesses currently operating in the market are often the most reliable sources.

Subsidies

Affordable access to reliable grid, mini-grid, and off-grid electricity in remote communities may require subsidy support. Specific technology supports for productive uses of electricity (such as water pumps) are driven as much by financial and technical modeling as by the overall mission requirements (poverty reduction, social inclusion); budget constraints; experience; and political imperatives related to the economy.

Those considering investments in and operating support for productive use of electricity should account for the costs of supply (for example, a new mini-grid) and demand (for example, an MSME's new electric pump). Support for investment and operations should design eligibility rules that consider market barriers, low incomes, risky and fragile household situations, and MSMEs' risk tolerance for external investors in remote communities.

Within the overall context of promoting the productive use of electricity, subsidies can focus on broader goals, such as the decarbonization of value chains. A minimal aim would be to provide subsidies to support clean and more efficient technologies that are at least equivalent to those for competing, lower-quality technologies. Existing diesel subsidies disadvantage micro and mini hydro grids, PV mini-grids, and off-grid solar products.

Access to information

Potential investors often expend scarce resources on investigating regulations, rules, and norms. For MSMEs the costs may be prohibitive. As with access to GIS-supported planning maps and resource data, information on institutions and procedures needs to be accessible in affordable, useful formats. The information should offer step-by-step guidance on the decision points (for example, access to subsidies, registering qualifying energy-supply businesses), application procedures, documentation, and other requirements.

To make information more accessible, freedom-of-information regulations can improve market functioning. Similarly, plans and documents available in other sectors—for instance in agriculture, water, and rural development—may make it easier to identify opportunities for investments in the productive use of electricity. Bringing these to the fore for investors through cross-sector collaboration, including agreements on information distribution and access, is essential.

CHAPTER 4

FINANCING THE PRODUCTIVE USE OF ELECTRICITY

An understanding of the financing context for the productive use of electricity begins with an assessment of the rural finance market for MSMEs, including productive users of electricity and suppliers of energy services and appliances. In addition to identifying the main institutions and actors, a comprehensive assessment would cover the following:

- Availability and accessibility of adequate finance services for energy operators, MSMEs, and communities
- Constraints on access to finance, especially for women and vulnerable populations such as refugees and internally displaced people
- Awareness raising, capacity building, and other interventions that may expand financing opportunities.

In most cases, where liquidity is low and risk perception high on both the demand and supply sides, additional incentives are needed to boost financing supply and access. They include concessionary credit lines, risk-mitigation instruments, and well-targeted subsidies. Innovation in this area, driven by digitalization, is ongoing.

This chapter highlights the use of finance for the productive use of electricity in several ways, including direct MSME microfinance, company-arranged financing for customers, financing instruments to stimulate productive uses, and financing productive uses in fragile settings.

Microfinance for productive users

In some communities, the supply of microfinance credit will be adequate and accessible. In other communities, existing credit supplies may be insufficient, too expensive, or too difficult to access. The interest of microfinance and similar organizations in income-generating enterprises, their expertise with cashflow analysis, and their outreach networks make them good candidates for supporting productive-use MSMEs.

Finance markets, however shallow and fragmented, operate in remote, rural communities, providing businesses and households with micro and small loans for productive purposes. Informal sources include community organizations, moneylenders, family, and unlicensed pawn shops; formal sources may include savings and credit associations in addition to banks.

Rural microfinance has evolved in the past 60 years, from Accion microfinance for microenterprises in Brazil in the 1960s to Grameen's social capital–based lending in the 1970s and Indonesia's Bank Rakyat's microfinance for MSMEs in the 1980s. Many institutions and models now provide poor communities, including women and asset-poor individuals within them, some level of access to savings and credit services. MSME lending has become a large industry, funded by a myriad of sources, including equity, deposits, governments, donors, nongovernmental organizations (NGOs), and community organizations, and a range of institutions and models for financial structuring. Development finance organizations, traditional investors, impact investors, and individuals can use Internet platforms to channel loans and raise funds. International guidelines for responsible digital finance are available (IFC 2022b).

With flexible collateral and guarantees, microfinance could help finance equipment purchases for the productive use of electricity. Experienced microfinance organizations accustomed to securing short-term working capital can be appropriate for loans, depending on an MSME's credit requirements and the local context.

However, many microfinance organizations aim to balance financial viability with the goal of providing services to underserved and unserved MSMEs and households. To achieve it, they tend to favor short-term lending, which is considered less risky than longer-term lending. MSMEs may require medium-term funding to purchase productive assets for the productive use of electricity. Loans to MSMEs for such asset purchases often present a challenge. The main microfinance organizations are typically regulated and rely on deposits for funding; many rural MSMEs will not meet their collateral and other requirements for medium-term asset purchases. First-time borrowers and the poor rarely qualify for credit for medium-term asset purchases from microfinance or other lenders. Depending on the market and circumstances, targeted credit lines may be an option for channeling support directly to MSMEs for productive uses.

Donor-funded programs on-lend to specialized banks or agencies to provide subsidized credits to mini-grid developers and off-grid solar companies to promote renewable energy and energy efficiency in countries such as Bangladesh, Kenya, Niger and Ethiopia. In Myanmar, the Japan International Cooperation Agency (JICA) provided a two-step loan to MSMEs, affording an opportunity to develop the productive use of electricity. Credit lines are often complemented by subsidies, some using results-based financing, to bring down the cost of on-lending and incentivize the adoption of the productive use of electricity. This approach seeks to motivate organizations to enter poor, remote, sparsely populated communities.

Company-arranged financing for MSME customers

Energy services and equipment companies often offer financing terms to their customers. Many companies offer lease-to-own and other credit options out of necessity. In-house financing of appliances has long been a commercial practice to motivate sales and add profit. Companies that provide in-house finance typically have a separate credit department to handle that side of the business.

If not done well, in-house financing can reduce cashflow and profitability, sometimes because of events over which the firms have no control. Successful solar home system companies that offered in-house credit to their customers—the business model on which the World Bank's first large-scale solar home system project was based—went out of business in the wake of the 1997 Asian financial crisis (de Lange 1997). Stand-alone solar suppliers now offer solar home systems and solar-powered appliances, using digital pay-as-you-go (PAYGO) and credit-financing solutions for the appliances they sell in off-grid communities. PEG Africa launched solar water pumps in West African markets catering to smallholders, livestock and poultry owners, and community drinking-water facilities. In East Africa, MKopa launched refrigerators financed through the same PAYGO platform used by their solar home systems, targeting primarily small businesses.

Utility companies and mini-grid developers have also developed models to integrate the financing of appliances, either through on-bill financing or partnerships with financial institutions. CrossBoundary Labs is supporting mini-grid developers seeking to sell productive equipment, such as electric grain mills and rice huskers, on credit to their customers. Kenya Power and Lighting Company is examining on-bill financing of appliances for last-mile rural and settlement customers. Its previous experience is with credit schemes for connection charges.

PAYGO payment methods are now widely available. There is a broad consensus on key performance indicators for the PAYGO solar industry (Khaki and others 2021). These methods rely on digitalization advances, including smart metering and links with mobile communication providers, to allow finance providers to manage credit to households and businesses that might not otherwise have access to credit. For MSMEs, PAYGO methods can facilitate the initial purchase of productive-use equipment, but the cost and risk can be problematic, both for the companies that blend loans and equipment sales and for MSME customers, who can end up in a sort of debtors' prison (Sotiriou and others 2018). Farmers locked out of productive appliances for nonpayment can be shut off from their primary path to repayment (the productive use of electricity), and recovery of equipment by the appliance firm can be expensive. Some lenders are hoping that consumer repayment data can help them fine-tune their lending practices and generate a track record that might entice external funders into the sector (Sosis, Gogo, and Hankins 2021).

Development partners have provided various types of financing to stimulate investments linked to rural energy, including the productive use of electricity. The methods range from straightforward public procurement of funds for specific purposes to loans, risk-mitigation instruments, and targeted supply or demand subsidies (table 4.1). These instruments can be combined to respond to market needs in specific contexts. They are often complemented by technical assistance support.

TABLE 4.1

Types of financing interventions to stimulate uptake of productive use of electricity

INTERVENTION	DEFINITION
Bulk procurement of appliances	Bulk procurement can be explored where the commercial market is very limited, as in poor and remote communities. Government, donors, and other stakeholders can aggregate demand and issue a tender for appliances to be distributed, installed, and maintained, at no cost or at submarket rates. Ensuring long-term maintenance is among key challenges faced by this business model.
Upfront grant	Grant funding to buy down the costs of developing and piloting new products or business models can focus on companies that are unwilling or unable to meet the immediate costs of undertaking business development in rural markets. Grants may be conditional upon the recipient contributing additional funds and other criteria. Monitoring the performance of such grants is critical.
Results-based financing (RBF)	RBF is an ex-post grant conditional on the recipient achieving a predefined result or milestone. Although many funders are attracted by the idea of paying for results, the RBF tool is best used to incentivize incremental—rather than fundamental—changes to appliance supply. Such changes involve targeting new customer groups or communities, raising sales volumes, and promoting the sales of specific new products. Hybrid funding structures are typical, with upfront funding to defray some of a company's early costs, and subsequent payments being results-based. RBF requires pre-financing capacity, a targeting methodology, and a robust verification mechanism, which ensures distribution of quality-certified products.
Social impact bond	Social impact bonds are finance instruments that incentivize social impacts and require their achievement. The aim is to raise patient private capital with repayments linked to performance. Where other performance-based instruments might target documented sales of appliances to households in a poor region, a social impact bond might target measured improvement in household incomes over time, which may be difficult to verify.
Demand-side subsidy	Demand-side grants provided to MSMEs (either directly or, more typically, through an energy, appliance, or finance supplier) aim to reduce the price paid by the enterprise for the energy, appliance, or finance product or service. They require a robust targeting mechanism. ESMAP, alongside other funders, is supporting the End User Subsidies Lab for off-grid solar, which is testing subsidy design and sharing lessons from previous schemes.
Specialized equity fund	Impact equity funds place capital in companies with the aim of generating measurable social or environmental impacts along with a financial return. Donors, development finance institutions, and foundations can invest in such funds to help attract commercial investments.
Credit line	External credit lines can provide liquidity and lending conditions to motivate the local financing sector to extend credit linked to productive uses. Local credit lines, however funded, can provide loans to energy or appliance suppliers and/or end-users directly (typically through a development bank) or indirectly through financial intermediaries. Financial engineering can enable the use of externally sourced funding for local currency lending to mitigate currency risks for companies paying for imported products in hard currency but whose receivables are in local currency. Credit lines may be appropriate in markets where established appliance suppliers are more likely to meet collateral or documentation requirements for externally sourced funding.
Specialized debt fund	Specialized debt providers such as SunFunder, ResponsAbility, SIMA, and Oikocredit raise international donor and impact investor funds to make loans to off-grid solar and other companies. Their funds are financially engineered (for instance, a tiered capital stack with different tranches) to meet the risk tolerance and return expectations of different investors. These funds are playing a significant role in providing working capital and receivables financing to off-grid solar and mini-grid companies.

INTERVENTION	DEFINITION
Crowdfunding platform	Similar to specialized debt funds, crowdfunding platforms (such as Trine, Energise Africa, and Bettervest) finance off-grid solar and mini-grid companies, including by providing working capital for productive-use activities.
First-loss guarantee and insurance	Risk-sharing between commercial lenders and donors in the form of guarantees and insurance products can reduce risks for financial institutions that would otherwise be reluctant to lend in the sector. A guarantee covers identified contractual cashflows such as loan repayments or losses. First-loss guarantees take losses up to a certain pre-agreed maximum.

Source: Original compilation, based on Rysankova and Miller 2022; Lighting Global, GOGLA, and ESMAP 2020; ESMAP 2022; the websites of Global LEAP, ARAF, and SunFunder; and case studies in annex A.

There is now a significant track record on the use of many of these financial instruments in promoting the productive use of electricity. Credit lines and RBF for off-grid solar have been leveraged to stimulate the productive use of electricity in Bangladesh, Ethiopia, and Niger. In Niger, the World Bank–funded Niger Solar Electricity Access Project (NESAP) extends credit to private companies that sell productive-use appliances such as solar-powered pumps. NESAP has provided more than $1.5 million in loans through its local financial partners to solar system importers, wholesalers, retailers, installers, and solar electricity service providers. The follow-up project, Niger Accelerating Electricity Access (HASKÉ), complements NESAP's credit line by providing RBF to make solar irrigation technology more affordable. In Burkina Faso, RBF has been complemented by a first-loss guarantee to unlock access to credit by farmers.

RBF has been mainstreamed in various off-grid electrification programs to advance market development for quality-certified-productive-use appliances. CLASP has leveraged RBF to lower the cost of procuring large volumes of certified off-grid solar appliances and facilitating new business partnerships for appliance suppliers that have invested in the production of high-quality off-grid appliances (see case study A.13 in annex A). Demand-side subsidies have been used to provide 5,000 solar-powered irrigation systems to farmers in Togo under the CIZO project (see case study A.8 in annex A). As part of the partnership, the government provides a 50 percent subsidy of the cost of solar irrigation systems (farmers pay the other half).

Matching grants to agri-businesses were provided on a demand-driven basis in Mexico's Sustainable Rural Development Project (see case study A.4 in annex A). The project's list of supported technologies included solar panels, solar thermal energy, biodigesters, turbines, and energy efficiency appliances (efficient milk chillers). The project demonstrated that investments in renewable energy and energy-efficient technologies could boost farmers' incomes by reducing energy input costs.

The multidonor-sponsored Aceli Africa is an example of social impact bonds. This new facility was designed to improve access to finance for agricultural MSMEs, including by providing technical assistance, first-loss guarantees, and social impact incentives that offer grants to lenders, such as commercial banks, that agree to make smaller loans than they would otherwise consider. Since launching, in September 2020, Aceli Africa has helped mobilize $27 million through more than 200 loans to productive MSMEs.

In Kenya, the government is seeking to close the access gap by providing electricity services to remote, low-density, and traditionally underserved areas of the country. One of the components of the World Bank–funded Kenya Off-Grid Solar Access Project consists of tenders for bulk procurement of solar water pumps at community facilities. About 380 boreholes are expected to benefit from the scheme. Through the Rural Electrification and Renewable Energy Corporation, the government hired private contractors to supply, install, and maintain the pumps.

Partnerships, innovation, and digitalization can support productive use development, as the case of asset financing by EnerGrow suggests (EnerGrow n.d.). This tech start-up aims to support sustainable, productive, rural electricity demand in Uganda, through an innovative mix of productive asset financing, training, and digital ID–based technology. Partnering with utilities and mini-grid operators, the EnerGrow model uses existing data to identify entrepreneurs that require business asset financing and assesses customer's eligibility through data-driven credit profiling. EnerGrow is dedicated to improving the revenues of electricity distribution companies by enabling increased energy consumption, ability to pay, and economic output.

EnerGrow provides a catalogue of comprehensive "business-in-a-box" solutions to customers at the lowest possible rate, including an energy-using productive asset, working capital if required, and financial literacy and business training. It insures loans to MSMEs and households for assets or appliances worth up to $5,000, over a period of six months to three years.

Financing the productive use of electricity in fragile settings

In fragile settings, such as refugee camps, various risks complicate the supply of appliances and make financing more complex. The costs for companies are higher in these settings, where the population is very poor. In addition, market information about credit histories and available products is meager, and distribution and retail channels are strained. Special field appraisals are necessary in such situations (Patel, Razzaq, and Sosis 2019).

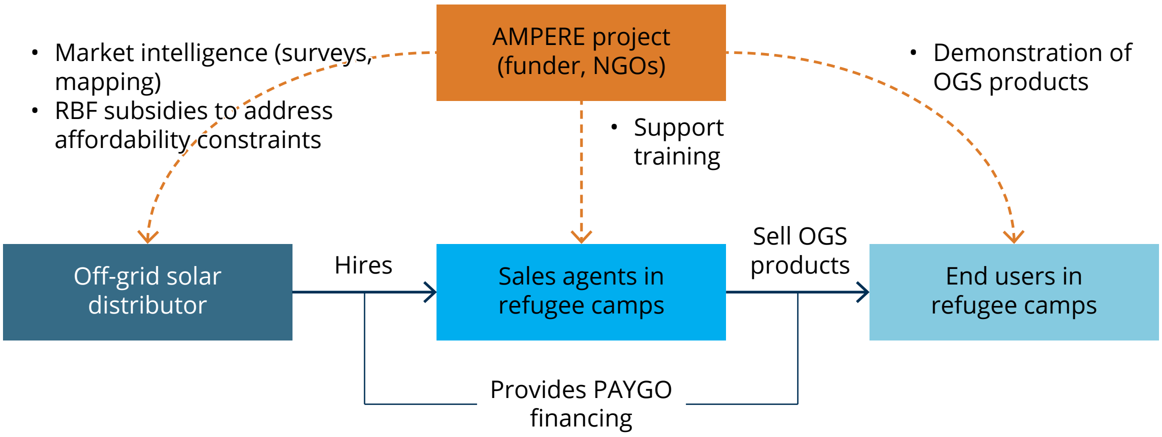
Areas marked by fragility, conflict, and violence tend to rely on grant funding, although various efforts are underway to encourage market-based financing (even if concessional), with the objective of narrowing the gap between refugee and host community energy and appliance markets. The Energy Solutions for Displacement Settings program at GIZ (the German International Cooperation Agency) funded several studies of the challenges to end-user financing in such areas. One of them is regulations that block refugees from obtaining identification documents, mobile numbers, or bank accounts. Another is fear of investing, because of uncertainty about relocation and extremely low purchasing power even with financing (EnDev 2021a).

The AMPERE project in Uganda is an example of RBF incentives that attracted energy and appliance suppliers to difficult markets (figure 4.1).

In addition to providing grant support, the project brokered partnerships between off-grid solar distributors and NGOs for training and awareness-raising among end-users. Under the project, companies sold thousands of off-grid solar products on a PAYGO basis in one of Uganda's largest refugee camps.

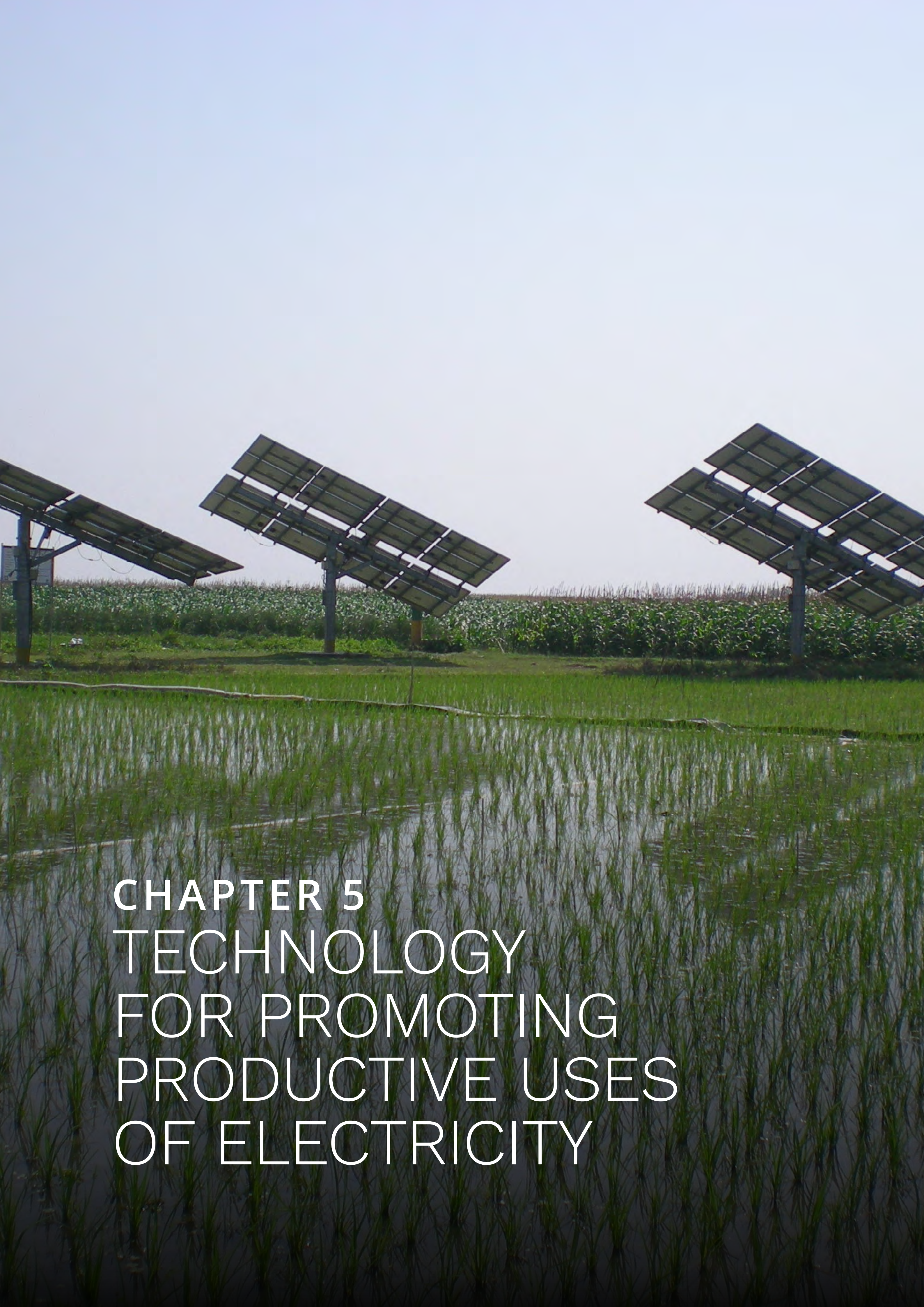
FIGURE 4.1

Design of the AMPERE project for refugee camps in Uganda



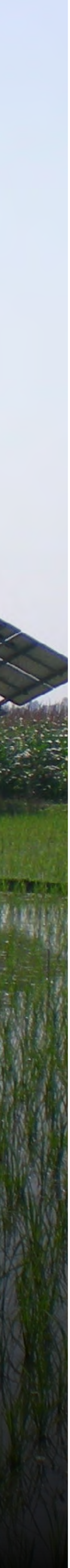
Source: ECA 2022.

Note: RBF = results-based financing; NGOs = nongovernmental organizations; OGS = off-grid solar; PAYGO = pay-as-you-go.



CHAPTER 5

TECHNOLOGY FOR PROMOTING PRODUCTIVE USES OF ELECTRICITY



The common energy supply technologies for productive use by rural MSMEs are main-grid service, mini-grid service, and stand-alone generation. In the first, a grid service provider sells energy to customers on a per kWh basis under an established tariff structure. Where the grid service is unreliable, more affluent consumers may install their own back-ups, such as solar photovoltaic with battery storage or a diesel generator, to ensure supply.

Mini-grid service usually implies an isolated local grid selling energy on a kWh basis. Modern mini-grids can offer reliable service, often exceeding that of rural grids, but a common constraint is the power available at any one time.

Stand-alone generation involves a dedicated energy supply, owned by or leased to an individual consumer. Reliability and cost depend on the design. Technology options include diesel generators, and off-grid solar, all of which may be tailored for specific appliances.

The quality of electricity supply has long been recognized as a major factor in encouraging or discouraging the growth of the productive use of electricity (Blimpo and Cosgrove-Davies 2019; Energy and Development Research Center 2003). Enterprise consumers require a quality and level of supply that meets their business needs. Outages can disrupt production and endanger business viability, with voltage variations and frequency fluctuations potentially damaging equipment and machinery.

The type of electrical connection affects the maximum power a source can generate. DC and single-AC phase services are limited to the operation of small loads. Three-phase AC power supplies can power large motors, pumps, compressors, and machines, but they are more costly for the supplier to connect and service. DC services are limited to specific DC appliances or may require dedicated inverters to convert to more flexible AC power to accommodate a wider range of appliances, which may be prohibitive in cost.

Accessibility to distribution lines is a critical factor in productive-use decisions by MSMEs and should be an important factor in the engineering designs of the electricity networks. If the power line is far from the end-user, the cost of making a connection will increase, potentially becoming a barrier to adoption. The locations of consumers in relation to the grid may not be optimal for expansion of the productive use of electricity if they were determined based on least-cost network planning for household connections.

An energy service provider's reputation for local customer service—which depends on its practices for connections, metering, billing, collections, and responses to service interruptions and maintenance—can facilitate or hinder the adoption of the productive use of electricity. MSMEs whose businesses rely on dependable energy supply also require some assurance that the supplier has adequate in-house or outsourced technical capabilities. The assurance will be reputation driven, derived largely from the observed performance of the supplier in the community.

Total energy charges play a major role in an MSME's decision making about the productive use of electricity. They include connection costs, tariffs, tariff incentives for large-scale users, time-of-use discounts, and maximum demand charges. For stand-alone systems, these costs include capital, fuel, servicing, and replacement.

Reliable electricity grids with affordable, competitive tariffs can provide a basis for developing the productive use of electricity. But grids or mini-grids that are unreliable or limited in capacity create opportunities for other suppliers to enter the market, even at a tariff premium. Table 5.1 compares the features of different ways of accessing electricity.

A customer-level competitive analysis that draws on data from rural appraisals of existing and proposed supply technologies would bring these market issues to the fore in the design of supply networks. Status quo technologies (notably diesel generators) often benefit from existing scale effects, because fuel, spare parts, skills, and experience may be widely and readily available, whereas new technologies must overcome these and other barriers. Assessing customer perceptions of reliability, affordability, quality of service, access, and the benefits of switching to cleaner energy sources would also inform the design of potential interventions related to supply-side technology.

Optimal technical and financial design and sizing of the supply technology can lower operational costs and increase reliability, benefiting both the suppliers and their customers (box 5.1). The technical and financial design is a major factor in the stability of the energy-supply service and the pricing it can offer to productive-use customers. Technological developments for decentralized electrification—such as lithium-ion batteries, power

TABLE 5.1

Comparison of features of main grid, mini-grid, solar home systems, and diesel or gasoline self-generation

SOURCE OF ELECTRICITY	COST OF CONNECTION (UP-FRONT COST)	COST OF ELECTRICITY (ONGOING COST)	AVAILABILITY AND RELIABILITY	ABILITY TO SUPPORT PRODUCTIVE-USE EQUIPMENT
MAIN GRID	●	●	○	◑
MINI-GRID	◑	◑	●	●
SOLAR HOME SYSTEM	◑	○	◕	◔
DIESEL OR GASOLINE SELF-GENERATION	○	◔	◑	◕

● Highest-performing ○ Lowest-performing

Source: Graber, Mong, and Sherwood 2018.

electronics (modularity for expandability, increasing compatibility among manufacturers), efficient PV modules, long-term warranty support, quality standards for components, and smaller integrated systems—are conducive to long-term price drops, improved service levels, and increased design flexibility to fit local contexts.

Electric productive-use appliances

Over the past five years, some innovations in appliance hardware have brought prices down and improved product performance. But high-value products such as solar water pumps remain too expensive for most farmers, even with financing. Table 5.2 shows typical productive electric appliances that add value in seven market applications, each of which involves various value chains.

BOX 5.1

DEVELOPMENTS IN SOLAR WATER PUMPING TECHNOLOGY

Developments in solar water pumping technology benefit supply-side operations while maximizing opportunities for service providers, water sellers, and large-scale irrigation schemes:

- Capacity has soared with the introduction of deep-well pump head technologies, including for off-grid pump systems, increasing competitiveness for a range of volumes.
- Prices have dropped for PV pump systems, as technology is adopted globally and solar pump programs gain traction and reach scale in individual countries.
- Hybrid operation—in the form of parallel or blended operation with diesel or grid power—allows the water output of the system to increase to accommodate seasonal demand. Reliability is increased, and systems are easily expandable. Using diesel to accommodate seasonal demand reduces underutilized capacity.
- Hybrid operation with batteries (for some technology suppliers) enables storage of excess energy for other electrical purposes (though usually seasonal).
- Prepayment water-dispensing technologies can be adopted for livestock water through consumers, domestic consumers, and irrigation consumers with higher flow devices. Prepaid meters improve viability by reducing non-revenue water, enabling 24/7 water access, and tracking water consumption accurately for expansion planning.

Source: IDCOL 2022.

TABLE 5.2

Market status of productive electric appliances

MARKET APPLICATION	TECHNOLOGIES	MARKET DEVELOPMENT
Agricultural production	Water pump, irrigation system, solar sprayer	Solar water pumps and irrigation systems can increase yields by up to 300 percent. Prices for solar pumps have declined by more than 80 percent over the past 20 years but are not yet at parity with more popular diesel pumps. They account for just 1 percent of total systems installed
Agricultural postharvest processing and storage	Mill, huller, thresher, crusher, paste-maker, oil press, cold room, refrigerator	Electric mills have gained attention recently in East Africa (an example is Agsol's micro-mill for use with off-grid solar). An efficient electric mill replaces a diesel or manual alternative or provides a value-adding opportunity over unmilled grain. These appliances are still considered "horizon" technologies. Postharvest cooling is estimated to have the potential to reduce crop losses by up to 15 percent. Walk-in cold room technologies such as those from InspiraFarms (on-farm or aggregator-level cool rooms) or SokoFresh (centrally located "cooling as a service" cool rooms offering shelf space for rent) are also considered "horizon" technologies in terms of market-readiness but are being piloted for viability and impact.
Dairy, poultry, and livestock	Cold room, refrigerator, freezer, ice-making machine, milk tank, cold transport, egg incubator, water pump, electric fence	Entrepreneurs have long used incandescent light bulbs for egg incubation. Solar-powered incubator kits (such as OvoSolar) are now coming onto the market.
Fisheries	Fishing light, water pump, ice-making machine, cold transport, electric boat motors	Mini-grids have integrated ice-making machines into their systems (on islands in Lake Victoria, for example) to replace diesel-powered alternatives or provide cooling where none was locally available (some fishers transport ice at great expense and loss along the way).
Light industry	Sewing machine, loom, drill, hammer, soldering iron, welder, compressor	Electric machinery can be used by mechanics, builders, carpenters, tailors, and other skilled and semi-skilled professionals. These appliances are generally not optimized for off-grid applications; they are sold mainly through hardware or electronics shops.
Small commerce	Two- or three-wheel electric vehicle, fan, TV, refrigerator, blender, juicer, electric pressure cooker, phone charger, internet, printer, hair clipper, salon kit, public address system	Electric vehicles are being piloted in several countries, in major cities and on isolated mini-grids for use as taxis and goods transporters. Other small electric appliances can generate new income for small businesses (for example, a restaurant that makes its own fruit juices).
Restaurants and hospitality	Lighting, television, refrigerator, stove, water heater	Restaurants generally adopt electricity for lighting, refrigeration, and cooking. The hospitality industry can take advantage of electricity by providing better lighting, televisions, and radios.

Source: Adapted from Sosis, Gogo, and Hankins (2021).

Appliance efficiency and innovation

Several innovations have expanded potential applications in off-grid communities and areas with weak grids. Supply voltage is a determining factor for electrical appliances and their suitability for a given consumer. Utility grids (and most mini-grids) offer an AC supply, which can run higher-power appliances. Off-grid solar systems, typically solar home systems, offer DC supply, which can directly run small DC appliances of lower power. Off-grid solar can convert DC to AC using an optional inverter to run higher-power appliances at an additional cost.

The development of efficient DC appliances (12V and 24V) initially focused on LED lights, then TVs and other audiovisual equipment. DC permanent magnetic motors offer up to 30 percent more efficient performance than AC motors, as evidenced in the proliferation of DC fans, pumps, and compressors in smaller refrigerators that can be powered by solar home systems. Other examples include device interoperability, where standardized connectors or adapters can link a wide range of DC appliances to a compliant solar home system. AC appliances have also become far more efficient, especially some AC motors that draw far lower power on start-up and can be run on small off-grid solar systems.

International donors and industry are supporting technical innovation in the electric appliance sector through various activities, including product research and development, piloting of projects, and innovation competitions, such as the Global Leap Awards (box 5.2). Efficiency for Access Research and Development Fund has helped 33 companies assess innovations in cooling and educational technologies for university students in off-grid and weak-grid areas.

BOX 5.2

MARKETING ENERGY-EFFICIENT LIGHTING AND APPLIANCES IN AFRICA

The Energy Efficient Lighting and Appliances (EELA) project aims to support the development of vibrant markets for energy-efficient lighting and appliances. Over five years (2019–24), it has or will be implementing a broad range of activities on energy-efficient lighting and appliances in four areas across the 21 member countries of the Southern African Development Community (SADC) and the East African Community (EAC).

- Market incentives will be put in place to stimulate the uptake of energy-efficient lighting and appliances. The project will offer supply chain actors technical assistance and financial incentives to deliver efficient and high-quality energy services.
- Policies and regulations for energy-efficient lighting and appliances will be improved through the project, with an eye to making them gender and climate responsive. This will involve developing a regional framework for lighting and harmonized minimum energy performance standards for various product groups. It will also involve addressing environmental issues such as the safe end-of-life disposal of lighting and appliances, including disassembly and recycling.
- Strengthening standard-setting and accreditation bodies, testing facilities, and the private sector will be an important part of the program, and will be supported through workshops, webinars, and other training events. A network for sharing knowledge within regions will be established. The project will offer equipment and capacity building to testing centers.
- Raising awareness about the benefits of efficient technologies among market players, policy makers, and consumers will be critical. Through the project, public information campaigns using TV, radio, social channels, and outreach events will promote the multiple benefits of switching to energy-efficient lights and appliances.

The project is implemented by the United Nations Industrial Development Organization (UNIDO) and executed with support from the East African Centre of Excellence for Renewable Energy and Efficiency and the SADC Centre for Renewable Energy and Energy Efficiency. Technical support is provided by the Swedish Energy Agency and CLASP. The project is funded by the Swedish International Development Corporation.

Source: EACREEE 2020.

Appliance supply and after-sales services

It is usually necessary to build appliance supply chains, networks for after-sales services, and, in the case of off-grid solar, power supplies. Appliance accessibility and affordability are critical. MSME and household users need to be able to find competitive, affordable appliances in the marketplace.

Depending on circumstances, analysis of potential will need to obtain data on the availability, accessibility, pricing, and servicing of relevant appliances in the target markets. Distribution networks and methods may be informal or absent in many markets, particularly in refugee camps; settings characterized by fragility, conflict, and violence; and communities with low purchasing power and difficult distribution logistics that deter even itinerant vendors. In markets that lack adequate distribution channels, it can be useful to explore opportunities to incentivize supply chain collaborations among appliance suppliers, energy suppliers, finance providers, and existing distribution capacities to make affordable appliances available in targeted areas.

Digitalization of business operations

The impact of digitalization on rural use of electricity is expanding. Digital tools for energy and appliance suppliers, and in many cases MSME end-users, can include performance monitoring, customer billing and applications, and after-sales consumer reporting. With new digital banking techniques, bills can be paid via cellphone. This data can be helpful in planning future projects.

Communities with good mobile communications, high levels of mobile access, and mobile money services offer opportunities for accelerating the impact of digitalization on the productive use of electricity. The Consultative Group to Assist the Poor compiles reports on how digitalization increases rural access to energy and other services (see, for example, Hernandez 2019).

Many mini- and off-grid solar businesses have integrated pay-as-you-go business models that provide credit, collect payments, generate customer data, and conduct sophisticated data analytics. The aims of commercial energy and appliance suppliers are to leverage digitalization to lower costs, improve margins, open new markets, increase sales, and promote their services. The broader development goal is that these advances will give customers better, more affordable access and improved service.

Agri-business and agro-technology

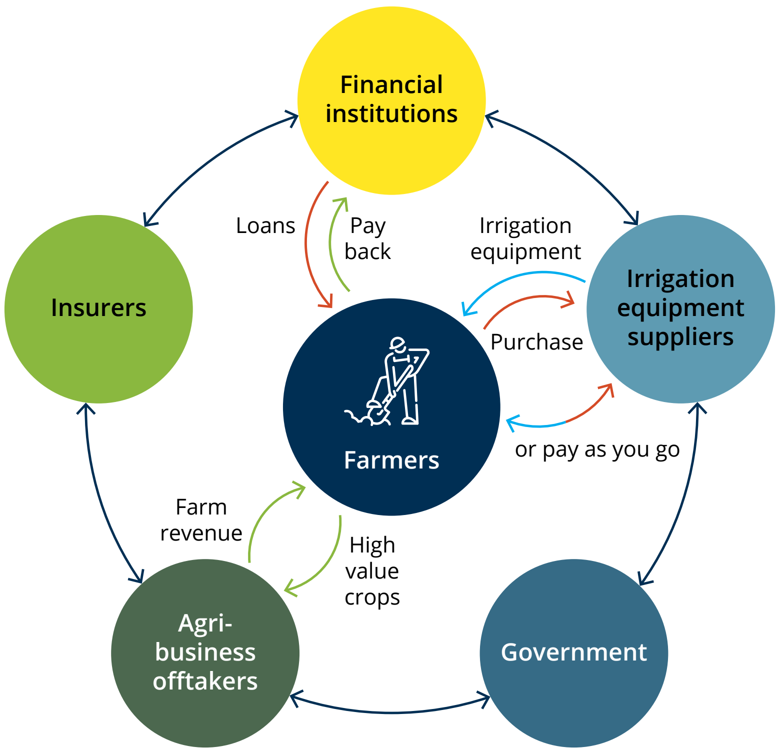
Agri-business encompasses the business environment supporting commercial agriculture, from input supplies to hardware, production to processing, and marketing to distribution, in addition to upstream and downstream activities across value chains. Innovations in agri-business improve productivity, ease activities for farmers, lower production costs, and increase profitability. Market conditions are often volatile; integrating smallholders into interventions aimed at agri-business will help them meet growing consumer demands in emerging economies.

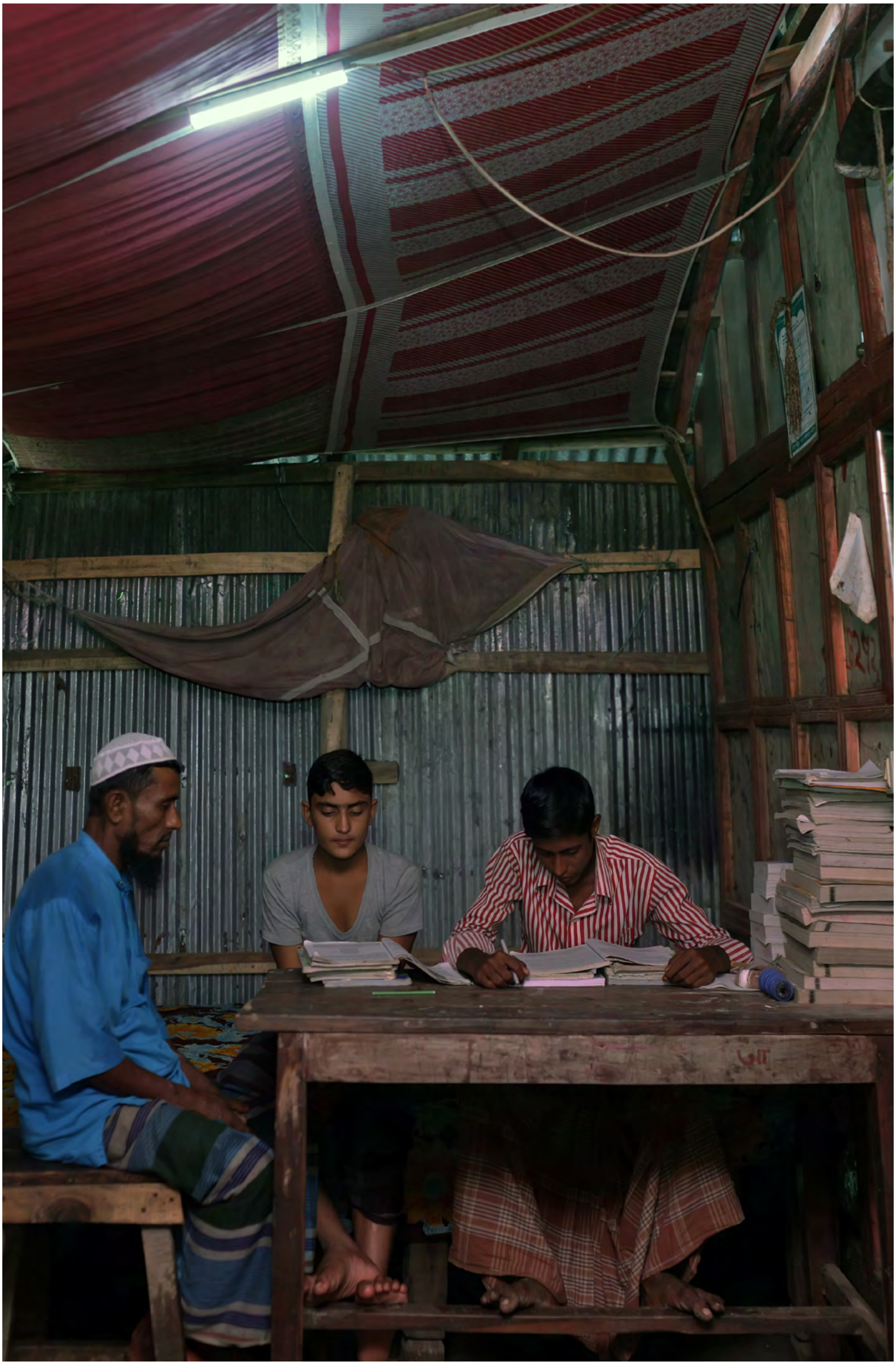
Agri-tech refers to digital agriculture and smart farming. It provides access to online services that can increase operational outputs through real-time, local-level advice (crop selection, planting, watering, etc.); a knowledge base of products, consumables, and appliances for production; access to finance; and access to markets.

When their access to markets and financing is hindered, farmers are unlikely to take the risk of investing in irrigation to improve yields and produce higher-value crops to sell. Using digital tools and channels, farmers can bypass structural barriers and directly access information on markets, technologies, and financing solutions that can accelerate irrigation development. Figure 5.1 provides an example of how digitalization can improve the value proposition of irrigation equipment for small farmers.

FIGURE 5.1

Digitalization of agriculture and farmer-led irrigation development





CHAPTER 6

MARKET AND BUSINESS DEVELOPMENT

For many rural MSMEs, having too few buyers for their products and services is a binding constraint to adoptions and expansion of the productive use of electricity. Global value chains made ever leaner increasingly offer ties to external markets for rural producers while distributing into local markets lower-priced merchandise and services that can be more highly valued than local products. Digitalization continues to enable many advances, including lowering MSME information costs, and easing MSME technology and credit access, and facilitating the flow of payments out of rural markets.

Activities to address this market constraint should be incorporated into projects at all stage. The applicable business adage is “product without promotion is a formula for failure.”

Market development strategy and budget

Individual elements of the building blocks of productive-use market development have long been understood (see, for example, NRECA International 2016). Often, however, they are addressed piecemeal, after engineering designs and implementation arrangements decisions have been made, distribution lines rolled out, and tariffs and prices set. A better approach would be to establish the strategy and provisions for promoting productive uses to MSMEs as early as possible in the goal-setting and design of rural electrification investments.

Assessments of strategic market development entry points depend on context. Along with load forecasting, typical issues include the following:

- Public awareness of the benefits of electricity
- Access of MSMEs to markets
- Applicability of technological and financial innovation
- Technical and business skills
- Supply chains and distribution networks
- The quality of complementary infrastructure electricity supply service and responsiveness to customer concerns
- Physical limitations of already installed distribution lines and locations
- Tariffs and other costs of accessing electricity
- Competing sources of energy
- Local social and political power and gender issues and disparities
- Hindrances and opportunities presented by the formal and informal business environment.

The market strategy development should include discussions and data gathering with MSMEs and other informed groups and individuals who can offer realistic insights into the actions that may be required. Participants should include electricity service providers; rural productive users and potential users; possible partners and value chain investors (for example, cold storage, warehousing, laboratory enterprises); local officials and businesses; community organizations; NGOs; finance providers; and others who are actively engaged directly and indirectly in the market

The strategy should include a budget envelope for dedicated market and business development activities with metrics against which to gauge the value of the spending. Allocations would evolve during implementation in response to market responses and dynamics. Budget requirements would begin with funding for the initial gathering of data and strategy development.

Even in a retrofit situation, having a funded strategy to increase productive-use uptake is best practice. In Bangladesh, an established program of the Infrastructure Development Company Limited (IDCOL) marketed productive uses on remote islands with mini-grid electricity systems (box 6.1). Electricity uptake was minimal after mini-grids were installed, with most productive uses performed using stand-alone diesel-powered machines. IDCOL adopted a market development strategy with outreach and promotional activities that encouraged residents to adopt electric machines and farmers to develop plots that had irrigation.

Promoting productive uses in collaboration with partners

Partnerships are critical across all strategies to promote the productive use of electricity. In complex rural contexts, no single organization can sustainably increase the productive use of electricity. Incorporating the input of many partners and stakeholders is a hallmark of successful actions.

Collaboration should begin at the information-gathering phase, when possibly viable paths for accelerating use are identified. Care will be needed in determining the partnerships that are most likely to be viable at the community level, as opposed to higher-level conceptualizing, planning, structuring and proposing levels. Well-founded partnerships able to deliver results in the field are not often readily identifiable. Much time and other resources can be lost in attempts to support, steady, and even scale unviable partnerships.

Commercially based collaborations are necessary. Active promotion of the productive use of electricity should be synced with access to electricity services, appliances, credits, and cross-sector and value-chain investments. Beyond market-based partnerships, large-scale promotion efforts have relied also on formal and informal collaborations among nonmarket players, including organizations active in rural communities, such as microfinance NGOs, livelihood and community development organizations, other development projects, and public sector organizations providing complementary infrastructure. Contributing to the successes of NGO–led market development in Indonesia and Peru were extensive noncommercial partnerships with local official and religious organizations, skills training organizations, and social and community groups focused on inclusive local development.

BOX 6.1

HOW IDCOL INCREASED THE PRODUCTIVE USE OF POWER FROM SOLAR HYBRID MINI-GRIDS IN BANGLADESH

The Infrastructure Development Company Limited (IDCOL) provides concessional project financing to mini-grid developers to help them deliver improved energy services via solar and solar-hybrid mini-grids in remote parts of Bangladesh. More than 20 mini-grids are in operation, with a total capacity of almost 5 megawatts peak; many more are planned for development. Sites are primarily on islands unreachable by grid extension during monsoon season, when rivers expand by several kilometers. Almost all productive energy use has historically been provided by dedicated diesel engines with belt drives. Under IDCOL, most households and shops have access to stand-alone systems.

Customer uptake was not initially as brisk as expected. Therefore, starting in October 2017, IDCOL launched three-day intensive customer-awareness campaigns led by international experts and trainers from major equipment manufacturers. Customer training was combined with entertainment, such as folk music performances, shows, and street drama. Customer acquisition rose by up to 500 percent.

IDCOL also arranged for skills development training to improve mini-grid managers' understanding of business opportunities. It also required all mini-grids receiving its funding to use remote real-time monitoring for rapid troubleshooting and tracking of historical trends.

Almost all the arable land on these islands can be cultivated over three cropping seasons, so IDCOL asked in-house agriculturists to identify plots with potential. Farmers received guidance on mini-grid irrigation services and learned that they operated at a lower cost than the diesel-based pumps they previously preferred.

Source: IDCOL 2022.

Scaling the productive use of electricity usually involves collaboration between the public and private sectors. This type of integration was a feature of the early successes in large-scale rural electrification in the United States, Ireland, Indonesia, and Peru. It is a feature of rural agricultural sector research and development (Global Center on Adaptation 2021). Indeed, an agricultural economist led the early work on the diffusion *S*-curve and lagging adoption rates for innovations (Rogers 1976, 1983) that framed the seminal Indonesia interventions to accelerate productive-use adoptions. With digitalization and data analytics, it is now possible to rapidly prototype and market-test products and business models in rural areas and channel market responses back to public and private sector designers in an iterative process over an ever-shorter cycle.

Identifying value propositions of micro, small, and medium-size enterprises

A key to effective productive-use promotion is determining the functional and other value propositions to the MSME or household user of a new energy supply or appliance (Hirmer and Cruickshank 2014). Business and market development interventions can address multiple value propositions and market segments. Uptake can often be facilitated by analytical support to appliance and energy suppliers to customize their value propositions to fit particular MSMEs and local contexts.

An MSME's decision to adopt electrical appliances (or conversion to electricity from diesel) is based partly on technical and financial factors. Cashflow and payback period analyses using verified technical and economic information can be starting points for assessing the value to the MSME of an appliance purchase or energy supply. Information necessary for modeling includes (a) reliable appliance labeling data (power rating, throughput); (b) upfront cost; (c) assumptions about operations (usage, capacity utilization); (d) energy supply costs and tariffs; and (e) the costs of service charged to customers or value added. Life-cycle costs can be estimated as well.

Energy and appliance suppliers should make this service and product information readily accessible to potential customers in their marketing materials. Power Africa recently published a series of guides on appliance brands and models. A study by EnDev in Kenya in 2021 found about 40 types of productive electric appliances for sale (EnDev 2021b). Efficiency for Access has published technology briefs on common appliances that provide background on how the devices function, their market maturity, and innovations (Efficiency for Access 2021). MSMEs are a key source for the local market input costs and usage assumptions.

Customized functional analyses may reveal previously unidentified potential for productive uses and enable MSMEs to assess the value in terms of lower costs, a wider range of products, better-quality products, faster response to orders, and ease of maintenance. An owner of a rural oilseed mill converting from diesel engines to modern electric motors powered by a reliable 24/7 mini-grid may realize immediate savings in fuel and operating expenses. In addition, the new electric machine may have higher throughput, pressing daily seed allocations more rapidly. Higher productivity could mean pressing even more oilseed more profitably if there were more raw material and a market for the additional product in the value chain. Alternatively, the freed-up time could be applied to other activities, including income-generating ones. These savings are offset against the capital investment in the new electric mill. An MSME considering a new oilseed press in a new location also has to consider the potential competition. Also, MSMEs considering changing over to grid supply will consider the potential business impacts of power supply interruptions.

The purchase decisions of MSME end-users are based on more than technical and financial criteria. Nonbusiness values that may influence the adoption and use of electricity for productive purposes include status, reputation, aspirations, ethics, community acceptance, network factors, and power relationships (Frederiks, Stenner, and Hobman 2015). These criteria vary across communities, market segments, and individuals.

Identifying well-founded value propositions is one purpose of integrating information developed from multiple sources—balancing findings based on GIS planning tools and data analytics with the data and insights from rural appraisals, for example. Market-experienced-based knowledge and skills to identify value propositions are often found among sellers and others already engaged in commercial transactions and advisory work, for instance, solar home system dealers, equipment sellers, and agriculture extension staff.

Gender differentiation can be significant in determining value propositions. Using electricity for productive purposes can be especially beneficial for women, who spend much time in agri-processing activities in many rural settings. The transformation of such activities was a focus of a project in Mali (box 6.2).

BOX 6.2

INCREASING THE PRODUCTIVE USE OF ELECTRICITY AMONG WOMEN: LESSONS FROM MALI

The World Bank's Africa Gender and Energy Program has worked with the government of Mali to ensure that the different needs of men and women are taken into account in rural electrification efforts. In cooperation with the government's Agency for the Development of Household Energy and Rural Electrification (AMADER), it conducted a survey that found that some women who gained access to electricity were leveraging it for income generation (for example, selling cold drinks or offering device charging) but they were less likely than men to do so. The explanations included the limited number of women-owned enterprises, lack of access to credit and training for those that did exist, and the design of energy projects focused on technological solutions rather than women's specific energy needs.

A second assessment and pilot project focused on the role of energy access in women-led agri-processing and marketing entities. It showed that these units enhanced business skill development in women but that financial sustainability was reduced by insufficient technical expertise on operating and maintaining the equipment, oversubscription of equipment, and the poor technical capacity and productivity of the equipment. These findings illustrate both the opportunities and the complexities of supporting effective and gender-responsive enterprise development linked to electrification.

Source: ESMAP 2019.

Increasing access to information

Today, the cost of conducting market research and obtaining performance data is much lower than it was in the past. This means that dissemination of quality standards, official plans, programs, procedures, and other information can be made more widely available. The pool of useful data includes information gathered for integrated rural electrification planning, especially layered GIS maps and data sets containing granular market survey data. The result is that information at the rural community level can lead to better support for market development.

Economic development professionals routinely share user-friendly information online and through road shows, demonstrations, and other activities. Networking and continual consultations by sector and local leaders, investors, and technology specialists can help generate opportunities for the productive use of electricity. Other sectors, projects, and entities often have useful information that can be made available through formal and informal partnerships. For instance, it is helpful to highlight and circulate information on publicly funded analyses of value chains (IFC 2022a; IRENA and FAO 2021).

Information-based advocacy can help increase the productive use of electricity. Rural businesses frequently report licensing delays, customs entanglements, and other problems related to governance that are costly to resolve and can stymie investments. Solutions might include training that engages both component importers and customs officials in interpretations of favorable duty regimes and qualifying components.

Upfront market development funds, perhaps on a cost-shared basis, may be warranted to assist in the compilation of information. Businesses, even those with experience with rural marketing and distribution channels, may find it too costly and risky to enter the remotest, most sparsely populated markets without cost sharing or other measures. These funds may be used for on-site community surveys, analysis of GIS maps and databases, or training for component importers and customs officials on interpretations of favorable duty regimes and qualifying components.

Building public awareness and legitimacy

Efforts to raise public awareness of energy supply and appliance options should commence as early as possible. Online and mass media, community groups, and word of mouth are typical channels. On-site awareness-building will be necessary in most cases. In Rwanda, ESMAP is supporting technology uptake for cold storage facilities funded under the Sustainable Agricultural Intensification and Food Security Project by engaging stakeholders across horticulture value chains, raising awareness of the benefits of climate-friendly and energy-efficient facilities, and adopting private sector business models for operation.

Individuals and groups engaged in commercial and social marketing and behavioral change communications in rural communities are best able to suggest and support awareness-raising strategies. Discussions and messaging strategies should fit the context; be pretested; and be in the local language, jargon free, and gender sensitive. The content and methods need to be tailored to suit the context.

Digitalization has expanded the opportunities for raising public awareness, particularly through devices with screens. With increasing digitalization, communications, and data analytics, it is possible to rapidly pilot communication strategies. Internet and mobile phone data may reveal what works in specific communities.

Awareness-raising should seek to build trust. Many rural energy services have bad reputations (based, for instance, on frequent or unscheduled outages, slow response times, billing inconsistencies, extra-legal charges) that hinder changeovers from established, trusted services (such as diesel motors). Problems often involve after-sales breakdowns, insufficient repair services, and unsupported warranties. Building awareness of quality-assurance labels (VeraSol, government standards), quality brand names and logos, certifications, warranties (if supported), and guarantees (if honored) are ways to mitigate quality concerns and build the capacity of potential buyers to make informed decisions. Ultimately, the field performance of brands and services will determine the reputation and adoption rate.

The Renewable Energy for Agriculture project in Mexico presents a template for awareness-raising activities (see case study A.4 in annex A) to attract potential adopters. Farmers in unelectrified communities were unaware of solar PV technologies for water pumping, irrigation, and cooling. Promotion, demonstration pilots, and technical assistance were critical in convincing them of the benefits of such investments. A private agency (Mexico's National Association of Solar Energy) led the courses, dissemination, and pilot activities. Suppliers of renewable energy systems and agriculture-related technologies, as well as various universities and technological institutes, were also involved in awareness-raising efforts.

Marketing the productive use of electricity to MSMEs

Marketing productive uses is essentially business-to-business marketing (Goldman Sachs 2016). Electricity suppliers, appliance sellers, credit providers, and sometimes other parties (such as mobile phone companies) need to persuade MSMEs and others that their products and services can help fix a problem or open new opportunities. This solutions-based promotion helps MSMEs (a) identify a problem (for example, high energy costs, low competitiveness because of poor-quality products, and slow turnaround times) that the seller's service or product might solve; (b) define and compare possible solutions; (c) facilitate transactions; and (d) provide after-sales training, information, and other support. Active marketing can be prohibitively costly for firms considering entering markets in remote, difficult to reach, and poor communities.

Project support for market surveys and promotions can reduce initial acquisition costs of electricity and appliance suppliers. The reason is that electricity suppliers will not have to do their own surveys and can concentrate on serving already identified areas where there will be a demand for their services. Such support can include finance and market access facilitation as well as more narrowly defined and targeted awareness-raising, skills training, and business planning advice. In community and livelihood development activities, the promotional support may also bring gap-filling expertise.

Digitalization has brought opportunities to reduce marketing unit costs and improve targeting, through activities such as the following:

- Training field workers in technical products and communications.
- Preparing customized online marketing materials.

- Having support staff respond to technology queries and complaints from MSMEs and making marketing field staff available via the Internet.
- Dispersing staff in different communities to share marketing experiences and insights virtually and often, to build skills and best practices organically in real time.
- Having marketing staff spend more time, in person and virtually, in front of MSME customers and community groups and less time preparing documentation and reports.
- Making digitized data on activities, payments, collections, and results available quickly for tracking against metrics (for example, comparing results of marketing in different communities) and reducing the time required for project adjustments.

Marketing to achieve improved sales has long been a separate field of knowledge. In recent years, findings from behavioral science (Duflo, Kremer, and Robinson 2011) have been applied. The World Bank devoted its 2015 *World Development Report* to behavioral change (World Bank 2015). The essential parameters of market development include that MSME customer can be made aware of both products and services. This includes energy services or electric appliances that are accessible, well priced, and fit an MSME need. The acquisition of a service or appliance by an MSME is a matter of behavior. An energy or appliance seller may find it efficient to provide solutions-based marketing support directly to its customers. Engie/Mobisol assisted buyers of their solar-powered hair clippers in starting barbershops. Social media offers online tutorials, peer-to-peer feedback, co-marketing opportunities, and other support. One example is the 16,000 member Facebook group Cottage Industries Kenya ARISE (Sosis, Gogo, and Hankins 2021).

In some circumstances, the most promising approach is to build on existing capabilities to change behaviors in rural communities rather than piloting new channels. Doing so can mean partnering with local organizations and people who are trusted. In Indonesia (World Bank 2021) and Peru (box 6.3), market development activities designed to persuade MSME innovators and early adopters to use grid services were included in national rural household electrification projects. The distribution companies outsourced their marketing to local NGO partners, whose field workers already had communication skills and who were then trained in basic business analysis—cashflow, payback, and SWOT (strength, weaknesses, opportunities, threats)—and provided with information on the requirements and preferential tariffs of the distribution companies. Underlying factors in the success of these efforts included the following:

- Leadership by individual champions in companies and NGOs who pushed efforts to address MSMEs' needs
- Understanding by the companies' management of the limits of their engineer-dominated organizational cultures and willingness to pilot the outsourcing to NGOs of their marketing, using business development methods, and their parallel commitment to improve service quality

- Recognition by the NGOs that the rural markets were complex and contestable (the grids were competing with diesel) and that their interventions would affect and be affected not only by the MSME adopters but also by the community's broader political economy.

BOX 6.3

PROMOTING THE PRODUCTIVE USE OF ELECTRICITY IN PERU, 2006-2017.

Under the World Bank rural electrification programs (FONER I & II) between 2006 and 2017, Peru's government and regional distribution companies competitively procured the services of nongovernmental organizations (NGOs) in two-phase contracts. Phase 1 consisted of about three months for rural appraisals, market assessments, coordination with other programs and sectors, and identification of specific market opportunities. The program and companies then negotiated performance targets with the NGOs, including for new customers and increased power sales for the productive use of electricity in Phase 2, based on the Phase 1 appraisals. Phase 2 consisted of about nine months of marketing, including support to micro, small, and medium enterprises (MSMEs) in awareness raising; capacity building; and forging of links with distribution companies, appliance sellers, and markets. The NGOs deployed field teams to handle the following tasks:

- Conduct time-limited awareness-raising activities through mass media in the community and through business-to-business arrangements.
- Analyze then assist MSMEs in appraising market opportunities and value propositions for electricity-based products.
- Assist MSMEs in preparing business plans, including for obtaining credit.
- Access information and support from other projects, sectors, and government programs.
- Coordinate with distribution companies on connections, tariffs, billing, and service issues.
- Obtain, assess, and distribute price, quality, and information on appliances.
- Link MSMEs with appliance sellers, buyers of their products, and credit services.

The NGOs segmented and targeted their support by type of business activity. Some groups learned about the productive use of electricity through group meetings and mass media. Training courses in business and technical skills were linked to specific uses, and technical assistance and demonstrations were provided in partnership with appliance sellers and the distribution company. The efforts raised electricity demand and the income of productive enterprises.

Source: Tarnawiecki and others 2013; Finucane, Bogach, and Garcia 2012.

In three Rwandan refugee settlements, the productive use of electricity component of Practical Action's Renewable Energy 4 Refugees, managed by Energy 4 Impact provided 360-degree assistance package to MSMEs including financial management training, market intelligence, technical appliance training, and tailored business advice. All 128 participating MSMEs registered an increase in profits over the course of the project, including during COVID. The Impact team encountered a range of challenges, however, including lack of interest on the part of MSMEs in obtaining support, relocation of project participants to other areas of the camps, and changes in electricity supply needs (Practical Action 2017).

Other approaches are being introduced. The Boost Africa platform funded by the African Development Bank and the European Investment Bank has a blended-finance investment platform and provides targeted technical assistance to MSMEs and entrepreneurs in agri-business, information and communication technology (ICT), and other energy-dependent sectors. The proposed Livelihoods and Energy Access Facility platform, announced by Energy 4 Impact in June 2022, is designed to be a pan-African e-commerce site that will facilitate business-to-business transactions for productive use of electricity products and services. The site plans to offer product sales, insurance, financing, transport and storage logistics, opportunity mapping, and tailored technical assistance (Energy 4 Impact 2022). Energy 4 Impact is seeking funding to prototype and pilot the platform.

Providing technical assistance, specialist expertise, and skills training

Technical assistance to provide expertise from local and external sources can boost confidence at the early policy stages. It can also foster community and fortify policy and business discussions about ways to increase the productive use of electricity. In comprehensive market development programming, expert advice may be vital during initial stages. Multidisciplinary teams are good practice for early discussions, strategy development, and data gathering with MSMEs, as well as for project implementation.

For skills development, support for early capacity building, including technical assistance, can help establish conditions that enable MSMEs to take advantage of the technology and market opportunities that electricity access can enable. Market development–linked training in new technology uses can be critical, as national and global markets set ever-more demanding standards and quality requirements for safety, traceability, and third-party certifications. Technical assistance, education, and practical, expert support are needed to develop and sustain the technical capabilities needed for MSMEs to profit from their place in value chains that reach into rural areas.

Technical support can help stimulate the introduction of innovations that might otherwise not be introduced because of context-specific barriers. In Mali (see box 6.2), for example, insufficient technical expertise was found to be a significant hindrance to the financial sustainability of women-led agri-processing and marketing enterprises.

Linking with markets and value chains

With often shrinking local markets for MSME products and global supply chains becoming leaner and ever more stringent in their requirements, local MSMEs typically have little pricing power. Lacking confidence that there will be buyers for their products, they may defer purchases of new assets for electricity services and appliances. Market development explores potential market linkages.

Decades of experience have produced a plethora of value-chain analyses and best-practice guides for conducting new ones. One possible avenue is to adapt existing studies to identify current opportunities that would benefit MSMEs. For small farmers, for example, these analyses would cover input providers, farmers, transport operators, financial service providers, warehousing and refrigeration facilities, processors, and traders. All value chain analyses need to be updated and localized to include agents, traders, and retailers, as well as prices and margins.

IDCOL's solar irrigation project in Bangladesh exemplifies the value of establishing market linkages. Under the Rural Electrification and Renewable Energy Development project, IDCOL developed a dynamic solar home system market. It sought to replicate this success by extending the same financing model to new technologies, such as solar irrigation. Early-stage implementation showed slow technology uptake. IDCOL brought in expertise on farming and markets to support farmers with seed, fertilizer, crop rotation, and water management and establish access to and links with markets.

CHAPTER 7
RECOMMENDATIONS

The productive use opportunities for enhancing the impact of rural electrification on both social development and economic growth are both possible and complementary to electricity access. Low levels of productive uses have been a key challenge in realizing the potential development benefits of rural energy access and the financial sustainability of suppliers. In the absence of dedicated efforts to address this challenge, the spontaneous growth of productive uses, including by MSMEs, has frequently been too low and too slow, especially in poor, remote communities.

Electricity access projects in many rural communities could increase their development impact and revenue by incorporating specific measures to stimulate productive uses. These recommendations are drawn from public, private and non-governmental interventions that have been successful in accelerating productive uses.

Establish increasing productive uses as mission critical

Intentionally and directly addressing the low productive uses challenge is a core recommendation. Much of the potential development impact of energy access can be realized only when electricity is used in productive, income generating ways. Establishing that productive uses are mission critical in energy access programs is a prerequisite to ensuring that program designs incorporate adequate efforts to increase productive uses. Once established as mission critical, the requirements for increasing productive uses will be a driver throughout the development cycle, from design through implementation and evaluation.

Mission clarity is essential. It is important to clarify the cross-cutting concerns that will influence the design of the productive use efforts. In many rural electrification projects, the commercial viability of suppliers has driven feasibility, and project interventions have sought to minimize costs of household access and lower market barriers for private suppliers. If, instead, the viability of the productive-use mission is assessed, for instance, by its contribution to poverty reduction or achievement of another strategic goal (for instance, improving food security or lowering oil imports by replacing diesel pumps with solar ones), the range of design options and the role of the state and subsidies expands, conditioned by budget constraints (Mazzucato 2021a, 2021b;). There is a wide range of potential cross-cutting concerns to consider in determining the scope of a productive uses mission. They can include the following:

- Poverty reduction
- Income and wealth disparities
- Gender disparities
- Resilience

- Reduced use of fossil fuels
- Disparate economic and social impacts on vulnerable groups and in communities marked by fragility, conflict, or violence
- Governance
- Scalability.

Perspectives on cross-cutting concerns are not fixed; this list is not exhaustive. Institutional circumstances and political economy drive the particulars and their prioritization. As the design, implementation, and adaptations of efforts to increase the productive uses continue through iterations, the views of multiple stakeholders should ideally coalesce, becoming more informed, contextualized, and relatively harmonized.

Adopt an ecosystem design perspective that focuses on MSMEs

Rural communities are complex systems in which the levels of productive electricity use are generally low. There is no panacea or rigid blueprint for solving the problem of electricity being used primarily for social purposes in the early stages of electrification. Different communities have different needs for the promotion of productive use. The consequence is that an inductive approach that aims to discover what might work to increase the productive use of electricity in specific rural communities is needed.

Due to the various needs and different types of communities, an ecosystem perspective is necessary to focus on the needs and productive possibilities for various MSMEs that might, include small businesses, smallholder farmers and income-earning households. Such a perspective is distinct from perspectives based on increasing least-cost household access to electricity, stimulating demand, developing value chains, and increasing investor returns, although they may also be useful.

A multidisciplinary design team and partnerships are needed. Adopting an ecosystem perspective requires multisectoral expertise across the five building blocks identified in chapter 1 (planning, regulation, finance, technology, and market and business development), honing interventions to achieve income gains and reduce poverty. The community's circumstances, the range of expertise on each of the building blocks, the depth of local knowledge, and the skills harnessed by designers and partners in engaging with stakeholders at all levels, from ministries to rural workshops and farms, should all be taken into account in planning and implementing interventions

Consider the impact of global trends and crises

Global trends and innovations could affect the uptake of electricity by rural MSMEs. Household energy access programs using renewable energy and energy-efficient appliances, including those driven by imperatives linked to climate change, are reducing the costs of reaching remote communities. Digitalization is conditioning virtually every enterprise endeavor. Greater connectivity is easing information constraints. Digital technologies are lowering the costs of suppliers of power and appliances. Geospatial mapping tools and analytics are lowering the costs of some technology choices, network designs, and higher-level mapping of potential productive activities. Advances in mobile communications, commercial payments, and credit technologies are boosting access to services and appliances. Longer-term trends have opened up new opportunities for rural productive use of electricity in renewable energy generation and grid integration, distributed generation, communications, remote sensing, data analytics and, throughout, digitalization. Engineering and materials innovations continue to improve efficiency and reduce the price of equipment.

Recent crises, such as the COVID-19 pandemic, Russia's invasion of Ukraine, and inflation, have challenged food security and disrupted supply chains that affect livelihoods and market functioning, including in rural communities. These crises have heightened concerns about resilience, fueling interest among policy makers in expanding local or distributed resilience in hard-to-reach rural communities by raising the productivity and production of rural MSMEs.

These trends and crises accentuate the opportunities for and urgency of promoting the productive use of electricity in ways that contribute to resilient, broadly based rural development. They also reduce the ability of rural MSMEs to find reliable buyers. Global supply chains reach ever more remote communities, offering modern products at competitive prices, cutting into local markets for local MSMEs. If they wish to participate in global value chains, MSMEs must be able to comply with stringent rules. Electricity is just one factor in rural development and is unlikely to be determinative. Cross-sectoral cooperation and partnerships will be necessary to sustain initiatives to make the productive use of electricity work for MSMEs aiming at the global market (e.g., by participating in a global value chain).

Collect data using both top-down and bottom-up methods

Both top-down and bottom-up methods are useful for data gathering, analytics, and mapping. Data for planning rural electrification are available at increasingly high resolutions. Advances in GIS–supported mapping, analytics, technology, and financial engineering have enabled more detailed opportunity scoping at all levels, from national to local. A great deal of remotely available data can be incorporated into GIS–generated maps. Examples include records, surveys, and maps of populations, electrification, connectivity, transportation networks, water resources, agricultural potential, and market access. GIS–generated maps also facilitate the co-location of donor-funded investments in various sectors (energy, agriculture, water) and the identification of synergies.

Remote data methods can generate resources, infrastructure, and other information that is useful in pre-screening communities for economic opportunities. Many value chain studies assess market opportunities. In some cases, specific investments can be prescreened using remote data methods and existing or additional value chain studies.

Increases in the productive use of electricity by MSMEs will depend largely on what happens in rural communities. Practical community-level information remains at the core of good design. A community's history, culture, and political dynamics affect both the uptake of electricity and the distribution of benefits. Also important are gender roles; exclusionary practices; and wealth, social, and market practices. A deep understanding of these aspects is essential for a workable, holistic assessment of how to grow the productive use of electricity.

Rural appraisals are needed to assess the potential for productive use of electricity. Ecosystem-type rural appraisals have a long history and established good practices. Thanks to increases in connectivity, they can now yield data less expensively and more quickly using audio, video, and online methods. In many communities, however, direct consultations and due diligence that involve potential beneficiaries, local stakeholders, and an ever-widening circle of sharers of local knowledge remain the *sine qua non* of valid appraisals. Consultations and local-level mapping can reveal a range of valuable opportunities, issues, possible entry points, and implementation partnerships that might otherwise be overlooked.

Designs that rely too heavily on top-down or skimpy rural data will result in or repeat mistakes, to the detriment of intended beneficiaries. For infrastructure investments, an ill-fitting engineering design can create long-term problems. For rural households and MSMEs in fragile situations, failure can be devastating, especially when household debt is incurred.

Assess plans, regulations, technology, and finance

Intentional planning, supportive regulation, fit-for-purpose technology, readily accessible financing, and business and market development services can all support increases in the productive use of electricity. Assessments of the details of the current status and dynamics of each of these building blocks are needed. The aim must be to find opportunities to optimize each within the context. The great is often be the enemy of the good.

The interplay of the building blocks is as important as the details of any one block. The ecosystem approach recognizes that communities are complex adaptive systems, but planning requires targeting actions at the building block level. Do the load forecasting methods used in top-level planning and technology assessments take into account the ecosystem perspectives and findings of bottom-up participative methods, or do they rely on the more common assessments of loads, with fixed factors for annual increases? Do the regulatory arrangements for import duties take into account the requirements of appliance use for productive purposes? Are financial and other supports for linking rural producers with global chains contributing to the productive use of electricity that increases MSME incomes and reduces poverty? Do national plans rely too much on remote data gathering and analytics, or do they incorporate sufficiently granular inputs reflecting the realities of the communities?

Assessments require extensive cross-sector cooperation, which can also help prepare the ground for later implementation partnerships. Assessments often rely on inputs from discussions and participative problem solving with stakeholders with local experience and expertise in rural energy delivery, agriculture and water, health and nutrition, literacy, housing and livelihoods, microenterprise and microcredit development, and current rural activities. Experts from academic institutions, think tanks, development organizations, business, and livelihoods support services can also be sources of inputs. Design teams should be familiar with relevant sector and national plans, legal and regulatory frameworks, budgets, institutional authorities, standards, and taxes and duties and have some grasp of informal practices, networks, and governance concerns that might affect the productive use of electricity in the communities targeted for interventions.

Prepare an actionable analysis

An actionable analysis describes concerns and opportunities in the ecosystem. It identifies the main actors, constraints, actionable entry points, and risks, identifying points for each ecosystem building block that could be addressed within a reasonable timeframe.

Business analytics should address typical business cases in terms of cashflow, payback periods, and key risks. The pathways from the proposed actions to the success of the MSMEs and the reduction of poverty should be central to the analysis. Poor rural households and MSMEs tend to operate in fragile situations. They avoid risk if they can. The business cases and analytics are different for investors, macro-projects, and private funders. The plan should use typical investment-return analytics, including strategies to manage and mitigate risks through common measures such as cost reduction, financial engineering, and contractual structuring. Regardless of investor and donor agendas, the actionable analysis must focus on viability at the MSME level.

Many rural projects offer examples of actionable analysis of a range of interventions that might be a possible fit within a particular ecosystem. The range of interventions to consider might include the following:

- Improvement of the enabling environment
- Regulatory changes

- Technology development and access
- Financial incentives and risk-management support
- Market and business development support
- Skills development
- Co-location and coordination of investments and actions
- Procurement structuring
- Direct support for MSMEs.

Mainstream the active promotion of productive use of electricity

Most energy access projects funded by the World Bank include interventions that may stimulate the productive use of electricity, but the portfolio of projects that actively promote its use is limited. Several practices based on successful cases in Bangladesh, Indonesia, Mexico, Niger, Peru, Rwanda, and Tanzania are recommended:

- Prioritize the design of productive-use actions at a level on a par with actions to increase household connections and the financial sustainability of electricity suppliers, by leveraging existing economic development strategies and electrification plans, using digital data analytics tools, conducting field surveys, and identifying productive-use interventions through policy and community engagements.
- Establish a strategy to actively support development through pragmatic actions within each building block in the ecosystem.
- Establish an active marketing strategy within which specific actions can be taken opportunistically to increase the productive use of electricity by MSMEs. Electricity suppliers can accelerate uptake in many communities with time-limited marketing campaigns that provide solutions to MSMEs in sync with the provision of reliable electricity service.
- Expedite MSME access to markets. Without markets for expanded sales of MSME products, any net increases in their income will be limited, while additional risks may have been incurred. Expanding access requires specialized market and multidisciplinary expertise specific to targeted markets and value chains.
- Establish service quality and affordability targets for energy suppliers and appliance sellers that are competitive.

- Design financing options to ensure the affordability of the connection or appliance, such as credit, smart subsidies, and risk-mitigation instruments. Digitalization can be embedded in the business model to improve affordability.
- Build on existing capabilities, including commercial capabilities and business models that are working, even if at low scale, of energy suppliers, appliance sellers, credit providers, mobile phone companies, and other services with established trust and distribution channels in nearby communities.
- Establish partnerships that reach into rural communities. Success will hinge on well-chosen partnerships—formal and informal, public and private—at all levels, especially in rural communities, where local champions can promote actions and enable synergies.
- Design flexible interventions. With nearly real-time data, and as experience accumulates, more rapid design iterations after rollout should permit rapid adjustments.
- Design for diversity in business models. The rural context has multiple entrepreneurs with experience and access to a range of promotion and business models. They are best positioned to know what works for them, including the risks they are willing to take.
- Establish viable implementation arrangements. What is acceptable and workable is context-dependent. Implementations managed by government agencies, parastatals, municipal organizations, development finance organizations, NGOs, and contractors have worked and have not worked. No one model fits all, and few "best practices" have survived over time. To the extent possible, build on the organizational capabilities and opportunities found in the context, avoid unhelpful political or governance pressures, enable rapid adjustments based on performance and changing circumstances, and assign roles and responsibilities with clarity.
- Fit the design of the intervention to the supply technology (grid, mini-grid, and off-grid solar services).

Be ready to adapt

The complexities of the context and the likelihood of unanticipated changes mean that adjusting while implementing is critical. Project implementers should recognize the importance of uncertainty, observation, and learning (Alacevich 2012, citing Albert Hirschman). Remaining flexible—rather than rigidly applying a specific approach—is critical. Only so much can be understood in advance. "That is not a bad thing," said John Holland (Holland 2014) a decade ago. "Both as humans and as scientists, we generally understand much more than we can establish through logical argument. There are a variety of tools we bring to bear: experiment, calculation, modeling, comparison, everyday reasoning, analogy, metaphor."

Track, monitor, and evaluate

Monitoring and evaluation are necessary for improving ongoing operations, making near-term structural adjustments, and developing data to contribute to longer-term knowledge development.

At the operational level, it will be critical to fix trackable market metrics for comparison across energy suppliers, appliance sellers, MSMEs, and other project agents. For energy services businesses, power sales, load curves, and payments from MSME customers can be tracked. Remote communication technologies can be used to gather data from other agents at a low cost. Partnerships among agents will support the timely collection of this type of performance data. Definitions can be set within projects for other data, in order to track details of use cases and the value of specific practices and actions.

At the project level, funders agree on key objectives and intermediate results indicators. The intention to be highly adaptable can be difficult to reconcile with the fact that key project-level parameters and actors are located far from rural communities and markets. These project metrics will drive much of the formal documentation of the design; because they tend to be difficult to amend, much effort should be made to fit them to current concerns and opportunities. Results in achieving productive use of electricity should be treated on a par with other objectives of the design, such as household connections, financial sustainability, and women's participation. Designers will then be incentivized to prepare and budget for actions and related provisions for M&E. M&E specialists can then prepare the detailed frameworks and methods for tracking and measuring achievements that are relevant to the productive use of electricity.

The tracking and evaluation of the benefits of interventions have generally not been subject to stringent peer-reviewed quality evaluations of the sort applied to lowering the cost of electricity or improving the welfare benefits of household connections. M&E professionals identify the data and documentation methods needed to determine socioeconomic benefits and pathways using regressions or other techniques. M&E is important to the broader development knowledge community as well as for informing and underpinning potential replication and scaling-up of the intervention. The M&E data sources, collection methods, analysis requirements, responsibilities, and budgets, including for knowledge development, should be clearly assigned, beginning at the design phase.

References

Alacevich, Michele. 2012. "Visualizing Uncertainties, or How Albert Hirschman and the World Bank Disagreed on Project Appraisal and Development Approaches." Policy Research Working Paper 6260, World Bank, Washington, DC.

Barnes, Douglas 2014. *Electric Power for Rural Growth: How Electricity Affects Rural Life in Developing Countries.* Washington, DC: Energy for Development; New York: Routledge Press.

Barnes, Douglas, Hussain Samad, and Sudeshna Banerjee. 2014. "The Development Impact of Energy Access." In *Energy Poverty: Global Challenges and Local Solutions*, edited by Antoine Halff, Benjamin Sovacool, and Jon Rozhon, 54–76. Oxford, UK: Oxford University Press.

Bernard, Tanguy. 2012. *Impact Analysis of Rural Electrification Projects in Sub-Saharan Africa. The World Bank Research Observer 27 (1), 33-51.*

Blimpo, Moussa, and Malcolm Cosgrove-Davies. 2019. *Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact*. Africa Development Forum Series. Washington, DC: World Bank.

Chambers, Robert. 1983. *Rural Development—Putting the Last First.* Essex, England: Longmans Scientific and Technical Publishers; New York: John Wiley & Sons.

———. 1994. "The Origins and Practice of Participatory Rural Appraisal." *World Development* 22 (7): 953–69.

Cramer, Christopher, Deborah Johnston, Carlos Oya, and John Sender. 2016. "Mistakes, Crises, and Research Independence: The Perils of Fieldwork as a form of Evidence." *African Affairs* 115 (458): 145–60.

Dalberg Global Development Advisors. 2017. *Improving Access to Electricity through Decentralized Renewable Energy Policy: Analysis from India, Nigeria, Senegal and Uganda*. Geneva: Dalberg Global Development Advisors. Improving access to electricity through decentralized renewable energy - Dalberg.

D-Lab. 2017. "Energy Needs Assessment Toolkit." https://d-lab.mit.edu/research/energy/energy-needs-assessment-toolkit.

De Lange, Robb. 1997. "Marketing Solar Home Systems." Proceedings, Roundtable on Rural Energy and Development, World Bank, Washington, DC.

Dercon, Stefan. 2022. Gambling on Development: Why Some Countries Win and Others Lose. London: Hurst Publishers Limited**.**

Donovan, Jason, Dietmar Stoian, and Jon Hellin. 2020. *Value Chain Development and the Poor: Promise, Delivery, and Opportunities for Impact at Scale*. Rugby, UK: Practical Action Publishing.

Duffield, Mark. 2014. "From Immersion to Simulation: Remote Methodologies and the Decline of Area Studies." *Review of African Political Economy* 41 (Sup 1): S75–S94, DOI: 10.1080/03056244.2014.976366.

Duflo, Esther, Michael Kremer, and Jonathan Robinson. 2011. "Nudging Farmers to Use Fertilizer: Theory and Experimental Evidence from Kenya." *American Economic Review* 101 (6): 2350–90.

EACREEE (East African Centre of Excellence for Renewable Energy and Efficiency). 2020. "Energy Efficient Lighting and Appliances (EELA) Project in Southern and Eastern Africa." https://www.eacreee.org/project/energy-efficient-lighting-and-appliances-eela-project-southern-and-eastern-africa.

ECA (Economic Consulting Associates). 2022. *Mainstreaming Demand Stimulation from Productive Uses of Electricity*. Background report prepared for the World Bank. London: ECA.

Efficiency for Access. 2021. *Solar Appliance Technology Briefs 2021*. Efficiency for Access. https://efficiencyforaccess.org/publications/2021-solar-appliance-technology-briefs.

———. 2021a. Humanitarian Energy: Energy for micro-enterprises in displacement settings. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://endev.info/wp-content/uploads/2021/04/EnDev_Learning_and_Innovation_Humanitarian_Energy.pdf.

EnDev. 2021b. *The Market for Productive Use of Solar Energy in Kenya: A Status Report*. https://sun-connect.org/wpcont/uploads/The-Market-for-Productive-Uses-of-Solar-Energy-in-Kenya-Status-Report-2021_web-002-1.pdf.

Energy and Development Research Centre. 2003. *A Review of International Literature of ESCOs and Fee-for-Service Approaches to Rural Electrification (Solar Home Systems).* Interim Report: Output 6. Cape Town, South Africa: Energy and Development Research Centre, University of Cape Town.

Energy 4 Impact. 2022. Programmes. [Online]. energy4impact-programmes. Available at: https://energy4impact.org/about/programmes [Accessed 2 December 2022].

EnerGrow. n.d. *EnerGrow - Services*. EnerGrow. Retrieved December 2, 2022, from https://ener-grow.com/.

ESMAP (Energy Sector Management Assistance Program). 2019. *Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers.* Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/31926.

———. 2022. *Designing Public Funding Mechanisms in the Off-Grid Solar Sector.* Washington, DC: World Bank.

Finucane, James, Juliette Besnard, and Raluca Golumbeanu. 2021. "Raising Rural Productive Uses of Electricity: A Case Study of a Successful Utility-NGO Partnership in Indonesia." *Live Wire* 2021/119, World Bank, Washington, DC.

Finucane, James, Susan Bogach, and Luis Enrique Garcia. 2012. *Promoting Productive Uses of Electricity in Rural Areas of Peru: Experience and Lessons Learned.* ESMAP Report 74044. Washington, DC: World Bank.

Frederiks, Elisha R., Karen Stenner, and Elizabeth V Hobman. 2015. "Household Energy Use: Applying Behavioural Economics to Understand Consumer Decision-Making and Behaviour." *Renewable and Sustainable Energy Reviews* 41 (C): 1385–94.

Global Center on Adaptation. 2021. Climate Smart Digital Technologies for Agriculture and Food Security, Africa Adaptation Acceleration Program. https://gca.org/programs/aaap/#csdat.

Goldman Sachs. 2016. *The Business Case for Off-Grid Energy in India*. New Delhi: The Climate Group. https://www.goldmansachs.com/citizenship/environmental-stewardship-and-sustainability/environmental-markets/cem-partners/gs-report.pdf.

Graber, Sachiko, Patricia Mong, and James Sherwood. 2018. *Under the Grid: Improving the Economics and Reliability of Rural Electricity Service with Undergrid Minigrids*. Basalt, CO: Rocky Mountain Institute, November 2018. www.rmi.org/insight/under-the-grid.

Hirmer, Stephanie, and Heather Cruickshank. 2014. "The User-Value of Rural Electrification: An Analysis and Adoption of Existing Models and Theories." *Renewable and Sustainable Energy Reviews* 34 (C): 145–54.

Holland, John H. 2014. *Signals and Boundaries: Building Blocks for Complex Adaptive Systems*. Cambridge, MA and London, UK: MIT Press.

IDCOL (Infrastructure Development Company Limited). 2022. "Solar Powered Irrigation to Enhance Climate Resilience in the Agricultural Sector of Bangladesh." March 16, 2022. https://www.esmap.org/sites/default/files/Presentations/IDCOL%20Solar%20Irrigation%20Program_Farzana%20Rahman.pdf.

———. 2022a. *Creating Markets in Uganda: Growth through the Private Sector and Trade*. Washington, DC: IFC. https://www.ifc.org/wps/wcm/connect/publications_ext_content/ifc_external_publication_site/publications_listing_page/cpsd-uganda.

IFC (International Finance Corporation). 2022b. "Responsible Investing in Digital Financial Services." IFC, Washington, DC. https://www.ifc.org/wps/wcm/connect/b737ffcd-dda1-41fc-aa39-6f17696bd647/IFC+Summary+Investor+Guidelines+for+Responsible+Investing+in+DFS-April+2022.pdf?MOD=AJPERES&CVID=o1N4TSO.

Integration Environment and Energy. 2022. "Assessment of Co-Located Mini-Grids and Agriculture Centers.": https://integration.org/environment-energy/.

IRENA (International Renewable Energy Agency), and FAO (Food and Agriculture Organization). 2021. *Renewable Energy for Agri-Food Systems—Towards the Sustainable Development Goals and the Paris Agreement*. Rome: IRENA and FAO. https://doi.org/10.4060/cb7433en.

IRENA (International Renewable Energy Agency), and SELCO Foundation 2022. *Fostering Livelihoods with Decentralized renewable Energy: an Ecosystem Approach*. Aby Dhabi: International Renewable Energy Agency https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Livelihood_Decentralised_Renewables_2022.pdf?rev=7f7ca5cd9eea443483dea7987ef952e9

ISA (International Solar Alliance), and NEDO (New Energy and Industrial Technology Development Organization). 2022. "Case Study: Operational Use of 'Anchor Load Business Community Model': Solar Mini-Grids: Uttar Pradesh, India." https://isolaralliance.org/uploads/docs/3d3f6a2d6a9b61883ecfd957bb2368.pdf.

Izzi, G., J. Denison and G.J. Veldwisch, eds. 2021. The Farmer-led Irrigation Development Guide: A what, why and how-to for intervention design. Washington, DC: World Bank.

Khaki, Nicky, Roan Borst, Kevin Kennedy, and Max Mattern. 2021. *PAYGo PERFORM: Financial, Operational, and Portfolio Quality KPIs for the PAYGo Solar Industry*. Technical Guide. Washington, DC: Consultative Group to Assist the Poor (CGAP).

Korten, David. 1980. "Community Organization and Rural Development: A Learning Process Approach." *Public Administration Review* 40 (5): 480–511.

Lighting Global, and IFC (International Finance Corporation). 2019. *The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa*. Washington, DC: IFC. https://www.lightingglobal.org/wp-content/uploads/2019/09/PULSE-Report.pdf.

Lighting Global, GOGLA (Global Off-Grid Lighting Association), and ESMAP (Energy Sector Management Assistance Program). 2020. *Global Off-Grid Solar: Market Trends Report 2020*. Washington, DC: IFC. https://www.lightingglobal.org/wp-content/uploads/2020/05/VIVID_OCA_2020_Off_Grid_Solar_Market_Trends_Report_Full_High-compressed.pdf.

Mazzucato, Mariana. 2021a. *Mission Economy: A Moonshot Guide to Changing Capitalism*. London: Penguin Books Ltd.

———. 2021b. *Public Purpose: Industrial Policy's Comeback and Government's Role in Shared Prosperity*. Cambridge, MA: MIT Press.

Morrissey, James. 2018. "Linking Electrification and Productive Use." Oxfam Research Backgrounder series. oxfamamerica.org/electrification.

Naik, B. S., S. Patel, P. Ojasvi, H. Biswas, R. Dupal, P. Muniasamy, M. Ramesha, K. Ravi. 2021. "Solar Pump with Drip Irrigation System for Enhancing Crop Yields and Farm Income in Semi-Arid Vertisols of South India: A Success Story," Bulletin No. 6, *Soil and Water Conservation Bulletin,* Indian Association of Soil and Water Conservationists, Uttarakhand, India.

NRECA International, "*Guides for Electric Cooperative Development and Rural Electrification, Module 9, Productive Uses of Electricity*", Arlington, VA. circa 2016. Available here: https://ocdc.coop/guides-for-electric-cooperative-development-and-rural-electrification/.

Orr, A., J. Donovan, and D. Stoian. 2018 "Smallholder Value Chains as Complex Adaptive Systems: A Conceptual Framework." *Journal of Agri-business in Developing and Emerging Economies* 8 (1): 14–33. ISSN: 2044-0839. https://cgspace.cgiar.org/handle/10568/93440.

Ostrom, Elinor, and Michael Cox. 2010. "Moving beyond Panaceas: A Multi-Tiered Diagnostic Approach for Social-Ecological Analysis." *Environmental Conservation* 37 (4): 451–63. doi:10.1017/S0376892910000834.

Patel, Laura, Faisal Razzaq, and Karin Sosis. 2019. *Assessing the Potential for Off-Grid Power Interventions in Turkana Country with a Focus on the Communities around Kakuma and Kalobeyi*. Smart Communities Coalition, March 2019. https://energy4impact.org/file/2087/download?token=BsWZzcRf.

Practical Action. 2017. Renewable Energy for Refugees (RE4R). [Online]. practicalaction.org. Available at: https://practicalaction.org/our-work/projects/re4r/ [Accessed 2 December 2022]

Rogers, E. M. 1976. *Communication and Development: Critical Perspectives*. Beverly Hills, CA: Sage Publications.

———. 1983. "Diffusion of Innovations." University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship. https://ssrn.com/abstract=1496176.

Ruttan, Vernon. 1984. "Integrated Rural Development Programmes: A Historical Perspective." *World Development* 12 (4): 393–401.

Rysankova and Miller 2022 Designing Public Funding Mechanisms in the Off-Grid Solar Sector (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/099300005162263450/P17515006776e102308e980bb2d798ca5c3.

Sablik, Tim. 2020. "Electrifying Rural America." Econ Focus. https://www.richmondfed.org/publications/research/econ_focus/2020/q1/economic_history.

Savanna Circuit Tech and UK Government (no date) "Savanna Circuit Technologies at Kenya Innovation Week." UK Government, Savanna Circuit Tech, Kenya Innovation Week: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://kenyainnovationweek.com/static/docs/savanna.pdf

Shiel, Michael. 2003. *The Quiet Revolution: The Electrification of Rural Ireland*. Dublin: O'Brien Press.

Sosis, Karin, Jessica Gogo, and Mark Hankins. 2021. *The Market for the Productive Uses of Solar Energy in Kenya: A Status Report.* Bonn: SNV; Nairobi: EnDev.

Sotiriou, Alexander G., Pepukaye Bardouille, Daniel Waldron, and Gianmaria Vanzulli. 2018. *Strange Beasts: Making Sense of PAYGo Solar Business Models*. Forum 14. Washington, DC: Consultative Group to Assist the Poor (CGAP).

Sovacool, Benjamin, Shannon Clarke, Katie Johnson, Meredith Crafton, Jay Eidsness, and David Zoppo. 2013. "The Energy-Enterprise-Gender Nexus: Lessons from the Multifunctional Platform (MFP) in Mali." *Renewable Energy* 50 (February): 115–25.

SPM (Smart Power Myanmar). 2021b. *TFE Energy, PACT: Agriculture Value Chains Study Myanmar*. Yangon, Myanmar: SPM.

Tarnawiecki, Donald, Miguel Aréstegui, Alfonso Carrasco, Giovanni Bonfiglio, and Rafael Escobar. 2013 *Usos productivos de la electricidad: Experiencias y lecciones en el área rural Peruana*. Lima: Soluciones Practicas.

TFE Energy. 2020. *Energy Access, Data and Digital Solutions*. Munich, Germany: TFE Energy. https://tfe-energy.vercel.app/project/Data4EnergyAccess.

Verploegen 2017 A Toolkit to Identify Sustainable, Market-Based Energy Solutions in Off-Grid Areas https://nextbillion.net/a-toolkit-to-identify-sustainable-market-based-energy-solutions-in-off-grid-areas/.

Vivid Economics. 2013. *Results-Based Financing in the Energy Sector: An Analytical Guide.* Energy Sector Management Assistance Program (ESMAP)Technical report 004/13. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/17481.

Wandschneider, Tiago Sequeira, Ngo Thi Kim Yen, Shaun Ferris, and Tran Van On. 2012. *A Guide to Rapid Market Appraisal (RMA) for Agricultural Products*. International Center for Tropical Agriculture (CIAT) and Catholic Relief Services (CRS). https://www.crs.org/sites/default/files/tools-research/guide-to-rapid-market-appraisal-for-agricultural-products.pdf.

World Bank. 2015. *World Development Report: Mind, Society, and Behavior*. Washington, DC.

———. 2018. *The Global Partnership on Output-Based Aid: A Guide for Effective Results-Based Financing Strategies*. Washington, DC.

———. 2020. *Doing Business* 2020. Washington, DC.

———. 2021. "Raising Rural Productive Uses of Electricity: A Case Study of a Successful Utility-NGO Partnership in Indonesia." *Livewire* 2021/119, Washington, DC.

———. 2022. "Terms of Reference: ESMAP—Nigeria—Pre-feasibility Assessment of Co-Located Mini-Grids and Investments in Agro-Processing in Nigeria." Washington, DC.

World Bank. n.d. "Standardized Process for Productive Uses & Gender Integration." Adapted from Mini-Grid and Gender Toolkit. Washington, DC. https://esmap.org/sites/default/files/Myanmar_Standardized%20Process%20for%20Productive%20uses%20Gender%20Integration_Web.pdf.

ANNEX A
CASE STUDIES

INDONESIA

Providing business services to complement rural electrification

INSIGHTS

Lack of awareness and information about the productive use of electricity opportunities by MSMEs and grid operators is a major constraint in many countries, which can be overcome through proactive, adaptive, advice-led marketing and information dissemination and strong partnerships

KEY OUTCOMES

Between 1996 and 2000, 63,386 enterprises in Indonesia invested in productive use of electricity equipment, 22,000 new jobs were created, and electricity consumption increased by 180 GWh per year.

The World Bank–funded Rural Electrification (RE) program (RE I: 1990–94; RE II: 1995–99) in Indonesia was designed to put the country's rural electrification program on an efficient and sustainable trajectory and extend electricity supply to additional rural communities. The project included incentives for private sector and local cooperatives to play an increasingly important role in RE distribution and to strengthen the institutional capabilities of the state power company (PLN) to undertake rural electrification planning and implementation.

Using rural data collection to identify barriers to and opportunities for productive use

One of the project's objectives was to develop economic activities in rural communities by promoting PLN's services. The two projects represented the World Bank's initial efforts to promote the productive use of electricity in a major rural electrification program. Pre-project Bank sector studies found that productive use of PLN grid electricity in many rural communities fell short of its potential, as existing businesses continued to use diesel motors, with PLN services used mainly for lighting.

Multiple pre-project participative rural appraisals confirmed these findings and the low awareness of PLN and the rural enterprises of the significant potential. To address this information constraint, the small business services component under RE I included active, solutions-oriented marketing activities and information dissemination to existing and potential businesses on opportunities for using electricity for productive activities. The pilot had satisfactory results, with 8,409 enterprises increasing productive use and annual loads increasing by almost 6 million kWh.

A 1992 survey of over 4,000 small enterprises in grid-supplied rural communities in non-project communities showed average monthly consumption of the productive use of electricity of about 40–50 kWh, with more intensive firms reaching 600 kWh per month. It indicated that PLN supplied only 8–15 percent of the market and found a lack of awareness of the business benefits of the productive use of electricity among both existing and potential users.

Working with local actors on business development

Building on the capacities developed under RE I, the follow-on Rural Business Services (RBS) component under RE II expanded active marketing efforts to 14 regions, with an emphasis on promotions outside Java. This component was more cost effective and targeted than the pilot. It provided for more active support to link MSMEs with finance and appliance sellers and used improved methods to provide customized advice to MSMEs to overcome business barriers. Methods were constantly adjusted in response to field learning, seasonal changes, and the situations of different communities. RBS also emphasize closer coordination between the utility's field staff and the marketing campaigns to resolve connection delays, service interruptions, voltage drops, and slow response times. It addressed central-level supply-side constraints by strengthening PLN's corporate capabilities in data collection and analysis and program management.

PLN outsourced the initial marketing services under RE I to five local NGOs. Rural appraisals conducted during project preparation identified several NGOs that had the trust of and significant development experience in the rural communities but had not worked with a state or external agency. During the pilot, PLN and the NGOs developed viable working arrangements.

For the scaled-up services under the follow-on project, PLN contracted 25 local NGOs. One of the original five was engaged to train field staff, prepare and publish standardized mass media promotional materials, and lead the sharing of successful marketing practices with the 25 NGOS. It also led consultations to improve collaboration with PLN field staff and other agencies, vetted data submitted by PLN field offices and the NGOs on uptake, helped target communities and subsectors for additional marketing campaigns, and identified NGOs working in communities.

Communities were selected based on their potential to increase the productive use of electricity (the presence, for example, of clustered businesses potentially able to switch from diesel or manual power to PLN). Individual businesses shortlisted during an initial pre-screening for participating in the RBS program had high energy use potential.

Results

The RBS component delivered impressive results between 1996 and 2000. PLN's engagement with rural NGOs motivated 63,386 enterprises to invest in equipment, creating 22,000 new jobs and raising electricity consumption by 180 GWh per year. Project performance greatly exceeded the initial target of 30,000 rural enterprises and an increase in the use of electricity for productive purposes of 36 GWh per year. The program's promotion of productive-use applications increased sales of equipment (106,118 units) and investment (Rp 148,160 million corresponding to USD$ 9,755) by over 80,000 enterprises. These achievements were particularly significant given the regional and national financial crisis that occurred during the project period, which placed strains on the power sector and rural electrification efforts. The success of the RBS approach highlights the importance of active marketing of the productive use of electricity by skilled marketing teams, especially soon after the grid's arrival in a community. PLN's outsourcing of the marketing (in this case, to the local NGOs) with the right capabilities in the local communities was critical. Marketing activities ranged from raising awareness to facilitating linkages with finance and appliance sellers, product markets, and other services. Marketing services included customized business development and technical support and advice to MSMEs on the options for and benefits of the productive use of electricity.

The success stemmed in good measure from its context-specific design process and provisions for successive results and context-dependent adjustments to improve performance, including continuously adapting marketing practices in response to market feedback and results. Throughout the projects, significant adjustments in targeting and selection methods at the community, sector, and business levels and in marketing materials and methods were introduced, driven by the experiences, good and bad, of NGOs in the communities.

World Bank teams and the lead government agencies agreed to this adaptive approach during the design phase. The aim was to implement initially as a proof of concept, followed, after a midterm evaluation, by a larger pilot that allowed for frequent in-the-field adjustments and then a rollout at scale during the follow-on project, which included the transfer of practice models that had worked to communities in different areas with somewhat similar circumstances. The adaptations, scaling, and transfers were based on experiential knowledge, growing confidence that impediments could be resolved, and determination by the World Bank and PLN that there was sufficient potential for increasing productive uses in additional communities.

The Indonesian program focused on attracting an initial group of MSMEs in the targeted communities and subsectors through intensive, six-month information campaigns rather than the more costly approach of attempting to reach a large share of enterprises through a long-term presence. The aim was to target innovators and early adopters, in order to accelerate uptake. This objective was framed based on the then widely known (in Indonesia) *S*-curve model of Rogers (1983).

Indonesia's successes were built on in-depth understandings of local socioeconomic dynamics, institutional frameworks, and marketing opportunities. Much of this understanding was embedded in the knowledge and skills of the NGO staff and PLN, especially its field staff, and the expertise of other stakeholders, such as credit and appliance sellers.

Sources

Finucane, James, Juliette Besnard, and Raluca Golumbeanu. 2021. "Raising Rural Productive Uses of Electricity: A Case Study of a Successful Utility-NGO Partnership in Indonesia." *Live Wire 2021/119, World Bank, Washington, DC.*

Rogers, E.M. 1983. "Diffusion of Innovations." University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship. https://ssrn.com/abstract=1496176.

World Bank. 1995. Indonesia: Second Rural Electrification Project. Staff Appraisal Report. Washington, DC.

———. 2000. Indonesia: Second Rural Electrification Project. Implementation Completion Report 20676. Washington, DC.

PERU

Promoting the productive use of electricity under foner i and ii

INSIGHTS

Countries with NGOs operating in rural communities with the trust of the communities should engage them in designing and conducting activities to build awareness, inform and train end-users, and facilitate linkages with appliance and credit suppliers and access to product markets.

KEY OUTCOMES

Electricity consumption for productive uses reached 2 GWh per year, and 24,000 enterprises adopted equipment, with total investment of $14 million.

Rural electrification in Peru in the early 2000s was at about 30 percent, one of the lowest rates in Latin America. The concession areas held by distribution companies were urban. Rural infrastructure was not financially viable. To attract more investment, wider participation, and financing from electricity service providers, Peru created a fund for rural electrification.

Program implementation

In establishing the Directorate General of Rural Electrification (DGER) under the Ministry of Energy and Minerals, Peru was able to create FONER I (Proyecto Mejoramiento de la Electrificación Rural, 2006–13) and FONER II (2011–17). Both programs provided competitive grants to fund rural electrification projects ($61 million), with support from the World Bank ($100 million). The main implementer of FONER I and II was DGER, now considered Peru's rural electrification champion.

Planning and business development with local actors

Peru's approach focused on capacity building by working with electricity service suppliers and NGOs. Both project phases supported electricity distribution companies in preparing, executing, and operating rural electrification subprojects as part of their commercial operations. Subprojects connected remote communities by extending grids or installing solar home systems. in FONER I, one pilot project was dedicated to promoting the productive use of electricity. In FONER II, the piloted model was integrated into operations.

In both FONER I and II, NGOs played an active role in identifying opportunities, barriers, and solutions. In cooperation with distribution companies willing to participate and other organizations, local NGOs assessed the market and committed to raising sales of electricity for productive uses, by building MSME awareness, skills, and market linkages and facilitating improvements in customer service by the distribution companies in the communities. Under FONER I and II, the DGER signed 17 contracts with 10 competitively selected NGOs, which partnered with 11 distribution companies. The NGOS were key actors and change makers, thanks to their links with the communities, field experience, communications and marketing skills, and motivation for social development.

Results

More than 25,000 household productive units benefited from the projects. An impact evaluation estimated that the intervention more than quadrupled average consumption of participating producers, raising it from 56 kWh to 240 kWh per month. It found that the project led to longer daytime productive hours (56 percent), higher production levels (39 percent), better-quality products (40 percent), and higher market prices (39 percent).

The cost of the productive use of electricity component of FONER was reported at $2.8 million in the final evaluation ($141 per enterprise). In addition, enterprises invested $14 million in equipment. A cost–benefit analysis reported a positive net present value for all scenarios and discount rates tested.

Lessons learned

FONER's success highlights the effectiveness of Peru's distribution companies outsourcing their rural marketing for the productive use of electricity to NGOs active in rural development in the communities. Rural electricity suppliers rarely have the skills to conduct marketing programs; in many settings, they benefit from contracting local organizations with the needed marketing, business, and social change capabilities to interact with MSMEs, other market participants and partners, and communities.

Underpinning the success in Peru was the structure of the NGO contracts, especially their results-based and phased approach. A first (planning) phase allowed the project team to set performance targets; a second phase involved implementation and capacity building.

Another vital element was flexibility. The project allowed NGOs to apply their strengths as they saw fit, interacting with individual producers, assessing the market, raising awareness, and so forth.

Rural electrification planners and implementing organizations must establish increases in the productive use of electricity as part of the mission of rural grid expansion; they must make the relevant provisions for actively marketing the services and developing the necessary partnerships. Distribution companies can also develop the market, by responding to the demands and constraints of productive users, engineering their distribution systems to foster productive uses, and adapting their pricing and service quality practices as much as possible to fit the capabilities of their MSME customers in the rural communities.

Sources

Franco, Janina, Susan Bogach, Inés Pérez Arroyo, and Maite Lasa. 2017. "Promoting Productive Uses of Electricity in Rural Electrification Programs: Experience from Peru." *Live Wire 2017/80, World Bank, Washington, DC. https://openknowledge.worldbank.org/bitstream/handle/10986/28623/120675-BRI-PUBLIC-24-10-2017-14-27-48-LWLJfinOKR.pdf?sequence=1&isAllowed=y.*

Gonzalez, Edgar. 2013. *Promoting Productive Uses of Electricity in Rural Areas of Peru: Experiences and Lessons Learned.* World Bank, Washington, DC, April 11. https://www.worldbank.org/en/results/2013/04/10/pomoting-poductive-uses-electricity-rural-areas-peru.

Prisma, Macroconsult, and Instituto Cuanto. 2016. *Servicio de consultoría para la evaluación de resultados e impacto del Componente 3: Promoción de usos productivos de la electricidad*. Lima: Ministry of Energy and Mines.

World Bank. 2013. *Peru: Rural Electrification Project. Implementation Status and Results Report. Washington, DC.*

———. 2019. "Promoting Rural Electrification in Peru." Results Briefs, May 13, Washington, DC. https://www.worldbank.org/en/results/2019/05/13/promoting-rural-electrification-in-peru#:~:text=Through%20distribution%20companies%2C%20Peru%20provided,systems%20installed%20in%20isolated%20areas.

BANGLADESH

Providing smallholder farmers with solar irrigation under RERED II

INSIGHTS

Solar irrigation programs require support for farmers to adapt agricultural practices and establish market linkages.

KEY OUTCOMES

Over 1,500 solar water pumps were installed, benefitting more than 60,000 farmers.

Since 2012, the World Bank has been supporting the Second Rural Electrification and Renewable Energy Development (RERED II) project in Bangladesh. Its objective is to improve access to renewable energy options in remote rural areas where grid electricity is not yet economically viable.

RERED II builds on the lessons learned under RERED I, in which the number of solar home systems rose from 2 million in 2012 to 4.2 million in 2018. Both RERED I and RERED II were implemented by the Infrastructure Development Company Limited (IDCOL), which sought to leverage the financing and institutional models of RERED I to develop new technologies, including solar irrigation pumps (SIPs), mini-grids, and efficient AC and DC appliances. The SIP program seeks to replace diesel-operated pumps by expanding water access via renewable energy for farmers at lower cost, increasing cropping yields by introduction of improved agri-practices and reducing carbon emissions.

Policy support and market identification

The program is made possible by the government's policy commitment to decarbonization and support for transition from diesel- to solar-powered water pumps. Recurrent diesel fuel subsidies are used to offset the capital required for the SIP program. As of 2013, 1.24 million diesel-operated pumps were used in irrigation, costing $900 million a year in fuel expenditure alone. Solar water pumps have lower life-cycle costs and almost negligible operating costs, allowing water tariffs to fall by 20–30 percent. They also avoid the frequent technical problems and costly maintenance of diesel pumps, which result in high water-extraction costs and have environmental and climate change mitigation benefits.

Financing instrument and business models leveraged on the success of RERED

The SIP program is driven by qualified private sector companies (sponsors) with track records under RERED I and II. These innovative companies seek to expand their fee-for-service/water business model under a 10-year operational tenure.

IDCOL's SIP program has put in place a blended finance mechanism that provides grants and loans to private sponsors that identify site locations and reach agreements with groups of farmers to sell water or small solar water pumps on credit. A grant covers 50 percent of the capital cost of eligible pumps, 10-year loans cover 35 percent, and the remaining 15 percent is the sponsor's equity contribution to the scheme. The capital buy-down grants are funded by the Bangladesh Climate Change Resilience Fund, the Global Partnership on Output-Based Aid, KfW Development Bank, the US Agency for International Development, and the Asian Development Bank. Loans are funded by the World Bank, the Japan International Cooperation Agency (JICA), and IDCOL's own funds.

Technology standards and technical support

A clear development and approval mechanism and oversight by a technical standards committee facilitated the introduction of new pumping technology in Bangladesh. The committee adopts international standards or sets its own standards, pre-approving suppliers and equipment that can benefit the scheme, ensuring quality, and requiring longer-term component warranties (which increased from two years to five years). IDCOL's internal units conduct financial and technical due diligence by assessing proposals from sponsors and site surveys and verifying installations and water output. Loans and grants are disbursed once IDCOL establishes that its criteria have been met. IDCOL also conducts ongoing performance and technical audits to ensure the quality and technical sustainability of the program.

Programmatic support for improved agri-practices

The first SIP projects quickly identified teething issues with technology adoption for farmers, which had financial implication for the sponsors. To address the problem, IDCOL prioritized intensive capacity development on agriculture as part of its technical assistance. It first addressed crop selection and productive cropping patterns, which informed the design of irrigation distribution and area coverage. Efficiency improvements that resulted in excess electricity from solar photovoltaic (PV) then went into improving mechanization, cold storage, and market innovations.

Agility and adaption to need

IDCOL also supported business model improvements, as both sponsors and farmers required support to adopt the solar PV technology and adapt their agricultural practices accordingly. IDCOL increased loan terms from 8 years to the current 10-year tenor. It also extended the grace period, from nine months to two years, to allow cropping patterns to emerge and allow sponsors to build financial reserves and develop mechanisms for managing seasonal excess energy.

Inclusive gender practices

The program includes gender-inclusive practices. In partnership with the United Nations Environment Programme, it supports women's efforts to undertake complementary productive-use and income-generating activities. Solar PV modules are used for crop cultivation and poultry farming, with excess electricity used for agri-processing and preservation.

Results

Through the program, 1,515 SIPs have been installed, providing 40 MWp of solar PV capacity. Lower water-extraction costs and higher incomes for 60,600 farmers contributed to progress on many of the SDGs (particularly SDG 2 and SDG 7) and created 2,178 new jobs with irrigation sponsors and equipment suppliers. A 2020 survey conducted by IDCOL on about 10 percent of its projects revealed that new crops grown because water is available increased farmers' revenues by 18 percent, efficient water management techniques increased paddy yields by 7.5 percent, and irrigation tariffs are 25 percent lower with solar irrigation than with diesel pumps. Together these benefits raised farmers' net income by 38 percent.

Building on the infrastructure set up under RERED II, the solar irrigation program is ripe for scale-up. Since 2012, IDCOL has developed 27 sponsors for project implementation, created a pool of 16 manufacturers for pump and pump controllers, and designed trainings for sponsors and farmers. The envisaged scaling of installations seeks to add 10,000 solar water pumps by 2030.

The initiative highlights the need for agility, adaption, and parallel capacity-building development in solar irrigation projects to give farmers the expertise they need to improve the design of irrigation systems, inform crop selection, and establish market linkages. The project also highlights the role of blended finance and favorable financing terms in soliciting financing from private sponsors.

Sources

IDCOL (Infrastructure Development Company Limited). 2020. "IDCOL Solar Irrigation Program: Driving Sustainable Agricultural Development in Rural Bangladesh." January 9. https://prize.equatorinitiative.org/wp-content/uploads/formidable/6/Presentation-IDCOL-Solar-Irrigation-Program.pdf.

———. 2022. "Solar Powered Irrigation to Enhance Climate Resilience in the Agricultural Sector of Bangladesh." March 16. https://www.esmap.org/sites/default/files/Presentations/IDCOL%20Solar%20Irrigation%20Program_Farzana%20Rahman.pdf.

World Bank. 2022. *Bangladesh: Rural Electrification and Renewable Energy Development II (RERED II) Project P131263. Implementation Status and Results Report. Washington, DC.*

Interviews with Shadman Bin Zahir (Assistant Manager, Renewable Energy); Mofazzal Hossain (Engineer); and Md. Belal Siddiqui (Assistant Manager), all of IDCOL, in March 2022.

MEXICO

Supporting sustainable rural development

INSIGHTS

Stakeholder buy-in, technical assistance, and training drive energy technology innovation projects in agriculture.

KEY OUTCOMES

Adoption of 2,286 renewable energy or energy-efficient technologies by 1,842 agri-businesses reduced 6 greenhouse gas emissions by 6.02 million tons of and saved 382 kWh of energy. It also built key institutions' policy development and monitoring capacity.

When the Sustainable Rural Development Project was first appraised, in 2009, agriculture was both a primary emitter of greenhouse gas in Mexico and a weak sector. The fact that renewable energy and energy-efficiency technologies were still nascent hindered the growth of small and medium-size agri-businesses.

The project had four components:

- Investment in sustainable technologies
- Matching grants covering 50 percent of total costs, initially up to $200,000, then $1 million, with the balance funded by the beneficiary
- Enterprise modernization through energy efficiency and renewable energy
- Investment/ production support.

Diagnostics and technical assistance were provided for implementation and to train agri-businesses and pilot sustainable/innovative technologies. Institutional strengthening helped the Ministry of Agriculture (Secretaría de Agricultura, Ganaderia, Desarrollo Rural, Pesca y Alimentacion [SAGARPA)] develop policy, build the capacity of FIRCO (Fideicomiso de Riesgo Compartido), and improve interministerial cooperation. It included training on project management within FIRCO and development and operation of an M&E system.

Providing policy support

Acknowledging the need to grow the agricultural sector, the government prioritized agriculture and rural development, making them more competitive and environmentally sustainable, especially given the need for climate change mitigation. A key part of this effort was promoting farmers' access to the solar market and renewable technologies. In its early years, private power producers supported the project by injecting energy into the national grid and receiving energy credits. Later the project benefitted from the 2015 Law of Energy Transitions, which allowed private power producers to sell excess energy into the grid.

Enabling access to finance

The initiative provided matching grants through subprojects to agri-businesses to promote investments in energy-efficient and renewable technologies. It provided a matching grant of up to 50 percent of total subproject cost, up to a maximum of $200,000, which was then raised to $1 million. These grants were administered by FIRCO, a decentralized agency of the SAGARPA. Small and medium-size enterprises interested in the project were identified through open requests for proposals. In parallel, FIRCO conducted promotional activities to raise awareness among MSMEs about the incentive scheme and the sustainable technologies available.

The project launched in 2009, building on the collaboration between the Mexican government and GIZ (the German international cooperation agency) on the use of solar technology in agriculture. It was supported by the World Bank through a loan from the International Bank for Reconstruction and Development (IBRD) of $50 million and a Global Environment Facility grant of $10.5 million. IBRD approved additional financing of $50 million in 2012 to scale up the initiative, with a focus on the most successful technologies (biodigesters, solar heating, and solar PV). The Mexican government contributed $33 million and project beneficiaries $143 million.

The initiative targeted agri-businesses operating within agricultural production chains, mainly fruits; vegetables; and intensive livestock (dairy, beef, and pork) requiring some scale and assets. Greater investment was expected in states with more agricultural activity.

Providing technical assistance for business development and capacity building

The project provided training and technical support to integrate new technologies into the operations of agri-businesses. Beneficiaries were to design business proposals, implement subprojects, and use and maintain sustainable technologies.

The project also helped strengthen institutions, by training the staff of FIRCO and dependent agencies, such as SAGARPA, to perform technical and economic evaluation and analysis of subprojects and promote sustainable technologies through interministerial collaboration and knowledge-sharing activities. SAGARPA and FIRCO project staff monitored activities by submitting quarterly physical and financial status reports. They also formulated policy implications and lessons learned. FIRCO provided technical assistance to small and medium-size agri-businesses on making new technologies part of their operations.

Results

Thanks to strong buy-in from the government and farmers, the program had a powerful impact on rural development in Mexico:

- The project reached twice the originally targeted number of beneficiaries, with 1,842 small- and medium-size agri-businesses adopting more than 2,200 renewable or energy-efficiency technologies.
- Greenhouse gas emissions fell by 6.02 million tons, saving more than 382 million kWh of energy over the course of the project and making the sector more competitive.
- As the project matured, the 2015 Law of Energy Transitions allowed private power producers, including agri-businesses, to sell their excess energy production to the grid, delivering benefits to 739 recipients of project-supported PV systems.

The initiative achieved its primary objective of increasing the use of renewable and energy-efficient technologies. In addition to accelerating the development of a solar market in Mexico through demonstration effects and pilots, the project built SAGARPA's policy development capacity and FIRCO's project management ability and capacity to measure impacts.

Lessons learned

Buy-in and adoption by agri-business depended on the following factors:

- Demand and supply drivers, including the state of market development and related technologies
- Supportive project procurement, to help establish quality standards and monitor results
- Technical assistance and training targeting the installation, operation, and long-term sustainability of systems
- Dissemination of the economic, social, and environmental benefits of adopting innovative and sustainable technologies.

Successful outcomes depend on well-designed impact assessment and M&E mechanisms, which can help in the design of future interventions.

Sources

World Bank. 2018. *Mexico Sustainable Rural Development Project*. Implementation Completion and Results Report ICR-4492, Latin America and Caribbean Region. Agriculture Global Practice, Washington, DC.

———. 2019a. "Improving Energy for Agricultural Competitiveness in Mexico." Results Brief, May 10. Washington, DC.

———. 2019b. *Mexico: MX Sustainable Rural Development*. Implementation Completion Report Review, Report ICRR0021504. Washington, DC.

TANZANIA

Accelerating solar water pumping through innovative financing

INSIGHTS

A mix of loans and grants to community-operated pumping schemes can support the transition from diesel to solar pumps. Renewable energy–powered schemes can bring environmental and economic advantages and improve service. Digitalization through remote monitoring of pump system performance and the introduction of prepaid water community water dispensers can increase efficiency and reduce financial losses. Community awareness and support are required for transition and uptake to succeed. A public-private business model may accelerate future uptake.

KEY OUTCOMES

Implementation began in 2019, securing the installation of 74 solar pumps as of 2022. The pilot scheme benefited approximately 500,000 rural residents and 110 village pumping schemes. Impacts are not yet known.

Lack of access to safe water affects nearly half the rural population in many Sub-Saharan African countries. Millions of people lack access, because rural water systems frequently break down and capital and operational costs and revenue losses are high. At least 30 percent of community-based water organizations with diesel-powered pumping systems are not financially sustainable. About one in five newly constructed water schemes breaks down within the first few years, often because of financial constraints.

Policy support for access to reliable and affordable water

Tanzania's Ministry of Water is taking measures to make rural water supply sustainable via a transition to solar pumping. This project seeks to develop a financing mechanism for community-based rural water supply with lower operating expenses.

Thousands of diesel-powered water schemes operate in rural Tanzania. Their operating expenses are high, raising the cost of water, and service is intermittent. Equity and financial sustainability are additional hurdles. Solar pump technology can slash the life-cycle cost of water extraction and make struggling water schemes in remote villages financially viable.

The solar water pump pilot was launched in 2019, to extend assistance to faltering water schemes. Awareness of the project was facilitated by local NGOs via workshops at the district and regional levels for community-based water supply organizations, local water government officials, and decision-makers.

Financing and business model

The design embraces private sector assistance, blended finance, and emerging digital technologies for service provision. The pilot was the first in Tanzania to involve the private sector at scale to install and maintain solar pumping systems, including prepaid water meters and mobile money payments (enabling cash-free transactions).

By scaling a village-cluster approach and providing four-year service contracts, the project is increasing the supply of safe water through rehabilitation, reliable service, and lower non-revenue water and operating expense. The pilot identified communities with productive-use potential—namely, pastoralist communities with sizable livestock herds (meaning high water demand) and above-average willingness to pay. The pilot involves about 500,000 residents in 110 villages.

The blended financing method finances 40 percent of the capital expenditure through a four-year loan to each community-based water-supply organization. Sixty percent flows from a grant funded by the Swedish International Development Cooperation Agency and the Dutch government through the World Bank's Global Partnership for Results-Based Approaches; the Global Water Security and Sanitation Partnership is also contributing. The pilot intends to demonstrate viability and mitigation of risk.

Technology and digitalization

Data analytics, digital technologies, and business development support are playing crucial roles. Site selection was guided by hyperlocal mapping via a GIS tool that selects villages according to water prices, water quality, and population/livestock density.

Modern solar water pumps with five-year performance warranties coupled with real-time remote monitoring provide supply-side assurances and reduce downtimes, at lower cost than diesel. Pump systems can hybridize seamlessly with diesel generators to meet peak demands. The project also supports pay-for-water-dispensers and a mobile banking payment platform to collect water-user fees.

Water-as-a-service model as an ultimate objective

In a follow-up project, a PPP approach is planned to mitigate longer-term risk. The objective is to phase out subsidies by extending loan tenors from 4 years to as many as 15, allowing community-based water organizations to keep the price of water low while repaying the loans and narrowing the sector-side financing gap for SDG 6. The approach consists of 15-year concessions for design-build-operate-transfer contracts for rural water schemes. To enable economies of scale, each lot may include 200–500 villages, with voluntary participation. Competitively selected private companies would invest in and rehabilitate rural water schemes, recovering most of the investment through revenues from water sales. Funds from the Danish government subsidize or buy down the risk (political, regulatory, currency, payment) for private companies. A competitive process awards the concession to the bidder asking for the lowest subsidy. Performance bonds, which would impose monetary penalties for poor performance by a private sector investor/operator, will be considered in the PPP tenders.

Lessons learned

The pilot harnesses the power of financing community development through combinations of subsidies and loans, using digital platforms and cash-free transactions. It supports a transition from diesel to solar power, with demonstrable advantages obtained through lower carbon dioxide emissions and high life-cycle cost savings, demonstrating in novel ways how to make communities environmentally sustainable through financial innovation. Conversion to renewable energy substantially reduces O&M costs and improves cashflow. It advances the rural-water-as-a-service model of using private sector operators to improve service quality.

Sources

World Bank. 2016a. "Accelerating Solar Water Pumping via Innovative Financing." Integrated Safeguards Data Sheet, Identification/Concept Stage, World Bank, Washington, DC.

———. 2016b. *Accelerating Solar Water Pumping via Innovative Financing. Project Information Document. Identification/Concept Stage. Report PIDC90459. Washington, DC.*

———. 2021. Accelerating Solar Water Pumping via Innovative Financing (P161757). Implementation Status and Results Report. Washington, DC.

Interview with Kristoffer Welsien (Task Team Leader for the project and Senior Water Supply and Sanitation Specialist).

UGANDA

Introducing productive use of electricity to enterprises in refugee camps under AMPERE

INSIGHTS

Refugee camps need enterprise development and assistance in establishing enterprises that use electricity. Subsidies for consumers and small businesses are critical.

KEY OUTCOMES

Off-grid productive electricity is used for barber shops, small shops, video cinemas, and education. Participating companies developed business solutions appropriate to refugees' needs. The project outperformed targets.

Policy support and financing

The Ugandan government supports a self-reliance model for refugees by offering income-generating opportunities and encouraging refugees to start agri-business and small businesses in and around camps. The Accessing Markets through Private Sector Enterprises for Refugees Energy (AMPERE) project leveraged grant support for private suppliers that do not usually operate in the settlements. With support, they can supply and finance off-grid solar systems for phone charging, connectivity, and microenterprises.

AMPERE is funded by the Netherlands Enterprise Agency (RVO) under the Access to Modern Energy (AME) partnership with the Dutch Coalition for Humanitarian Innovation (DCHI). It is implemented by a consortium led by Mercy Corps Netherlands, in partnership with SNV and the Response Innovation Lab (hosted at Save the Children).

AMPERE sought to test, prove, and build evidence for quality, affordable, reliable market-driven energy access solutions in humanitarian response programming. The project worked closely with pay-as-you-go solar providers Village Power and d.light, both based in the Bidibidi refugee camp in Yumbe District, Uganda. The two companies benefited from a results-based financing (RBF) subsidy to enable refugees to purchase systems. The systems include stand-alone PV systems ranging from lantern/phone chargers to 120 Wp business systems for barbershops, video cinemas, and trading premises.

RBF subsidies incentivized solar providers to reach areas like the Bidibidi refugee camp. End-users also benefited from the pay-as-you-go (PAYGO) financing mechanism, addressing the affordability constraint of appliances. RBF subsidies were large, because refugees are financially constrained. Seasonal fluctuations in refugee income called for phasing awareness creation and distribution strategies.

Business and market development support with a gender perspective

Data analytics, including market surveys and mapping exercises, were used to collect information on the energy needs of businesses in refugee communities.

Working closely with Village Power and d.light, the project developed supply chains for systems that meet the energy needs of MSMEs while supplying electricity to several thousand refugee households by developing commercial distribution channels/agents in the camps. Strong market linkages were built between PAYGO suppliers and consumer demand categories in the camps. Partnerships with humanitarian organizations, NGOs, donors, field survey groups, and the private sector were vital.

The project recruited female sales agents, who were taught business development support and skills to market and support solar PV. Also vital was support for demonstration of all system types, to develop awareness about the benefits of these systems and grow demand.

Results and lessons learned

The project outperformed targets by supplying 3,683 systems over the one-year implementation period. Thirty businesses use off-grid electricity, for barber shops, small shops, video cinemas, and education. Demand for business systems was strong. Participating companies developed business solutions that met the needs of refugees.

This project reveals that humanitarian agencies and host governments can lead enterprise development in refugee communities by providing access to sustainable energy. Subsidies for consumers and small businesses are likely to be critical.

Sources

Bansal, Aditi, Angelo Benny Bertagnini, Chandni Sinha Das, Faiza Haq, and Tenzin Dawa Thargay. 2020. *EmPower Bidibidi: Assessing the Scalability of the Pay-as-You-Go Model in Refugee Settlements. School of International and Public Affairs at Columbia University, New York.* https://sipa.columbia.edu/sites/default/files/embedded-media/EmPower%20Bidibidi%20FINAL%20Report.pdf.

Mercy Corps. 2020. "Ensuring Access to Affordable, Reliable, Sustainable and Modern Energy for All.", August 10, Portland, OR. https://www.mercycorps.org/research-resources/affordable-reliable-sustainable-modern-energy.

Ragazzi, Cecilia, and Emmanuel Aziebor. 2021. *One Year on: Paying for Darkness. Strengthening Solar Markets for Refugees in Uganda*. Mercy Corps, Portland, OR. https://www.mercycorps.org/sites/default/files/2021-02/One-Year-On_Paying-for-Darkness_Short_final.pdf.

KENYA

Promoting the productive use of electricity in business settings

INSIGHTS

Access to affordable service relies on a strong distribution network that serves off-grid households, businesses, and social institutions. Strengthening that network requires an enabling environment and the establishment of relationships with stakeholders on the supply and demand sides.

KEY OUTCOMES

The COVID-19 pandemic delayed outcomes. Restrictions were eased in the second half of 2020. The project contributed to the expansion of solar off-grid market for productive uses, capacity building and policy advocacy.

This project aims to accelerate access to clean energy services for MSMEs by overcoming the barriers to distribution and uptake of solar PV systems in income-generating activities. It works with stakeholders throughout the value chain to develop the market. On the supply side, it partners with the private sector. On the demand side, it facilitates support to small-business users, including small-scale traders, service providers, and smallholders. To enhance the enabling environment, the project bolsters private sector–led associations and supports the work of relevant government ministries, institutions, and like-minded development partners. Supported by the Energising Development (EnDev) program, the project has been implemented by the SNV Netherlands Development Organisation in Kenya, in partnership with GIZ, the German international cooperation agency, since 2019.

Creating an enabling policy and regulatory framework

Implementation of the enabling environment component began in 2019. It focused on sector coordination; advocacy/policy advisories on fiscal incentives (taxation), including the development of solar standards for productive use; and support for enforcing existing policies and standards.

The project facilitated a sector study led by the Kenya Renewable Energy Association (KEREA) that examined the productive use of electricity market in Kenya. Its objective was to develop briefings for investors and policy makers and to propose measures to address the market challenges created by the COVID-19 pandemic.

Identifying markets and selecting companies selling solar-powered appliances

The project team analyzed sectors that could be served by solar-powered appliances and looked at products available to serve them. Examples of solar-powered solutions identified for support included solar irrigation kits; egg incubators; solar cooling and refrigeration; drying, grinding, and milling processes for agriculture; phone charging; and solar-powered clippers for barbers.

Companies were selected to participate in the project based on their technical and distribution capacities. More than 70 companies are active in the sale of solar power for productive use. They include plug-and-play PAYGO suppliers of the smallest systems; component-based system suppliers of custom-tailored systems; mini-grid companies that finance their clients' appliances; and specialized companies that serve key rural value chains such as horticulture, dairy, fisheries, and water supply.

Enabling access to finance and business development support

Market development took place between October 2019 and March 2021, informed by interviews with the private sector. The project drew on this experience and information to craft advisory services and business development support, including market intelligence and knowledge development, as well as financial support to strengthen technical and last-mile distribution, capacities, awareness, and demand creation while connecting solar manufacturers, distributors, retailers, and financiers with end-users.

The project used data analytics to understand viable solar applications; product value chains; and the diverse actors, small and large, in the market. To provide evidence of the ability of solar applications to generate economic returns to consumers, MSMEs, financiers, and the government, SNV partnered with the World Resources Institute and the Strathmore Energy Research Centre to develop a platform providing open-source data to inform energy access planning and relevant investments, including decision-making support on COVID-19. Governments at all levels and private sector players will have access to the datasets from the platform to support their energy planning and inform market development.

To expand and deepen the market reach of solar companies, the project improved end-users' access to credit from rural credit providers. To help companies selling larger productive use of electricity systems to develop, stock, and distribute product lines, it provided financial support on direct financing and derisking instruments to improve access to commercial financing through March 2021.

Results

The project's results included the following:

- An expanded rural sales network of 11 solar distributors of 875 solar-powered systems
- Technical assistance to off-grid sector organizations lobbying against the negative fiscal impacts of a planned reintroduction of VAT on solar systems, reversing the original VAT decision under the Kenya Finance Act of 2020/2021
- Expansion of the Energy Access Explorer data platform to include information on clean energy markets in Kenya
- Training for representatives of three county governments and private sector players to use the data platform to identify priority interventions for agriculture electrification, support their energy planning, and update the platform.

Sources

EnDev Kenya. 2019. *Solar for Productive Use: Request for Expression of Interest: Version 1: Partnership with Solar Distributors to Establish and Strengthen Supply and Distribution of Quality Solar Powered Systems for Productive Use in Business Settings.* https://c.smartrecruiters.com/sr-company-attachments-prod/58919688e4b0672cc03331a9/d17ca413-8417-4bca-852a-771a1c5c8973?r=s3.

SNV. n.d. *EnDev III Kenya: Accelerating Access to Energy Services. https://snv.org/project/endev-iii-kenya-accelerating-access-energy-services.*

Sosis, Karin, Jessica Gogo, and Mark Hankins. 2021. The Market for the Productive Uses of Solar Energy in Kenya: A Status Report. Eschborn, Germany: EnDev.

TOGO

Building productive use into off-grid rural electrification

INSIGHTS

In countries that cannot attract commercial solar companies (because of small markets or fragile market conditions), a well-planned and -coordinated public program can achieve strong rollout of solar-powered electricity. Government plays a market-enabling role, with off-grid solar companies overseeing marketing and distribution.

KEY OUTCOMES

The program has seen vigorous uptake of pumps, despite pandemic-induced delays to the rollout of the irrigation systems. About 3,200 solar systems have been installed, and another 1,160 are being manufactured.

Off-grid solar projects using PAYGO finance can incorporate productive-use applications. The CIZO (*sun* in Togolese) project encouraged its commercial partners to integrate solar-powered pumps into the networks they had already developed.

Providing policy support. The role of demand-side subsidies

CIZO is a project of the Togolese Rural Electrification and Renewable Energies Agency (AT2ER). It is supported by the EU–Africa Infrastructure Trust Fund, the African Development Bank, the Sustainable Energy Fund for Africa, and the government of Togo, who together have contributed $32.3 million.

Demand-side subsidies are being used to electrify 600,000 off-grid households. Private companies—including Bboxx, in partnership with Electricité de France; Soleva; Fenix International (now Engie); Solergie; and Moon—have built distribution and provided post-installation service.

The government has funded consumer-awareness campaigns, provided VAT exemptions, and issued lines of credit. Digital PAYGO tools have boosted renewable energy uptake among the rural poor using project-subsidized payments. A government champion for the project helped build policy support and secure long-term tax exemptions and regional buy-in. Consistent demand-side subsidies are funneled directly to customers.

The initial energy access objectives were expanded with an initiative called PRAVOST, which offered farming communities greater access to energy for households, community infrastructure, and small-scale agricultural productivity. Expanded objectives included providing PAYGO financing to solar power to 314 health centers and 400 drinking-water supply stations. Under PRAVOST, 5,000 solar irrigation pumps were deployed on small farms, and solar mini-grids provide electricity to 2,000 households.

Leveraging digitalization for planning, financing, and monitoring

The initiative used geospatial mapping to identify off-grid markets where grid expansion was unlikely to occur. Centrally collected data from installed systems allowed planners to evaluate project outcomes. The project relied on established partnerships among the government, communities, and a few supply companies to achieve scale in the small market and introduce new solar pumping products.

The transition from plug-and-play, off-the-shelf solar products to more expensive and complex solar irrigation systems was challenging. Customer identification, training, and after-service support were more complex than comparable support for off-grid solar for lighting households and powering appliances. Field support from a supplier addressed these issues.

In December 2020, Bboxx–EDF entered into a partnership with SunCulture, a solar irrigation supplier, to deploy solar-powered water pumps. As part of this partnership, the government provided a subsidy to 5,000 farmers that halved the costs of solar-powered farming and irrigation. The Togolese market will benefit from the large-scale rollout of SunCulture's solution in East Africa, and EDF and Bboxx will get to showcase their off-grid solar expertise. Using Internet of Things (IoT) technology, Bboxx's management platform will integrate the water pumps with remote management and monitoring. These services use the same PAYGO model used by Bboxx's solar home systems.

Results and lessons learned

Hundreds of solar pumping systems have been deployed, and thousands of farmers have taken up small-scale solar power for irrigation.

The projected yielded several lessons that are valuable to countries struggling to attract commercial solar companies:

- Central government championing of the program overcame the coordination and fragmentation issues that affect many energy access programs.
- Inclusion of solar pumping technology for rural farmers is important for the off-grid sector, which has focused on consumer goods that build little value-added economic incomes.

- The requirement that all systems be monitored—and that companies provide information to a central agency—enabled the program to have impact, track demand-side subsidy spending and avoid fraud, and assess the performance of partner companies.
- Long-term demand-side subsidies provide an equitable rural electrification solution for off-grid consumers and enable low-income consumers to pay off systems over a manageable period.

Sources

Africa Clean Energy. 2021. *Demand-Side Subsidies in Off-Grid Solar: A Tool for Achieving Universal Energy Access and Sustainable Markets. Nairobi: Tetra Tech International Development.*

African Development Bank. 2019. Republic of Togo: Project to Support the Social Component Rural Electrification Programme CIZO (PRAVOST). Project Appraisal Report. Abidjan.

Bauer, George Kibala, and Zachary White. 2021. "Smart Subsidies and Digital Innovation: Lessons from Togo's Off-Grid Solar Subsidy Scheme." GSMA blog, March 25, 2021. https://www.gsma.com/mobilefordevelopment/blog/smart-subsidies-and-digital-innovation-lessons-from-togos-off-grid-solar-subsidy-scheme/.

Bboxx. 2019. "Bboxx Customers in Togo Receive First Ever Government Subsidy for Solar Payments in Africa." March 1. https://www.bboxx.com/news/bboxx-receives-a-first-ever-government-subsidy/#:~:text=London%2C%20United%20Kingdom%20%E2%80%93%201%20March,solar%20energy%20payments%20in%20Africa.

Pombo-van Zyl, Nicolette. 2020. "Partnership Cultivated to Deliver Solar-Powered Farming in Togo." ESI Africa, December 17. https://www.esi-africa.com/renewable-energy/partnership-cultivated-to-deliver-solar-powered-farming-in-togo/#:~:text=Partnership%20cultivated%20to%20deliver%20solar%2Dpowered%20farming%20in%20Togo,-By%20Nicolette%20Pombo&text=Bboxx%2C%20a%20next%2Dgeneration%20utility,thousands%20of%20farmers%20in%20Togo.

Renewable Energy World. 2020. "Renewable Companies Team Up with Togo to Expand Solar-Powered Farming." Renewable Energy World, December 31. https://www.renewableenergyworld.com/solar/renewable-companies-team-up-with-togo-to-expand-solar-powered-farming/#gref.

BURKINA FASO

Using innovative financing to support irrigation

INSIGHTS

Innovative financing mechanisms such as RBF complemented by additional measures, such as first-loss guarantees, ensure lenders against the risk of default on their loan repayments and increase access to finance.

KEY OUTCOMES

In Burkina Faso, 250 of the 1,000 initially targeted cotton farmers received support to purchase irrigation equipment, and capacity building reached 1,400 farmers.

Agriculture accounts for 30–40 percent of GDP in the Sahel region. Despite its development potential, only 3 percent of cultivated land in the Sahel is irrigated. Without recurrent subsidies for irrigation, most areas are underdeveloped and face maintenance constraints. These barriers have mounted in recent years, for a host of reasons, including minimal local engagement in decision making, technical design errors, poor construction quality, limited access to finance, unclear responsibilities for operating and maintaining irrigation schemes, and insufficient coordination among stakeholders.

The Sahel Irrigation Initiative Support Project (SIIP) addresses these barriers and scales up the development objectives in the six Sahel countries. By engaging both public stakeholders and local communities in irrigation schemes, it promotes the efficient use of land and water. The project has three components:

- Strengthen the capacity to scale up irrigation through natural resource assessment and local development planning and train project beneficiaries in irrigation management.
- Finance design, construction, and technical assistance for small-scale schemes and include contributions from beneficiaries and results-based financing grants.
- Disseminate information through regional knowledge platforms, and engage in targeted communication between participating countries' M&E systems.

Unlocking access to private capital through subsidies and first loss guarantees

One SIIP subproject leverages an output-based aid (OBA) mechanism, an innovative tool used in Burkina Faso to target smallholder cotton farmers. Cotton is the country's second-largest source of export revenue, but it is rain-fed in Burkina Faso and vulnerable to droughts and uncertain rainfall patterns. The cotton industry, therefore, sought to scale up irrigation development in Burkina Faso. La Société Burkinabè des fibres textiles (Sofitex) is the country's largest cotton processor, collecting the harvest from over 160,000 smallholders grouped into 7,000 village cotton producer cooperatives (GPCs). The GPCs finance the purchase of inputs and equipment at the start of the growing season, taking loans from commercial banks. Sofitex packages and sells the cotton to the international market and uses the proceeds to pay the farmers their net profit through the cooperatives, after repaying the banks. Implemented by Sofitex and co-financed by the International Finance Corporation and a grant from the World Bank's Global Partnership for Results-Based Approaches (GPRBA), the project includes three components:

- Training for farmers ($790,000): Training 5,000 farmers on best practices for land and water management helped ensure that irrigation equipment is used effectively. The project also planned to train 3,000 farmers on the operation and maintenance of the irrigation technologies supported by the subsidies. To ensure long-term sustainability, the training was led by Sofitex, which has experience in building farmers' capacity.
- OBA subsidies to support irrigation technologies ($4.95 million): This component helped 1,000 farmers purchase irrigation equipment. It focused on supplementary irrigation during dry spells in the rainy season, when solar technologies do not provide energy. One-time subsidies of 50–80 percent of the cost of diesel pumping systems were provided when equipment installation and proper functioning were verified.
- Partial-risk fund to support access to loan finance ($400,000): Given the novelty of the RBF arrangement, the project deployed a partial-risk fund to ensure lenders against farmers defaulting on their loans. This mechanism was introduced to mitigate the fragilities of Burkina Faso's high-risk operating environment (limited legal options to settle disputes, borrowers' liquid collateral and investments in unknown technologies).

Results

Although procurement and project coordination delays, exacerbated by the pandemic, initially slowed implementation, progress on project objectives is evident. Most sites for irrigation subprojects have been identified in all countries, and feasibility studies are underway. Works are also being tendered or implemented in Chad, Mali, Mauritania, Niger, and Senegal.

The GPRBA–financed subproject in Burkina Faso faced delays; the execution rate stands at about 25 percent. About 47 percent of farmers included in the program have been trained in irrigation technologies, just short of the target of 50 percent.

Lessons learned

The Burkina Faso initiative shows how innovative financing for supplementary irrigation (such as the GBRBA grant) can raise incomes among cotton producers. Given the novelty of this arrangement, the project deployed a combination of RBF and first-loss guarantee to mitigate the risks of payment defaults and encourage banks to lend.

The strong value chain for cotton in Burkina Faso eased farmers' access to market finance. The installation of irrigation equipment (farm ponds, diesel-pumping systems, and hose-move sprinkler irrigation) increased the efficiency of water use and diverted more water to cotton, a high-value cash crop in the Sahel, increasing farmers' incomes.

Sources

GPRBA (Global Partnership for Results-Based Approaches). 2018a. "Irrigation to Stabilize Burkinabé Smallholder Cotton Farmers' Production: International Funding to Aid Vital Commodity's Resilience." Press release, May 1. https://www.gprba.org/pr-burkina-irrigation.

———. 2018b. "Irrigation Systems Introduced for Small-Scale Cotton Farmers in Burkina Faso." May 27. https://www.gprba.org/news/irrigation-systems-introduced-small-scale-cotton-farmers-burkina-faso.

World Bank. 2016. *Project Information Document (Identification/Concept Stage): Burkina Faso Access to Irrigation for Cotton Farming*. Report PIDC62093. Washington, DC.

———. 2017. *Sahel Irrigation Initiative Support Project. Project Appraisal Document. Report 1870, Africa Region, Water Global Practice and Agriculture Global Practice, Washington, DC.*

———. 2021. Sahel Irrigation Initiative Support Project. Restructuring Paper on a Proposed Project Restructuring, Report RES43114, Washington, DC.

MALI

Empowering women through multifunctional platforms

INSIGHTS

Rural energy access projects are most effective when productive-use components are aligned with the interests, needs, and potential of women and men. Successful outcomes depend on capacity building at different scales and for a range of stakeholders.

KEY OUTCOMES

Between 1999 and 2004, 514 "platforms" were installed, and hundreds of women and rural artisans were offered training and capacity building. The project saved women up to six hours per day on labor-intensive activities, allowing them to earn higher incomes and access more education.

Mali's social and economic development has lagged that of other developing countries. Per capita income is just $470 per year, and more than 70 percent of Mali's population lives on less than $1 per day. A mere 24 percent of the population has access to electricity (13 percent in rural communities). To overcome these challenges, the government of Mali launched a four-year energy policy to increase electricity access at affordable prices, promote solar energy, and reduce poverty.

Using policy support to expand electricity access

The Multipurpose Functional Platform (MFP) project started in the early 1990s, with initial grant support from the United Nations Industrial Development Organization (UNIDO) and the Food and Agriculture Organization (FAO), followed by support from the United Nations Development Programme (UNDP), and the International Fund for Agricultural Development (IFAD), through a pilot designed to install four platforms in 1995. Support from these sources totaled $10 million. Bilateral development agencies in Denmark, France, the Netherlands, and Norway and the Bill & Melinda Gates Foundation provided additional funding of $20 million.

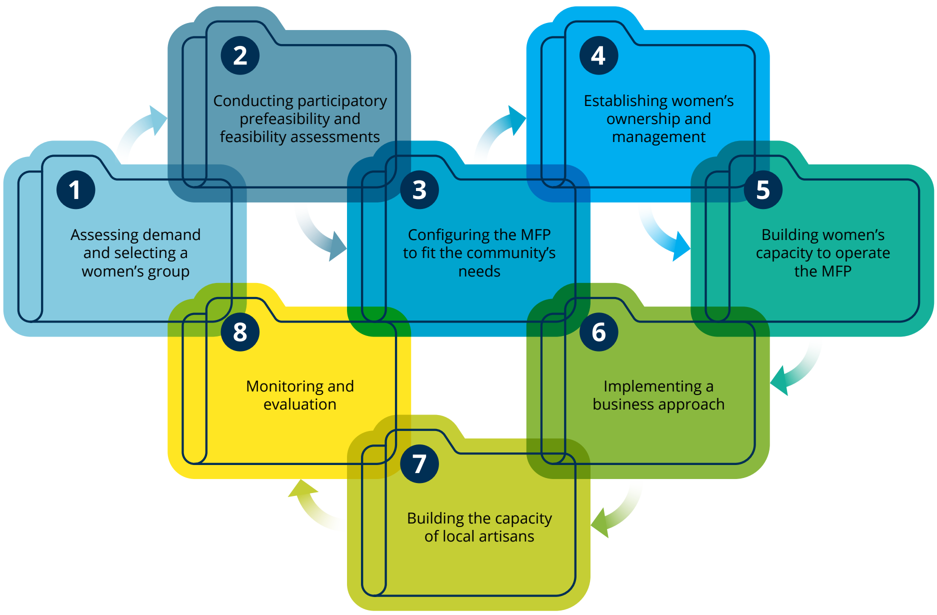
Each platform consisted of a diesel engine mounted on a chassis, which was added to a variety of end-use equipment, such as grinding mills, de-husking, oil press, battery charges, water pumps, vegetable or nut oil presses, welding machines, carpentry saws, and mini-grids for lighting. In 1996, the project was rolled out nationally, executed by Mali's Industry and Commerce Department.

Promoting the productive use of electricity through gender equality and empowerment

To promote gender mainstreaming in the energy sector, the MFP was designed to target women as prime beneficiaries by reducing the time they spend on energy-intensive tasks they usually handle. The program consisted of pilot (1995–98), demonstration (1999–2004), transition (2005–07), and dissemination (2008–13) phases. It was initially developed to support social development and reduce poverty in rural areas. It evolved into a major vehicle to promote gender equality and empowerment, creating income-generating opportunities through the provision of affordable energy services. The development and installation of MFPs involved an eight-stage sequential model (figure A.10.1).

FIGURE A.10.1

Eight-stage sequential model of Mali's Multipurpose Functional Platform



Results

During its first year of implementation, the project installed 48 platforms and trained 240 people to operate them, empowered women, improved educational opportunities, enhanced food security, and promoted community cohesion. By the end of the program, in 2004, it had installed 514 platforms, exceeding the initial target of 450, and provided hundreds of women and rural artisans with training and capacity building.

The program's most direct benefit was the expansion of energy access to about 500,000 women (5 percent of the rural population). By 2006, more than 1,500 villages had requested MFPs, and additional platforms were installed. The success of the project led many other West African countries—including Burkina Faso, Ghana, Guinea, Niger, Senegal, and Togo—to start their own national programs, collectively providing energy services to 3 million people.

According to a review of the project by UNDP, every MFP monitored through 2004 led to an average of $44 in additional annual income and up to six extra hours of time per day. A follow-up analysis estimated the increase in annual revenue at $40–$100 per household—a huge increase from the region's average household income of $500 a year. The income gains reflected increased productivity from agricultural processing and time savings that allowed women to dedicate more time to education and to other income-generating activities.

The MFP project empowered women by freeing them from labor-intensive drudgery, lightening their household workload, and promoting their participation in the local economy. Women saved about six hours per day on tasks such as grinding, de-hulling, and water fetching, improving their income, health, social status, and quality of life. The MFP gave women greater choice in the use of their time, enabling them to gain greater recognition and social standing in the community. The time saved also improved girls' school attendance and performance, increasing girl–boy ratios at school. MFPs are also linked to lower dropout rates, better performance on tests, and a larger share of girls entering secondary education (an increase of 31–38 percent across eight villages in Mali).

Lessons learned

The success of the project is rooted largely in its cross-sectoral approach to energy access, gender empowerment, and business development services (general business skills development, accounting, technical, managerial project implementation skills); the tailoring of technology to the needs of different villages; and the leveraging of data from feasibility studies and the pilot phase before scaling up the initiative nationwide and replicating it in other countries. An important lesson is the role of capacity building at different scales and among different stakeholders, ranging from national government to local women's groups. Women and entrepreneurs were trained to operate and maintain the MFP, budget and manage bank accounts, and develop enterprise skills that equipped them to perform technical and economic oversight.

Sources

Bates, Liz, Steven Hunt, Smail Khennas, and Nararya Sastrawinata. 2009. *Expanding Energy Access in Developing Countries: The Role of Mechanical Power. Warwickshire, United Kingdom: Practical Action Publishing.*

Brew-Hammond, Abeeku, and Anna Crole-Rees. 2004. Reducing Rural Poverty through Increased Access to Energy Services: A Review of the Multifunctional Platform Project in Mali. Bamako: United Nations Development Programme.

GEF (Global Environment Facility), and UNDP (United Nations Development Programme). 2016. Promoting Sustainable Electricity Generation in Malian Rural Areas through Hybrid Technologies. Project Document for CEO Approval. https://www.thegef.org/projects-operations/projects/5819.

Sovacool, Benjamin, Shannon Clarke, Katie Johnson, Meredith Crafton, Jay Eidsness, and David Zoppo. 2013. "The Energy-Enterprise-Gender Nexus: Lessons from the Multifunctional Platform (MFP) in Mali." *Renewable Energy 50 (February): 115–25.*

MYANMAR

Supporting the productive use of electricity among mini-grid customers

INSIGHTS

Data analytics and an ecosystem approach were expected to improve operational viability and inform site selections. The systematic approach was designed to lay the foundation for scaling up.

KEY OUTCOMES

Developers expected to improve energy sales and uptake at pilot mini-grid sites, with improvements to viability leading to further investments in mini-grid capacity.

Using grid and off-grid technologies, Myanmar's National Electrification Plan (NEP 2015) aimed to provide access to affordable energy by 2030 for the 58 percent of the population that was still unserved when the plan was launched. Initially, the World Bank supported NEP with $400 million (including $80 million for off-grid power), in partnership with other development partners active in the country. NEP's off-grid electrification component, implemented by the Department of Rural Development (DRD), deploys least-cost mini-grid and stand-alone solar technologies for households, public institutions, and productive uses. The mini-grid program relies on the NEP ecosystem for private sector development, which emphasizes opportunities for local companies.

The mini-grid program was supported by technical assistance from GIZ, the German international cooperation agency (evaluation support to the DRD, assistance developing the regulatory framework); Smart Power Myanmar (market intelligence, financing, productive use of electricity stimulation); the Asia Foundation (institutional framework/decentralization); the Asian Development Bank (mini grid assessment tools); ESMAP (energy surveys, mini grid tools, assessment of the electric cooking market); UNDP (framework); and Agence Française de Dévelopment (financing mechanisms).

Business model and financing support package

Requests for proposals invite submissions of business plans from mini grid-developers for sites identified by developers or the DRD. The developer's scope is design, build, own, operate, and transfer over 8–12 years, with cost-reflective tariffs. A GIZ expert team evaluates the proposals to make sure they meet minimum criteria. Viable proposals are eligible for a DRD–financed support scheme that provides up to 60 percent of the capital cost in the form of a results-based grant; at least 20 percent is an equity contribution by the developer, with the remaining 20 percent collected upfront from village beneficiaries. To sustain the scheme, beneficiaries are charged a consumption tariff sufficient to cover operations, maintenance, and component replacements and provide a return on equity to the developer over eight years. Prospective financial returns incentivize developers to expedite connections, maximize sales, expand the customer base, and innovate.

DRD awarded grants to 104 mini-grids selected through requests for proposals, 73 of these projects were operating as of March 2021. Performance varied. Average consumption per commercial connection was 0.70 kWh/day, far lower than the forecasted 2.66 kWh/day, with 75 percent of commercial connections consuming less than 2 kWh/day. Commercial connection rates were below target, especially for water supply (64 percent of expected), agri-processing (42 percent), and cold-storage (40 percent). Projected versus actual loads for sites identified in the first call for proposals are presented in figure A.11.1 By contrast, energy use by small retail shops and workshops exceeded targets.

Interventions have been planned to improve mini-grid performance. Learning exchanges with the IDCOL mini-grid program in Bangladesh suggested that the DRD pursue independent load forecasting based on on-the-ground assessments of sites. RBF schemes associated with requests for proposals had to be adjusted to provide greater incentives to achieve connection targets and load growth; encourage more realistic load forecasting, planning, and design; and be more proactive in promoting load. Incentives could have been structured in several different ways:

- Timely achievement of targets could have been incentivized by withholding a final grant tranche of 20 percent until connections and kWh sales reached 80 percent of mature demand (measured over a 12-month period to avoid seasonal load distortions).
- Incentives could have been offered for staged expansion. Developers could have been allowed to qualify for an additional DRD grant to expand generation and distribution provided its load targets were met or exceeded, thus permitting developers to phase their investment in response to demand growth rather than frontloading the investment.
- Fast-tracked, batched proposal approvals could have been used to support developers who consistently achieved connection and load targets.

Improved data analytics and management information systems

Improved data analytics and management information systems were applied to monitor performance based on outputs, accompanied by a requirement for remote monitoring of all mini-grids and a requirement for developers to report monthly sales by customer categories (households, public facilities, productive uses) and diesel fuel usage. Smart Power Myanmar initiated value chain assessments of productive uses to support the identification and development of mini-grid sites using specialist survey and planning tools and private village data analytics that co-locate investments in productive loads. The best way to evaluate all possible points of energy intervention along agricultural value chains needs to be determined, so that investment can be prioritized.

Policy and regulations: Tariffs and quality of service

Mini-grid evaluators who analyzed the business plans submitted in response to requests for proposals recommended that developers start with low tariffs and apply an escalating tariff structure over time. Time-of-day meters and tariffs were recommended to shift demand to daytime and reduce peak demand, offering consumers incentives for daytime usage and lower tariffs for meeting monthly consumption minimums.

Lower household tariffs for minimum use (lifeline tariffs) could be offered by cross-subsidizing them with higher industrial/commercial tariff. In March 2021, when COVID-19 measures were in force, 11 developers serving 115 villages offered lower tariffs and free electricity for a limited period, encouraging bulk prepaid purchases. Developers also provided communities with personal protective equipment.

Time-of-use demand optimization ensures that the output of renewable generation is used; diesel generators are reserved primarily to ensure 24/7 reliability. Reporting diesel fuel use helps optimize system efficiency.

Access to financing for appliances

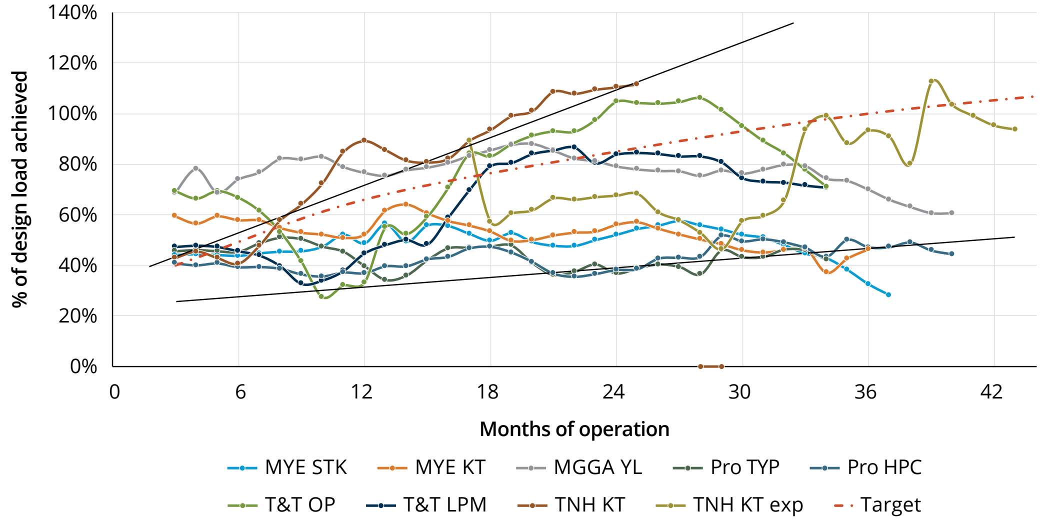
Some developers partnered with microfinance institutions to finance appliance purchases. Examples include PACT and Proximity Designs (https://proximitydesigns.org/), which provided income-boosting products for farmers via agricultural services platforms that offer technical, financial, and agronomic services. Smart Power Myanmar's Energy Impact Fund financed purchases of appliances by households and local productive enterprises, working directly with village committees to manage loans and mitigate risk. The possibility of expanding the small-business credit line provided by the Japan International Cooperation Agency to include mini-grid developers was discussed and agreed to, with support from DRD. Reduced collateral requirements would free working capital for mini-grid operations and expansion rather than tying up valuable liquidity as equity investments.

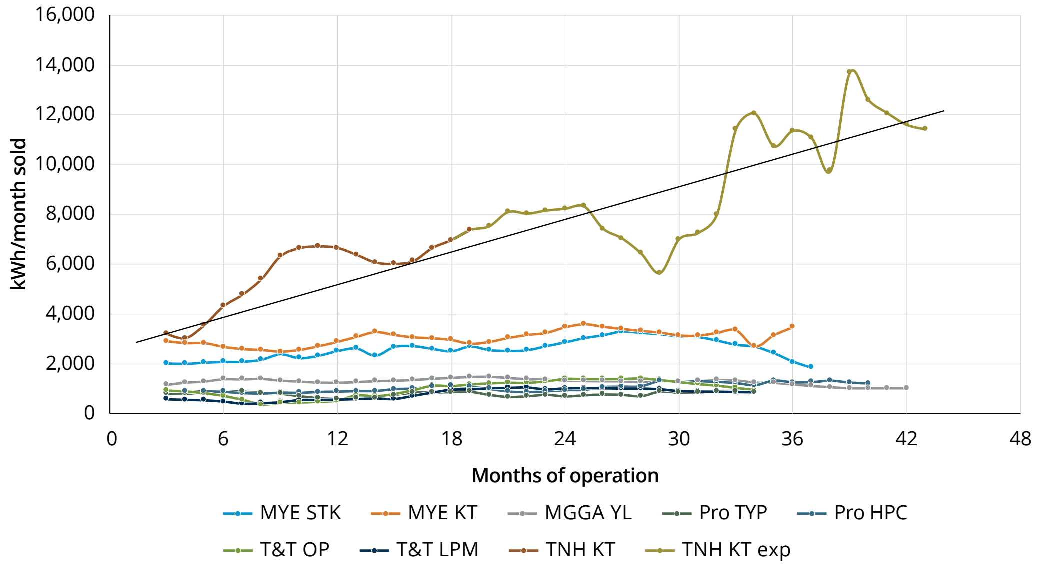
Mainstreaming gender by enabling access to electric cooking

NEP's scale-up was intended to promote social inclusion and increase development impact through support for the productive use of electricity. Access to electricity (grid or off-grid), coupled with clean, efficient electric rice-cookers, can help reduce the health, safety, and gender issues associated with non-electric cookers. ESMAP assessed the markets and enabling frameworks for clean cooking appliances as well as the suitability of RBF to address affordability gaps. Clean cooking solutions offer significant energy-efficiency improvements and major benefits to both grid and off-grid programs.

FIGURE A.11.1

Projected and actual load for sites identified in first request for proposals





Source: Department of Rural Development.

Note: Figure shows three-month moving averages.

Sources

Smart Power Myanmar. 2021. Agricultural Value Chains Study. Draft Report. https://downloads.ctfassets.net/nvxmg7jt07o2/265uoR92gMm7veosC7wEVj/6077eab18a9fc48e319d6525d973856c/Final2_SPM-Short-Report_EN_Interactive.pdf.

World Bank. 2021. *Myanmar: National Electrification Project (NEP) Project P152936. Implementation Status and Results Report. Washington, DC.*

Crossboundary innovation lab: Providing financing for productive appliances to increase the profitability of mini-grids

INSIGHTS

Mini-grid profitability increases when anchor loads, which boost revenues and generate value-added incomes for MSMEs, are added.

KEY OUTCOMES

Use of electric grain mills raised mini-grid profitability 11–44 percent; use of refrigerators increased profitability 6 percent.

Devices such as maize mills and refrigerators can increase rural incomes; when used as anchor loads, they also contribute to mini-grid profitability. Inadequate consumer finance has stalled the uptake of these catalytic appliances in rural mini-grids.

CrossBoundary Innovation Labs—with support from the Rockefeller Foundation, UKAid, the Shell Foundation, the DOEN Foundation, and P4G—helped mini-grid operators introduce (and finance) productive-use appliances. It worked with developers to provide income-generating machines and help MSMEs finance them at 13 mini-grid sites in Kenya, Nigeria, and Tanzania. Devices included mills, TVs, refrigerators, wood-working tools, and sewing machines. The objective was to stimulate use of high-power appliances by MSMEs and help them build incomes based on increased power use. The project determined the impact of appliances on mini-grid profitability and grid loads as well as the impact of appliances on the success of MSMEs.

Facilitating access to finance for consumers

The project provided affordable financing terms so that MSMEs and developers could find appliances that best met their needs. Financing was critical, because consumers cannot many of these devices without it. Participants were eligible for a 12-month loan term with a 20 percent deposit and a 2.55 monthly interest rate.

Supporting market development through partnerships

Consumers are not knowledgeable about electrical devices and their labor-saving and income-generating benefits. Demonstration and education are therefore vital.

Over the course of the project, the Lab helped appliance manufacturers better understand the needs of last-mile consumers. It also created strong partnerships among mini-grid operators, equipment providers, MSMEs, and finance groups to stimulate supply chains, reduce equipment costs, and share experiences across target developers. The Lab is working with the World Bank, ESMAP, the Collaborative Labeling and Appliance Standards Program (CLASP) to bring energy-efficient, electric-powered income-generating machines to market at scale.

Analyzing markets and technology

Of the devices examined, electric maize mills had the greatest potential to replace diesel-powered units. They can increase the profitability of mini-grids by over 20 percent. Although only 20 percent of mini-grid customers are business owners, they typically consume over 70 percent of mini-grid energy and can be a major stimulant of business. The project also found that (a) MSMEs and households accept slower throughput, provided the pricing structures of electric mills competes with diesel units and (b) both locally produced electric mills and imported units can develop the sector (imported units were more market-ready at the time of the trials).

Results

Income-generating devices have shown the strongest potential for increasing consumption and improving mini-grid revenue. Maize mills increased daytime load and generated income for business users. Electric grain mills boosted mini-grid profitability by 11–44 percent. Refrigerators raised profitability by 6 percent. Income-generating machinery increased consumption and mini-grid revenue. Maize mills increased daytime load and generated income for business users.

Lessons learned

Mini-grid operators can stimulate the productive use of electricity and add value to agricultural enterprises. Operators can build demand for the electricity they produce while raising the incomes of community members. Mini-grid operators can become market surveyors, innovators, incubators, and financiers of equipment as well as supply agents and after-service providers. Continual monitoring of power use by individual mini-grid customers and overall load profiles is critical to understanding how appliances affect mini-grids.

Financing is vital to the uptake of appliances by both households and MSMEs. Access to affordable financing unlocks latent demand for appliances—and has the potential to create a much larger-scale positive feedback cycle for mini-grid businesses. Mini-grid companies may need partner financiers to help introduce the productive use of electricity.

Sources

CrossBoundary. 2019. "Innovation Insight: Appliance Financing." *Energy4Impact, August. https://www.crossboundary.com/wp-content/uploads/2019/08/CrossBoundary-Innovation-Lab-Innovation-Insight-Appliance-Financing-Final-07-Aug-2019-1.pdf.*

———. 2020. "Milling on Mini-Grids: How Africa's Largest Crop Could Go Diesel-Free." April 15. https://www.crossboundary.com/wp-content/uploads/2020/04/CrossBoundary-Innovation-Lab-Off-Grid-Electric-Mills-Blog-Final-15-Apr-2020.pdf.

———. 2021a. "Offering Household Appliances on Credit Did Not Significantly Increase Mini-Grid Revenues." Appliance Financing 1.0 Innovation Insight (Newsletter), April. https://www.crossboundary.com/wp-content/uploads/2021/04/CrossBoundary-Innovation-Lab-Appliance-Financing-1.0-Innovation-Insight-29-Apr-2021.pdf.

———. 2021b. "PowerGen Partners with CrossBoundary Energy Access, Oikocredit, Triodos Investment Management and EDFI ElectriFI to Connect 55,000 People to Electricity in Rural Nigeria." Press release, July 22. https://www.crossboundary.com/wp-content/uploads/2021/07/2021-07-22-Press-Release-PBG-Closing_final-1.pdf.

Rockefeller Foundation. 2020. "Electrifying Economies: Appliance Financing." CrossBoundary Mini-Grid Innovation Labs East Africa, Zambia, and Nigeria. https://www.rockefellerfoundation.org/wp-content/uploads/2020/10/EE-Download-Solutions-CaseStudies.pdf.

Offering results-based financing to promote energy-efficient appliances

INSIGHTS

Reducing the cost of bulk purchases and facilitating the formation of business partnerships for appliance suppliers that have invested in producing high-quality technologies can increase the uptake of efficient productive-use appliances.

KEY OUTCOMES

Between 2019 and 2020, more than 8,000 solar water pumps were procured and distributed in East Africa, Senegal, and Zambia. By increasing access to clean water and farming productivity, these pumps slashed the average costs of water pumping by 91 percent, lowered the proportion of users below the poverty line by 23 percent, and improved the quality of life for 89 percent of users.

Since 2014, the Global LEAP Awards have promoted energy-efficient appliances in energy-constrained settings. Twelve competitions have been organized. The most recent one focused on cold-storage units and solar water pumps, which play a critical role in improving rural livelihoods and incomes while delivering environmental benefits and mitigating the impact of climate change.

Winners and finalists participated in the Global LEAP Results-Based Financing (Global LEAP+RBF) program, launched in Bangladesh in 2016 and expanded in 2017 to cover Kenya, Tanzania, and Uganda; Senegal and Zambia were added in 2019. The program aims to promote the uptake of efficient, high-quality appliances by lowering the cost of bulk purchases and facilitating new business partnerships between appliance manufacturers and companies that distribute products created by Global LEAP Awards winners and finalists. The program was implemented through the Efficiency for Access Coalition; it is managed by CLASP, with support from Energising Development, Power Africa, Powering Agriculture, UK Aid, and USAID. Other partners are Ideas to Impact, Energy 4 Impact, Acumen, Shell Foundation, and the Global Off-Grid Lighting Association (GOGLA).

All products identified as Global LEAP Awards winners or finalists were eligible for procurement. The RBF mechanism provided a pathway to deploy these best-in-class products at a larger scale and on shorter timelines than would have been possible under normal market circumstances. Global LEAP+RBF also (a) created opportunities to consolidate partnerships, by providing financial incentives to appliance manufacturers and off-grid solar distributors that partner to supply large volumes of high-quality, off-grid appliances; (b) extended opportunities through the Efficiency for Access Coalition Investor Network, a network convened by Acumen that included the Shell Foundation and 18 other investors; (c) participated in global promotional campaigns to connect with distributors and investors in key markets; and (d) generated data on the productive-use appliance market.

Collecting data and tracking results

The Global LEAP Awards provided reliable, accurate information about the quality and energy performance of appliances by interviewing thousands of people in six countries in Sub-Saharan Africa who purchased products through the program. The NGO 60 Decibels used these data to verify the purchase of solar water pumps and to gain additional insights into consumers.

Results

Research by 60 Decibels concluded that Global LEAP plus RBF facilitated the procurement and distribution of solar water pumps to more than 8,000 smallholders. Distribution through the program, which ranged across East Africa and Senegal between 2019 and 2020, accounted for 60 percent of sales recorded by GOGLA. Twenty-one participating distributors sold these solar water pumps to smallholders.

The 2019 Global LEAP Awards solar water pump competition shed light on product durability and performance issues. Although the proportion of customers reporting technical challenges with their solar water pump fell from 45 percent in 2018–19 to 32 percent in 2020–21, customers continued to report problems with faulty valves and controllers, the general unreliability of the pump, and short battery life. To address these issues, Efficiency for Access launched a discussion with solar water pump companies to identify measures manufacturers can take to improve pump system durability and performance.

Before they had solar water pumps, customers spent an average of $6.62 a week on fuel or hired workers to help them pump. Solar water pumps cut their weekly average costs to $0.57 per customer, a 91 percent drop. By increasing access to clean water and farming productivity, solar water pumps reduced the share of customers living below the poverty line ($3.10 per person per day) by 23 percent and improved the quality of life for 89 percent of customers.

Sources

CLASP (Collaborative Labeling and Appliance Standards Program). 2017. *Global LEAP Off-Grid Appliance Procurement Incentives: Supporting Distribution of the World's Best Off-Grid Appliances. https://www.clasp.ngo/research/all/global-leap-off-grid-appliance-procurement-incentives/.*

Efficiency for Access Coalition, and 60 Decibels. 2019. Uses and Benefits of Solar Water Pumps: Kenya, Tanzania and Uganda Consumer Research. https://storage.googleapis.com/e4a-website-assets/Use-Benefits-SWP-Report_FINAL.pdf.

———. 2021. Uses and Impacts of Solar Water Pumps: Insights from Kenya, Rwanda, Senegal, Tanzania, Uganda, Zambia. https://storage.googleapis.com/e4a-website-assets/Use-and-Impacts-of-SWPs-July-2021-v2.pdf.

GOGLA (Global Off-Grid Lighting Association). 2019. "Global LEAP-RBF Refrigerators & Solar Water Pumps." https://www.gogla.org/global-leap-rbf-refrigerators-solar-water-pumps.

Increasing output through powering agriculture: An energy grand challenge

INSIGHTS

Milestone-based grants for results-based financing and capacity building are key for sustainable interventions that increase agricultural productivity. All end-users, project managers, entrepreneurs, NGOs, and other stakeholders of the energy–agriculture nexus should receive training.

KEY OUTCOMES

Solar water pumps increased crop yields and household incomes in Kenya by 13 percent, and investing in cold storage avoided produce spoilage and increased farmer revenues by 6 percent. The initiative also led to a reduction in greenhouse gas emissions of up to 13,500 tons a year through solar irrigation and 8,000 tons a year through cold storage facilities.

Launched in 2012, Powering Agriculture: An Energy Grand Challenge was a $51.2 million multidonor initiative to support the deployment of clean energy technologies in agricultural value chains. The initiative provided grants to design and pilot innovative solutions throughout the agricultural production cycle. It leveraged funds to guarantee and promote investments in the clean energy and agriculture space, supporting solutions as they reach commercial scale, integrating them within national or regional agriculture production and food security programs, and hosting knowledge management platforms to document lessons learned and foster continued engagement among stakeholders. The initiative funded projects throughout Africa, Asia, and Latin America. Managed by the US Agency for International Development (USAID), it oversaw the selection of grantees, provision of funding, and monitoring and evaluation, with support from funding partners the German Federal Ministry for Economic Cooperation and Development (BMZ), Duke Energy, and the Swedish International Development Agency (SIDA).

Powering Agriculture was designed to go beyond funding activities that require ongoing support, in order to ensure the sustainability of the intervention and the development of new technologies by seeding a market, generating attention, attracting investment, and testing innovations with the potential to reach scale. It was supposed to have closed at the end of 2019, but some projects were extended, and donor partners agreed to fund similar projects under a new Grand Challenge, Water and Energy for Food program focusing on the nexus of water, agriculture, and renewable energy. The lessons learned from Powering Agriculture will help this program identify the most promising innovations and support them as they grow and achieve scale.

The initiative set four program objectives:

- Boost agricultural yields and productivity.
- Limit postharvest losses.

- Improve income-generating opportunities and revenues for farmers.
- Increase energy efficiency for farm operations and agri-business.

To achieve them, partners focused on four areas:

- Technology and business-model innovation
- Commercial finance
- Grant provision to mainstream knowledge
- Technical assistance for knowledge dissemination and partnerships.

Most funding was awarded to 24 innovative projects across four technology categories:

- Solar-powered irrigation (six projects)
- Cooling and heating using renewable energy (six projects)
- Mini-grids and micro-grids (seven projects)
- Agricultural processing (five projects).

Of the 24 projects, 11 targeted Africa, 8 Asia and Pacific, 3 Latin America, and 2 the Middle East. Several projects operated in more than one country.

Support for business development and technology innovation

Most project winners received milestone-based grants, with funds disbursed following the achievement of specified results. The grants were designed to help awardees make progress on technology development, business development, and, ultimately, widespread diffusion. As part of its activities, Powering Agriculture set up the Powering Agriculture Investment Alliance to catalyze private sector financing for businesses recipients of the project's grants for clean energy solutions to boost agriculture productivity in developing countries.

Training end-users played a critical role in the program. Trainers educated civil servants, project managers, entrepreneurs, and employees of NGOs at the energy–agriculture nexus. Using SIDA's gender-gap analysis and tools, Powering Agriculture also helped innovators integrate gender considerations into their operations.

Program partners conduct extensive outreach, through conferences, workshops, and international development meetings at which innovators are encouraged to share their knowledge. On behalf of BMZ, GIZ (the German international cooperation agency) assumed chief responsibility for knowledge management and the dissemination of Powering Agriculture's objectives and activities, touting its success stories and building awareness about the relationship between clean energy and agriculture.

Powering Agriculture also supported the deployment of innovative clean energy technologies and business models for agricultural value chains, including technology development, initial in-country pilot testing, and early-stage commercialization. Two global calls were issued in 2012 and 2014, to screen innovation proposals from universities, nonprofits, and for-profit firms in developed and developing countries.

Results

The agricultural projects funded by Powering Agriculture increased productivity, raising farmers' incomes and limiting spoilage:

- Solar water pumps increased crop yields, which boosted household incomes by $224–$811 per year—a 13 percent increase in Kenya, where annual average income is $6,318. Gains were even greater for rural households with substantially lower incomes.
- Cold storage kept produce fresh, raising farmers' revenues by about $220–$350 per year—a 6 percent gain in Kenya.
- The projects also improved gender targeting and reduced greenhouse gas emissions.

Many Powering Agriculture awardees received grants to support their technology and market development. The hypothesis underlying the programs' approach is that development impacts begin to accrue in a meaningful manner only when these products and services are widely used. In some cases, innovators developed technology but faltered at the business development and diffusion stages.

A number of innovators reached the diffusion stage; their technologies enjoyed widespread uptake, reduced greenhouse gas emissions, and raised agricultural productivity and income. But impact took time: In East Africa, the effects first became evident more than seven years after implementation and multiple grants per technology. Eventually, a commercially viable market emerged that has enjoyed growth independent of donor involvement. Other technologies, such as cold storage and agri-processing, are on a positive trajectory toward achieving their intended impacts but are still behind those seen for solar water pumps.

Source

Crane, Keith, Brian Zuckerman, and Emma Thrift. 2020. *Powering Agriculture: Summative Evaluation. https://pdf.usaid.gov/pdf_docs/PA00WPX1.pdf.*

BANGLADESH

Stimulating the uptake of productive use of electricity from mini-grids

Insights: Uptake in greenfield mini-grids is frequently overestimated, resulting in sunk investment and losses if adequate load is not reached within three years. Stimulating demand for the productive use of electricity by households and MSMEs is essential from the outset. Mini-grids must be expandable to meet demand growth.

Key outcomes: Uptake improved when MSMEs were provided with financing to make the switch to electricity. Tariff incentives were combined with awareness campaigns to address knowledge gaps (costs, benefits, appliances).

The Infrastructure Development Company Limited (IDCOL) is providing concessional project financing to enable mini-grid project developers to deliver improved energy services via 26 solar mini-grids in remote parts of Bangladesh. The 26 mini-grids had total capacity 5.03 MWp in 2021.

Planning for electrification and productive use of electricity

The mini-grid sites are located on islands that the grid cannot serve because rivers widen by several kilometers during the monsoon season. Uninterrupted off-grid power is therefore needed.

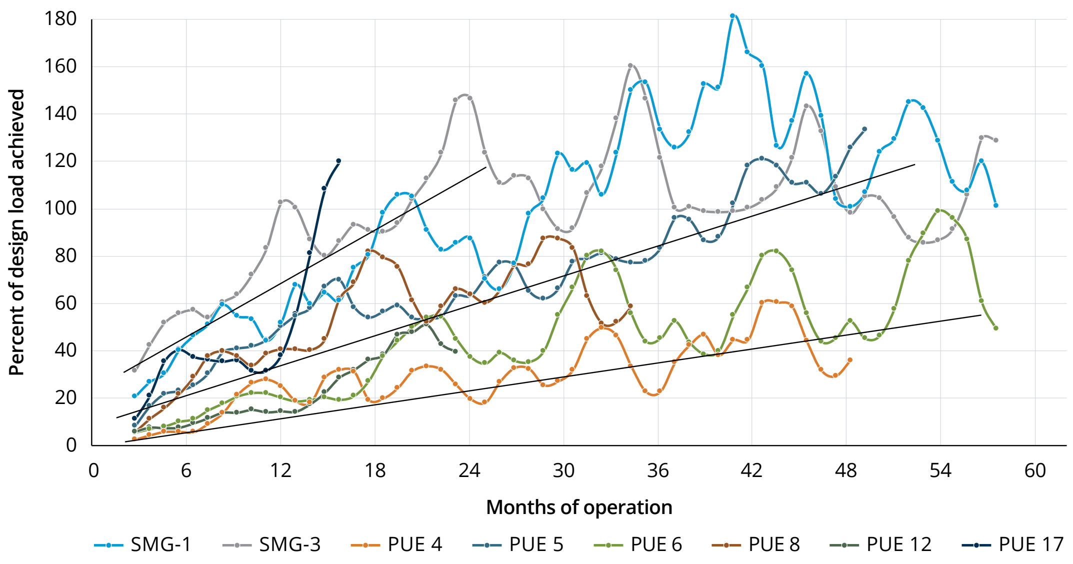
Each site has its own microeconomy, usually a mix of seasonal productive activities such as fisheries; agriculture (rice, sunflower, and other vegetables); agri-processing (milling, husking, and oil pressing); and wood production and sawmills. Supporting businesses include carpentry and metal workshops; diesel engine repair shops; and many small retailers of services, products, and foods in local bazaars, which are open into the evenings. Transport on the islands is usually by motorbike; there are also a few cars. Dedicated diesel engines with belt drives provide almost all energy for productive use. Most households and shops have had access to stand-alone solar home systems for several years, thanks to IDCOL's program.

Uptake patterns and strategic interventions

The uptake response to mini-grids varied wildly, even given highly seasonal demand patterns (figure A.15.1). Six mini-grids reached high plant utilization within 36 months, breaking even under the financing package provided. Eleven are still at the uptake phase, and three struggle to reach design-load demand and face loan repayment hurdles.

FIGURE A.15.1

Three-month moving average of expected load achieved by mini-grids on islands in Bangladesh



Source: IDCOL.

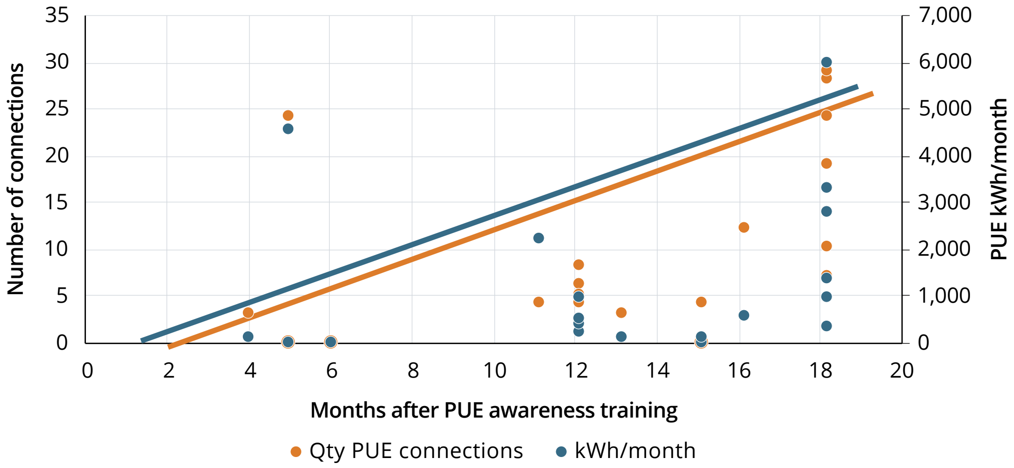
Note: Rules show trend lines for each mini-grid, after eliminating seasonal demand effects.

For larger mini-grids (>200 kWp), daytime productive users were not connecting as planning had predicted they would, as existing diesel users did not migrate to electrical appliances powered by mini-grid. Larger night-time load components were saturating plant capacity—and doing so more quickly than expected. The larger plant investment, low demand loads, and low plant utilization resulted in higher exposure and negative cashflows and risks. Mini-grid developers in this position are less likely to invest further in marketing and extension campaigns.

IDCOL conducted intensive customer-awareness campaigns to fill knowledge gaps (on upfront costs, benefits, appliances) and reduce barriers to conversion from diesel-mechanical to electric appliances. The reduction in upfront costs, design knowledge, and access to motors and more efficient appliances increased the productive use of electricity but only slightly (figure A.15.2). These sites present challenges for mini-grid developers. Accordingly, IDCOL arranged for management skill development training to improve mini-grid developers' understanding of business opportunities through promotion of the productive use of electricity.

FIGURE A.15.2

Post-awareness-raising increases in number of productive use of electricity connections and kWh sales



IDCOL provided developers with financing for on-lending for conversion packages ($120–$400 for electric motors, pulley gears, and belts, depending on the industry and load), but such packages require mini-grid developer to play a design role. Developers are also required to play a lead micro-financing role (the background of many of them). Developers teamed with electrical appliance providers to ensure the presence of appliances at sites.

Going forward, the project plans to implement demand-side stimulation strategies, including supply-side incentives for daytime/off-peak loads via time-of-use tariffs, lower connection charges, bulk tariff rebates, and seasonal rebates.

Financing support for mini-grid sites tended toward softer loan terms (longer repayment terms and extended grace periods) to improve the cashflow of developers over the load development phase. IDCOL also required all funded mini-grids to (retrospectively) adopt remote real-time monitoring capabilities for instantaneous troubleshooting and tracking trends in generation; new sites must use digital prepaid meters, to enable tracking of individual household and MSME usage.

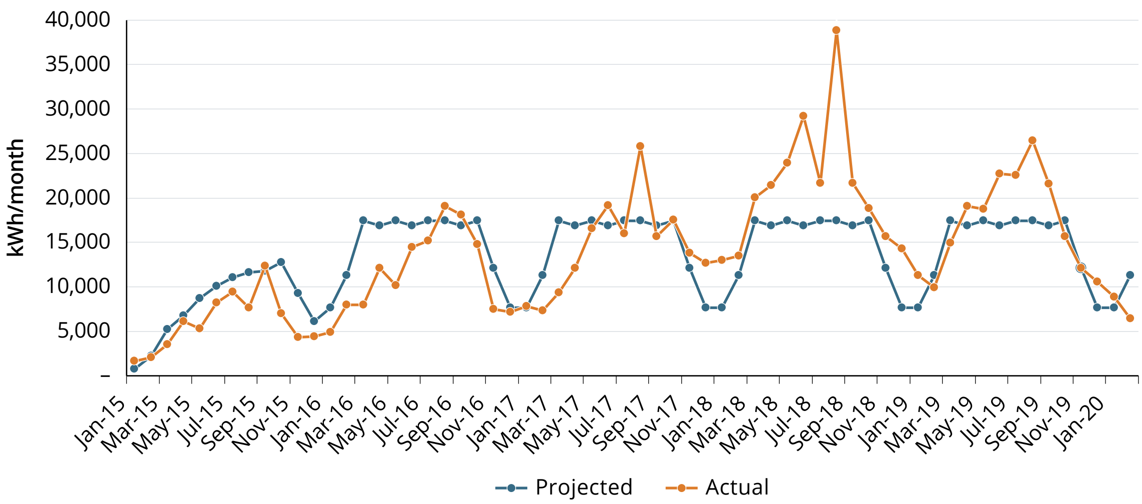
Success stories

The experience at several sites was highly successful. One was the first mini-grid to be implemented, the Suro Bangla mini-grid, in Narsingdi District. Located on Paratoli Island, this mini-grid is a solar/diesel/battery hybrid comprising a 141 kWp solar array, a 66 kVA diesel generator, 72 kW of bidirectional battery inverter, 888 kWh of battery storage, and 8 km of distribution network. It reached maturity and viability within two years by selling 17,000 kWh/month (484 kWh/day) with 848 connections to about 50 percent of households and 100 percent of shops. No bold projections were made for commercial or productive use of electricity loads, although the targeted cluster did include productive users. Tariffs were fixed at $0.38/kWh, with a connection charge of $50 (including meter and accessories). Within 18 months of commissioning (in December 2014), sales reached an average of 17,434 kWh/month. The plant operated at optimal utilization, with little excess or wasted capacity. Shortly thereafter, new and unplanned loads started coming online (figure A.15.3). Time-of-use power demand and overall energy demand required a diesel generator to meet the increased hours per day (increasing plant capacity by up to 170 percent of design energy demand). The new average loads of 30 kW–40 kW include 32 public facilities (schools, mosques, offices, and *madrassahs*) and 7 workshops (steel, furniture, and carpentry). Contracts were signed for a cellphone tower base-load (24-hour) after 36 months. In the final stage, 3 separate EV charging stations (29 auto-rickshaw charging points) came online as night load.

Eventually, power and energy demand exceeded plant capacity, and the developer initiated a second phase of capital investment, procuring an additional diesel generator of 66 kVA (rather than more capital-intensive expansion of PV array, battery, and inverters). Although the marginal cost of diesel generation is higher, every kWh sold is better than not selling, and it increases demand. The cashflow-positive planning approach, with higher diesel fractions, is proactive, dynamic, and versatile.

FIGURE A.15.3

Actual and projected energy sales from mini-grids on islands in Bangladesh, 2015–20



Source: IDCOL's mini-grid program M&E framework.

With load demand established, the sponsor could base tariffs on seasonality and time of use, incentivizing the shift of large loads to mid-day (where demand can be met with cheaper solar power) and optimizing capital investment in more efficient renewables (PV array, battery, and inverters). The track record justifies additional loads.

Lessons learned

Planning for larger mini-grid investments with ever-larger load projections may delay completion; inhibit plant utilization; and increase exposure, risk, and paralysis. The productive use of electricity component is highly uncertain. Smaller plants that are flexible, scalable, and expandable can reach targets and generate positive cashflow with more agility than larger plants. Starting with smaller mini-grids design and then expanding is also operationally and financially more robust than starting too large with significant sunk assets. Market and business development interventions to stimulate uptake can be successful, but they must occur in conjunction with the capacity to expand mini-grid plants, in order to avoid overinvestment.

Sources

World Bank. 2022. *Bangladesh: Rural Electrification and Renewable Energy Development II (RERED II) Project P131263*. Implementation Status and Results Report. Washington, DC.

Data shared by Enamul Karim, Head of Renewable Energy, and Farzan Rahman, VP Renewable Energy, IDCOL.

Interview with Hassan Muhaiminul Aziz, Manager, Renewable Energy, IDCOL in March 2022.

ANNEX B. MONITORING AND EVALUATING PRODUCTIVE USES

Improving operations requires the tracking, monitoring, and evaluation of projects. They are important for making mid-project adjustments and assessing the effectiveness of interventions for long-term development. These activities not only help projects achieve their goals; they also yield lessons for future efforts to improve the socioeconomic benefits of programs resulting from energy access.

Collecting data before projects begin and preparing for monitoring and evaluation

Screening before a project can reveal both barriers and opportunities. The data from such screening can provide baselines for later tracking, monitoring, and evaluation.

Advances in GIS remote mapping, data analytics, technology, financial engineering, and remote data-gathering methods make it possible to collect information at many levels. Public data are available at increasingly granular levels. Remote mapping can incorporate data from national and local planning records. Local data that can be used to prepare maps include data from or on census records, livelihood surveys, electrification rates, transportation networks, agriculture potential (including water resources), and market access.

Community-level information remains at the core of pre-project data gathering and monitoring and evaluation (M&E), because a community's history, culture, political dynamics, and market factors affect its productive use of electricity. Gender disparities and the levels and distribution of income and wealth affect the purchase of machines and the number of businesses that can be supported. Understanding community-level characteristics are essential for a holistic assessment of ways to increase the productive use of electricity.

Remote audio and video calls can lower the costs of surveys, community meetings, focus groups, and community discussions. In most cases, however, it will still be necessary to conduct on-the-ground consultations and surveys. Consultations and local-level mapping can reveal information on opportunities and possible entry points for community and local partnerships.

Tracking operational performance

Continuously tracking performance is necessary so that adjustments can be made to improve project effectiveness. Tracking can help determine which marketing messages motivate sales or whether supply barriers are limiting the growth of productive uses.

Trackable metrics are critical for monitoring operations. They enable continuous analysis of energy suppliers, appliance sellers, and MSMEs.

For energy services businesses, metrics for kWh sales, load curves, and payments from MSME customers can be tracked as part of standard business models. For appliance sellers, credit agencies, and MSMEs, performance can be tracked with proprietary data that actors feel comfortable sharing with investigators. With digitalization and remote communication technologies, both proprietary and market data can be analyzed in real time and shared at low cost, possible by taking advantage of new technologies such as smart meters, pay-as-you-go applications, and other advances in data analytics. The collection and tracking of all types of enterprise-level data should be sensitive to enterprise concerns about confidentiality.

Operational data can include information on the number and types of MSMSs, appliance sellers, and other market actors. Such data can be obtained through interviews, surveys, focus groups, and participant observation. For energy suppliers, locally generated data on outages, complaints, and connection delays can be important. Standardized definitions enable a comparison of cases and practices. Most of these data will be digitized and made available for rapid and shared analysis with businesses participating in the project.

Monitoring project results against indicators and objectives

Funders set objectives and intermediate results indicators before projects are implemented. Many of the data used to track operations will be useful for monitoring performance against project-level objectives and indicators.

Project implementation arrangements should set goals and milestones for monitoring at the design stage. Budgets should reflect the importance of both project performance and the generation of knowledge that will be useful for future programs. Evaluation specialists skilled in labor markets, non-farm income, rural microfinance, rural enterprise, livelihoods, and other areas are well suited to designing and conducting evaluations.

Guidelines for M&E of rural electrification programs are available. They can be adjusted as needed to fit local contexts and the priorities of particular programs.

The benefits of energy access projects have been extensively studied and evaluated. However, the productive use of electricity components of such projects have only rarely been subject to stringent evaluations. Periodic follow-up rural appraisals are essential for evaluations of the broader development pathways and their impacts in rural communities.

Evaluating outcomes

Measuring development impact is different from tracking project accomplishments. It goes beyond project indicators (such as the number of household connections, the financial sustainability of suppliers, and participation by women). Development objectives and results indicators should be treated on par with other project objectives.

Project evaluation aims to assess the effectiveness of investments and the contributions of different components to a project's development goals. Assessing the effect on development requires an evaluation that goes beyond performance tracking. Such an evaluation might include surveys to assess the level of income and changes in social welfare. Project evaluations can be based on a range of methods, including participant observation, focus discussion group, and surveys.

Many forces, including structural shifts, cyclical effects, and technology changes, generally occur during a project. Assigning causality to a single factor is therefore difficult. Challenges in identifying causality can be addressed with properly structured surveys, quasi-experimental methods, and randomized control trials.

Evaluation results generated by rigorous methods can identify lessons for future programs. Specialists can identify the frameworks, data requirements, and documentation methods needed to assess socioeconomic benefits and pathways using regressions or other techniques. These types of methods need to be combined with information and insights generated by repeated appraisals in the rural communities to give a well-rounded picture of both project success and effectiveness in increasing development outcomes. Both qualitative and quantitative insights are necessary to make sure that projects are accomplishing their development goals.

ANNEX C

BENEFITS OF THE PRODUCTIVE USE OF ELECTRICITY

The overarching goal of development interventions is to reduce poverty and raise household income. Electricity augments farm and household income in a number of ways (table C.1). Radio and television broadcasts and Internet access create awareness of employment and other economic opportunities (Barnes 2014; Asaduzzaman, Barnes, and Khandker 2009). Electricity also increases access to learning (Kulkarni and Barnes 2018). Better educational opportunities improve long-term income (Psacharopoulos and Patrinos 2018). Household lighting increases the number of lighting hours for home-based enterprises (Barnes and others 2002). These benefits are complemented by increases in household income, business development, and gender equality.

TABLE C.1
Estimated percentage increases in rural household income associated with increased access to electricity in selected countries

COUNTRY (TYPE OF ELECTRICITY)	FARM INCOME	NONFARM INCOME	TOTAL INCOME
Bangladesh (grid)	31.3	35.3	21.2
India (grid)	0.0	68.8	38.6
Vietnam (grid)	0.0	27.5	28.0
Nepal (micro-hydro)	0.0	11.2	0.0

Source: Barnes, Samad, and Banerjee 2014.

Increases in income

Many studies find that adoption of electricity adoption in homes increases household income. In Bangladesh, farm and non-farm income increased by almost 25 percent after adoption of electricity (Khandker, Barnes, and Samad 2012). In India, electricity improved income by as much as 68 percent. In India, irrigation with electric pumps is associated with higher crop yields Naik and co-authors 2021). In Nepal, the use of electricity from micro-hydro systems was associated with an 11 percent increase in income (Banerjee, Singh, and Samad 2011).

Studies show that electricity consumption is modest immediately after households adopt electricity but that over time households purchase more appliances and energy-saving machines (Khandker, Barnes, and Samad 2012, 2013; Barnes 2014; Barnes and others 2002). As a result, both electricity consumption and the benefits from electricity grow. Income growth allows more households to afford electricity and purchase appliances. The goal of productive use programs is to shorten the period in which both electricity use and the benefits for households take place, so that the benefits of electricity access can compound and improve both household income and welfare.

Increases in women's productivity and well-being

Women's uses of technology are more likely to be overlooked economically or deemed "merely" social rather than productive. But "non-productive" use of an appliance does not mean that it has no value. The time, labor, and money saved thanks to electric appliances are important. These savings are likely to significantly increase the well-being of women, even if the increase cannot readily be measured in economic terms.

Women make productive use of household appliances in ways that national accounts do not usually capture. Access to electricity increases well-being for women in many ways, including by reducing the time they spend performing household chores and time poverty and increasing the likelihood that they participate in income-earning activities (Samad and Zhang 2019). Researchers have investigated the effect of electricity on the well-being of rural women, but most studies conclude that the means through which it happens need more attention (Clark 2021).

Mali integrated the benefits for women in a productive-use project (see box 6.2). The project conducted a simple gender assessment in order to understand how women differ from men in the way they use electricity in a productive manner.

Projects need to pay attention to the improvement of household well-being and income-generating potential for women. Access to electricity can increase opportunities for women to run small businesses, such as small retail stores or ironing and sewing enterprises.

Business benefits from renewable and grid electricity

The use of electricity allows businesses to increase their productivity and reduce costs. Solar irrigation can help farmers increase crop yields. Refrigeration of fruits, vegetables, and milk dramatically reduces losses of farm produce. Mills for grinding and machines for de-husking grain can add significant value to agricultural production.

The productive use of electricity has been found to improve development outcomes (table C.2). In Kenya, for example, solar water pumps increased crop yields by as much as $800 per year, and solar-powered cooling reduced losses and improved dairy sales by 40 percent (Ecozen Solutions. 2014) In Mali, mills for grinding and machines for de-husking saved women six hours of drudgery per day (Sovacool and others 2013). These savings free women for productive activities elsewhere.

TABLE C.2
Evidence of benefits of productive use electricity

BENEFIT/INTERVENTION	IMPACT	COUNTRY	PROJECT/SOLUTION
Increased income			
Solar water pumping	Solar water pumps boosted crop yields and annual household incomes in Kenya by $224–$811, a 13 percent increase; rural households enjoyed even larger increases.	Regional	Powering Agriculture, 2020 (Crane, Zukerman, and Thrift 2020)
Cold storage	Investing in cold storage prevented produce spoilage and increased annual farmer revenues in Kenya by $220–$350, a 6 percent increase.	Regional	Powering Agriculture, 2020 (Crane, Zukerman, and Thrift 2020)
	Solar-powered cooling systems improved by more than 150% the key dairy performance indicators characterized by an increase in milk quality and production and in farmer's income, by cutting milk losses and the time spent delivering milk to bulkers, particularly for women and youth.	Kenya	Savanna Circuit Tech & UK Government (nd)
	Solar cold storage enabled farmers to reduce spoilage and sell better-quality produce at higher prices, increasing their profits by 40 percent.	India	Ecozen Solutions (2014)
	Solar Cold Hubs reduced food losses, saving nearly 11,400 tons of fruits and vegetables since 2016 and nearly doubling the monthly income of over 450 farmers, retailers, and wholesalers.	Nigeria	ColdHubs (2015)
Solar water pumping and cooling	Installation of water-pumping systems and milk-cooling tanks increased farmers' net income by 25 percent.	Mexico	Renewable Energy for Agriculture (2000–06) (World Bank Group 2010)
Reduced costs			
Solar water pumping	Before solar access, customers spent $6.62 a week on fuel or hired labor to help with pumping. Solar water pumps reduced weekly average costs to $0.57 per customer, a 91 percent decrease.	Regional	Efficiency for Access and 60 Decibels study (2019)
Reduced poverty			
Solar water pumping	Solar water pumps lowered the proportion of households living below the poverty line ($3.10 per person per day) by 23 percent and improved the quality of life for 89 percent of customers.	Regional	Efficiency for Access and 60 Decibels study (2021)
Improved gender equality			
Solar water pumping, cooling, processing	More than half (54 percent) of innovators cited gender equality as a project goal, integrating women beneficiaries at high rates.	Regional	Powering Agriculture (Crane, Zukerman, and Thrift 2020)
Various	Welding machines, grinding mills, and de-hullers saved women up to six hours per day, lightening women's workloads and raising their social standing.	Mali	Multipurpose Functional Platforms (1995–13) (Sovacool and others 2013)

BENEFIT/INTERVENTION		IMPACT	COUNTRY	PROJECT/SOLUTION
Improved education				
Various		Time saved from energy-intensive household tasks boosted school attendance for girls and the proportion of girls entering secondary education by 31–38 percent.	Mali	Multipurpose Functional Platforms (1995–13) (Sovacool and others 2013)
Increased electricity consumption				
Various		Productive activities more than tripled the electricity consumption of participating producers, from 56 KWh to 240 KWh per month.	Peru	FONER I (2006–13) and FONER II 2011–17) (World Bank 2019)

Source: The table was compiled by Economic Consulting Associates from World Bank project documents, case studies of a project financed by USAID, reports prepared by the evaluation group 60 Decibels, and other documents.

The conclusion from the table is that the productive use of electricity manifests itself in a large variety of ways, ranging from improvements directly related to higher business income to time saved in labor-intensive activities. Programs should therefore be open-minded and broadly focused to have the highest impact for rural communities.

Cost–benefit analysis for large and small energy projects

The benefits of the productive use of electricity can be identified through formal cost–benefit analysis. However, cost–benefit analysis is often conducted only for larger projects and not for productive use of electricity interventions components within them. The few cost–benefit analyses of productive use of electricity interventions that have been conducted have shown beneficial impact of both renewable energy and grid rural electrification projects.

For renewable energy projects, the Food and Agriculture Organization (FAO) conducted feasibility-type studies to document the potential financial and economic value of biogas- and solar-powered operations for chilling milk, pumping water, processing rice, and de-husking grains (Flammini and others 2018). Most of the technologies it assessed had high benefit–cost ratios (table C.3).

TABLE C.3

Cost–benefit analysis of renewable energy and productive use of electricity

COUNTRY/ TYPE OF PRODUCTIVE USE	SYSTEM COST (THOUSANDS OF DOLLARS)	PROJECT ECONOMIC INTERNAL RATE OF RETURN (PERCENT)	CUMULATIVE 20-YEAR ECONOMIC NET PRESENT VALUE (THOUSANDS OF DOLLARS)	MAIN BENEFITS
Cambodia: Rice husk gasification	76	17	8.0	• Time saving • Employment creation • Lower indoor air pollution
Kenya: Solar milk cooler (compared with diesel system)	40	17	11.9	• Avoided cost of diesel fuel • Reduced milk losses • Higher-quality milk • Lower greenhouse gas emissions
Kenya: Solar-powered water pumping for vegetables	650	51	960	• Reduced fuel costs • Lower greenhouse gas emissions • Time savings from pumping • Lower maintenance and labor requirements • Higher water use efficiency
Papua New Guinea: Solar-powered domestic rice processing	4.9	43	10.9	• Reduced time spent milling (women's workload) • Employment creation • Reduced fossil fuel use • Lower greenhouse gas emissions
Tanzania: Biogas-powered domestic milk chiller	1.6	92	7.5	• Reduced milk losses • Time savings from trips to milk delivery point • Lower greenhouse gas emissions • Employment creation

Source: Flammini and others 2018.

Note: Project performance indicators such as financial and economic net present value, internal rate of return, benefit–cost ratio, and payback time were calculated by applying discounting to their flows.

For larger electrification projects, the small number that have included cost-benefit analysis have shown the value of the productive use of electricity. For instance, Peru's FONER I project (2006–13) conducted an impact evaluation of the productive use of electricity component by comparing participating villages with a control group (Prisma, Macroconsult, and Instituto Cuanto 2016). In participating villages, household income rose 60 percent, net income for businesses increased 174 percent, and school attendance and literacy rates rose. Comparing these gains with the cost of the project ($2.8 million), the investment household businesses made in equipment ($14 million), and O&M and other costs reveals a positive economic net present value for all discount rates tested and an internal rate of return of 19 percent. In Indonesia, the utility company PLN's review of its rural business services program indicated that the “benefit (of increased sales) compensates the cost of the program incurred by PLN with a benefit-cost ratio of 1.29 and a payback period of 5.7 years” (Menelaws 1999).

Revenue benefits for electricity industry

By boosting energy consumption, the productive use of electricity can increase the revenue and financial viability of electricity suppliers. A report by Oxfam describes a virtuous cycle of higher nonpeak electricity demand and lower KWh costs, making electricity more affordable while increasing demand (Morrissey 2018). Assessments of relatively large anchor loads and smaller productive uses, including irrigation and cold storage, are often key factors in the sizing of decentralized renewable energy investments (Dalberg Global Development Advisors 2017).

Anchor loads are steady sources of electricity demand with reliable payment streams. Daytime anchor loads can complement the typical peaks of household demand during evening hours. New business use of electricity generally occurs during the day. With loads spread over the day and evening, investments in generation and the distribution lines and poles can be more cost effective. In Peru, the adoption of electricity by commercial enterprises raised their average electricity consumption from 56 KWh to 240 KWh per month (a 330 percent increase) (Prisma, Macroconsult, and Instituto Cuanto 2016).

Research confirms the potential of productive use of electricity to increase demand for mini-grid services. For instance, mills and pumping can make mini-grids more commercially viable, especially with asset utilization and demand profiles that fit their cost structures (CrossBoundary 2020). Credit is a proven measure for stimulating demand for electricity, boosting mini-grid revenue by as much as 18 percent. Electric water pumping and milling can shift demand-load profiles and cut the cost of mini-grid service by as much as 16 percent. A study by ESMAP (2019) calculates the levelized cost of electricity (LCOE) with and without productive uses (box C.1). The LCOE is an estimate of electricity costs based on initial outlays for equipment and installation, operations (such as staff and fuel), and equipment replacement over the lifetime of the mini-grid. Regulated electricity companies often use it to set tariffs. The costs depend on the system load, or the combined time and capacity of the mini-grid, which depends on the size of the system and how much of its capacity is used on a typical day. The LCOE works out to be equivalent to the minimum average tariff to cover project costs, typically expressed per kWh.

Increased sales of electricity for productive use can benefit suppliers (grid, mini-grids, off-grid solar). The question for suppliers is how to increase sales. Businesses have other options for running motors, usually diesel-based ones; whether they choose the mini-grid, grid service, or another technology depends on many competitive factors, all of which are variable, including price, reliability, and quality.

The productive use of electricity leads to significant benefits for new and existing business income, household income, and human welfare. Short-term benefits positive, and the value of programs compounds over time.

BOX C.1

HOW PRODUCTIVE-USE PROGRAMS LOWER THE COST OF MINI-GRID ELECTRICITY

Energy from mini-grids usually costs more than grid electricity in remote communities. It is used mostly after sunset, with the spare capacity unused during the day.

Productive daytime consumption can transform levelized costs. For the mini-grid systems modeled by ESMAP, productive uses reduce the levelized cost of electricity (table C.1.1).

TABLE C.1.1
Levelized cost of electricity in 2018, 2021, and 2030 at load factors of 22 and 44 percent

	LEVELIZED COST OF ELECTRICITY ($ PER KWH)		
Load factor (percent of system capacity used)	2018	2021	2030
22	0.55	0.38	0.29
40	0.42	0.28	0.20

Source: ESMAP 2019.

Note: Data for 2018 are for a "best-in-class" 294-kW solar-hybrid mini-grid in Bangladesh serving more than 1,000 customers (more than 5,000 people). Data for 2021 are based on a representative mini-grid synthesize from average costs and consumption levels in three mini-grids in Ethiopia, Myanmar, and Nigeria commissioned in 2020 and 2021. Data for 2030 are for a "best-in-class" mini-grid based on projected component costs that year.

Conservative assumptions estimate the additional productive-use load from commercial business and activities at a load factor of up to 40 percent. This additional load reduces the LCOE from $0.55/KWh to $0.42/KWh in 2018 (a 24 percent reduction) and from $0.38/KWh to $0.28/KWh in 2021 (a 26 percent reduction). Under the right circumstances, boosting the productive use of electricity in communities with mini grids could simultaneously cut the cost and perhaps even the price of electricity while providing economic benefits for the community.

Source: ESMAP 2019.

References

Asaduzzaman, M., Douglas F. Barnes, and Shahidur R. Khandker. 2009. *Restoring Balance: Bangladesh's Rural Energy Realities. Energy Sector Management Assistance Program (ESMAP) Energy and Poverty Special Report 006/09. Washington, DC: World Bank.*

Banerjee, Sudeshna, Avjeet Singh, and Hussain Samad. 2011. *Power and People: The Benefits of Renewable Energy in Nepal.* Washington, DC: World Bank.

Barnes, Douglas. 2014. *Electric Power for Rural Growth: How Electricity Affects Rural Life in Developing Countries.* New York: Routledge Press.

Barnes, Douglas, Hussain Samad, and Sudeshna Banerjee. 2014. "The Development Impact of Energy Access." *In Energy Poverty: Global Challenges and Local Solutions,* ed. Antoine Halff, Benjamin Sovacool, and Jon Rozhon, 54–76. Oxford: Oxford University Press.

Barnes, Douglas, Henry Peskin, Aleta Domdom, and Virginia Abiad. 2002. *Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits.* Washington, DC: World Bank.

Clark, Lauren. 2021. "Powering Households and Empowering Women: The Gendered Effects of Electrification in Sub-Saharan Africa." *Journal of Public & International Affairs.* https://jpia.princeton.edu/news/powering-households-and-empowering-women-gendered-effects-electrification-sub-saharan-africa.

ColdHubs. 2015. https://www.coldhubs.com/.

Crane, Keith, Brian Zuckerman, and Emma Thrift. 2020. *Powering Agriculture: Summative Evaluation.* https://pdf.usaid.gov/pdf_docs/PA00WPX1.pdf.

CrossBoundary 2020. *Milling on Mini-Grids: How Africa's Largest Crop Could Go Diesel-Free. Washington, DC.* CrossBoundary-Innovation-Lab-Off-Grid-Electric-Mills-Blog-Final-15-Apr-2020.pdf.

Dalberg Global Development Advisors. 2017. *Improving Access to Electricity through Decentralized Renewable Energy Policy: Analysis from India, Nigeria, Senegal and Uganda. Geneva: Dalberg Global Development Advisors.* Improving access to electricity through decentralized renewable energy - Dalberg.

Economic Consulting Associates, Ltd. 2022. *Integrating Demand Stimulation and Productive Uses of Electricity to Electrification Planning: A Practical Toolkit.* London. Background report prepared for the World Bank.

Ecozen Solutions. 2014. https://www.ecozensolutions.com/ecofrost.

Efficiency for Access Coalition, and 60 Decibels. 2019. *Uses and Benefits of Solar Water Pumps: Kenya, Tanzania and Uganda Consumer Research.* https://storage.googleapis.com/e4a-website-assets/Use-Benefits-SWP-Report_FINAL.pdf.

———. 2021. *Uses and Impacts of Solar Water Pumps: Insights from Kenya, Rwanda, Senegal, Tanzania, Uganda, Zambia.* https://storage.googleapis.com/e4a-website-assets/Use-and-Impacts-of-SWPs-July-2021-v2.pdf.

ESMAP (Energy Sector Management Assistance Program). 2019. *Minigrids for Half a Billion People: Market Outlook and Handbook for Decision Makers. Washington, DC: World Bank.* https://openknowledge.worldbank.org/handle/10986/31926.

Flammini, Alessandro, Stefania Bracco, Ralph Sims, Jeanette Cooke, and Agata Elia. 2018. *Costs and Benefits of Clean Energy Technologies in the Milk, Vegetable and Rice Value Chains. Rome: Food and Agricultural Organization (FAO).*

Khandker, Shahidur R., Douglas F. Barnes, and Hussain A. Samad. 2012. "The Welfare Impacts of Rural Electrification in Bangladesh." *Energy Journal* 33 (1): 187–206.

———. 2013. "Welfare Impacts of Rural Electrification: A Panel Data Analysis from Vietnam." *Economic Development and Cultural Change 61 (3): 659–92.*

Kulkarni, V.S., and D.F. Barnes 2017. "Education in Rural Peru: Exploring the Role of Household Electrification in the School Enrollment." *Journal of Research in Rural Education 32 (10)*: 1–19. https://www.researchgate.net/publication/326720542_Education_in_Rural_Peru_Exploring_the_Role_of_Household_Electrification_on_School_Enrollment.

Menelaws, R.D. 1999. "Best Practices Guide for Productive Use Marketing." PLN, Indonesia; World Bank, Washington, DC.

Morrissey, James. 2018. "Linking Electrification and Productive Use." Oxfam Research Backgrounder Series. https://ousweb-prodv2-shared-media.s3.amazonaws.com/media/documents/Electrification-Morrissey-final.pdf.

Naik, B.S., S. Patel, P. Ojasvi, H. Biswas, R. Dupal, P. Muniasamy, M. Ramesha, and K. Ravi. 2021. "Solar Pump with Drip Irrigation System for Enhancing Crop Yields and Farm Income in Semi-Arid Vertisols of South India: A Success Story." *Soil and Water Conservation Bulletin* 6, Indian Association of Soil and Water Conservationists, Uttarakhand.

Psacharopoulos, George, and Harry Anthony Patrinos. 2018. "Returns to Investment in Education: A Decennial Review of the Global Literature." *Education Economics* 26 (5): 445–58, Returns to Investment in Education: A Decennial Review of the Global Literature (worldbank.org).

Prisma, Macroconsult, and Instituto Cuanto. 2016. *Servicio de consultoría para la evaluación de resultados e impacto del Componente 3: Promoción de usos productivos de la electricidad*. Lima, Peru: Ministry of Energy and Mines.

Samad, Hussain A., and Fan Zhang. 2019. "Electrification and Women's Empowerment: Evidence from Rural India." Policy Research Working Paper WPS 8796, World Bank, Washington, DC.

Savanna Circuit Tech and UK Government (no date) "Savanna Circuit Technologies at Kenya Innovation Week." UK Government, Savanna Circuit Tech, Kenya Innovation Week: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://kenyainnovationweek.com/static/docs/savanna.pdf

Sovacool, B.K., S. Clarke, K. Johnson, M. Crafton, J. Eidsness, and D. Zoppo. 2013. "The Energy-Enterprise-Gender Nexus: Lessons from the Multifunctional Platform (MFP) in Mali." *Renewable Energy 50: 115–25).* https://doi.org/10.1016/j.renene.2012.06.024.

World Bank. 2013. *Peru: Rural Electrification Project. Implementation Status and Results Report. Washington, DC.*

———. 2014. *Mexico: Renewable Energy for Agriculture Project* Washington, DC. Mexico - Renewable Energy for Agriculture Project (worldbank.org).

———. 2019. "Promoting Rural Electrification in Peru." Results Briefs, May 13, Washington, DC. https://www.worldbank.org/en/results/2019/05/13/promoting-rural-electrification-in-peru#:~:text=Through%20distribution%20companies%2C%20Peru%20provided,systems%20installed%20in%20isolated%20areas.

World Bank Group. 2010. *Renewable Energy for Agriculture (2000–06*). Washington, DC.

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