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Microfinance and Energy Poverty: Findings from the Energy Links Project

Final Report to AED (now FHI 360) and USAID under the FIELD Project

CENTER FOR FINANCIAL INCLUSION AT ACCION INTERNATIONAL

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Microfinance and Energy Poverty: Findings from the Energy Links Project

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FINANCIAL INCLUSION
AT ACCION INTERNATIONAL

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Foreword

This report summarizes the results of the Energy Links project, a three-year pilot by the Center for Financial Inclusion at ACCION International, financed by USAID's Microenterprise Development Office (through AED's FIELD Project) and the Wallace Global Fund. Energy Links' aim was to determine how the established microfinance sector in African countries can alleviate energy poverty by increasing access to small-scale clean energy solutions at the household level.

The goals of this initiative were:

- To improve access to renewable energy for underserved populations
- To focus on the household level to address lighting and cooking needs
- To promote a financially sustainable approach that would last well beyond the project term, through innovative financing mechanisms to establish and grow the micro-energy sector.

The Energy Links Project began in late 2007 to investigate whether a broker among microfinance providers, clean energy providers and distributors, and people needing financial services could accelerate the access of rural households to modern energy. Energy Links initially looked at traditional microfinance institutions (MFIs) as the most likely financial partner but soon realized that to reach massive scale among the off-grid population the project should also look beyond them to organizations with deeper presence in rural areas and less overlap with those who are already connected to the electricity grid. This led to partnerships with nongovernmental organizations (NGOs) promoting savings groups (SGs).[1] However, the needs for clean energy are vast, involve many kinds of products and finance, and cannot be addressed by any single institutional type. As Energy Links continued, it pursued parallel initiatives, with some efforts focusing exclusively on MFIs and others exclusively on savings groups. Both of these complementary efforts are discussed below.

Energy Links also found that, in order to go beyond successful independent experiences with micro-energy, a sector-wide approach can be successful at building a critical mass of institutional capacity and putting the sector on the path to long-term viability. Through Energy Links we learned a great deal about energy use at the base of the pyramid, and ways to alleviate energy poverty. This paper is an effort to share what we have learned.

Acknowledgments

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1. Savings groups have been promoted by CARE as *Village Savings and Loan Associations* (VSLAs), by Oxfam as *Savings for Change* groups, by CRS as *Savings and Internal Lending Communities* (SILC), and by Aga Khan Foundation as *Community Based Savings Groups* (CBSGs). Much information about savings groups is available at Savings-Revolution.org.

Introduction

Access to energy is a driver of economic development and improved living conditions. It is well established that at the macro level the correlation between energy access and economic growth is high. At the micro level, energy is a fundamental daily need for low-income families who need energy to light their homes and cook their food. Children, families, and micro-entrepreneurs also need to work or study at night, to power machinery, to communicate by phone, and to access information. And yet low-income people tend to have limited access to energy, often from sources that are costly, time consuming, unhealthy, and environmentally destructive. Throughout the developing world, 1.4 billion people lack access to electricity in their homes and shops or workshops.[2] The potential benefits of better and more reliable energy sources are both economic and social. They affect dimensions of life from increased productivity to increased safety, improved health, and less environmental degradation.

The majority of African households purchase energy for two uses only: lighting and cooking. Energy Links focused on lighting, with a small foray into cooking. It worked on building the market for affordable and scalable lighting and, to a lesser extent, cooking in Uganda, Mali, and Tanzania. In Uganda it worked with portable solar lighting through both MFIs and savings groups, and it carried out a small pilot to introduce biomass briquettes as an alternative to firewood and charcoal. In Mali it focused on portable solar lighting in partnership with savings groups. In Tanzania it investigated the broader base of the pyramid (BOP) energy market and worked with an MFI to develop energy finance products.

We realized that the key to a successful program lies in understanding the energy needs of the target population: carefully selecting adequate products, adapting existing designs to serve clients better, and involving target communities. The project took an entrepreneurial approach to catalyzing the spread of solar lighting and, to some degree, biomass briquettes. Its activities ranged widely as needs were identified, always with the intent to help build functioning value chains. At various points, the project carried out small-scale market-acceptance tests of solar lanterns, experimented with delivery mechanisms, engaged in broad stakeholder consultations to spread knowledge of new possibilities, and assessed interest and capabilities of specific partners. It progressed to field research on various distribution models. At project end, the groundwork had been laid for scale. The first container loads carrying 20,000 lamps were entering Mali, and the connections were in place for this to continue with no further engagement from Energy Links. In Uganda, BASE Technologies, a subsidiary of Barefoot Power, has a vigorous sales program and has adopted savings groups as a principal sales channel. It is also attempting to spread the model to other countries, based on the experience in Uganda.

The focus of the project was on the financing and distribution of modern energy products through partnerships with MFIs and SG organizations. However, in order to make this work, it was also necessary to work at two other levels: first at the client level to understand demand, and second at the energy-SME (small and medium enterprise) level on issues relating to importing products and SME finance. Finally, the project was dedicated to sharing knowledge as it went along.

The Market for Clean Energy at the Base of the Pyramid

Despite public sector efforts to expand the electric grid, most people who are now off-grid will remain so. Projections are that from 1.4 billion off-grid worldwide today, the number will drop by no more than 15 percent by 2030. While the number of people without access to electricity in Asia will decrease from 800 to 550 million, Africa will actually become the largest off-grid market, growing from 590 to more than 650 million, as population grows over the next two decades.[3] In rural and remote areas of Africa, only 20 percent of the rural

2. UNDP/IEA. "Energy Poverty: How to Make Modern Energy Access Universal?" Special early excerpt of the *World Energy Outlook 2010* for the UN General Assembly on the Millennium Development Goals, September 2010. p. 7.
3. UNDP/IEA. "Energy Poverty: How to Make Modern Energy Access Universal?" Special early excerpt of the *World Energy Outlook 2010* for the UN General Assembly on the Millennium Development Goals, September 2010. p. 10.

population is connected to the grid, a figure not likely to change soon.[4] Under most credible scenarios, electricity will not be brought into the homes of millions of Africans during their lifetimes. This electricity gap constitutes a real and significant handicap for development in Africa, and the results in terms of health, safety, education, lifestyle, and household finances are significant (see Appendix 2).

At the same time, this widening gap presents a great opportunity for the development of a growing and potentially sustainable market for off-grid energy products and associated services for the population at the base of the pyramid. This is particularly true for lighting: With more than 1.7 million barrels of oil going daily into kerosene for lighting,[5] the global off-grid lighting market is larger than US$50 billion per year,[6] making it quite attractive for new market entrants. In focus groups conducted by Energy Links in Uganda and Mali, respondents typically reported spending as much as a quarter of their disposable income on lighting. This payment stream can be harnessed to finance more efficient lighting solutions that give users more value, while reducing both spending and energy consumption.

While the electric grid would still be the least expensive source of power for those who can afford to keep their homes bright for many hours in the evening, high hook-up costs, prohibitive monthly minimum charges, and above all lack of physical access means that there is no plausible scenario under which the grid can reach most rural Africans in the coming decades. In the meantime, innovative energy service providers have developed standalone solutions that can reap the benefits of modern energy—now at affordable prices. Energy generation appliances using solar and livestock biomass (or higher-efficiency devices using fossil fuels) are starting to reach points of price and quality that make them viable options for off-grid residents of Africa. Just as mobile phones spread rapidly across the continent, leapfrogging the need for landlines, the need and opportunity exist for off-grid energy. The stage is set for the rapid spread of solar lighting and other solutions.

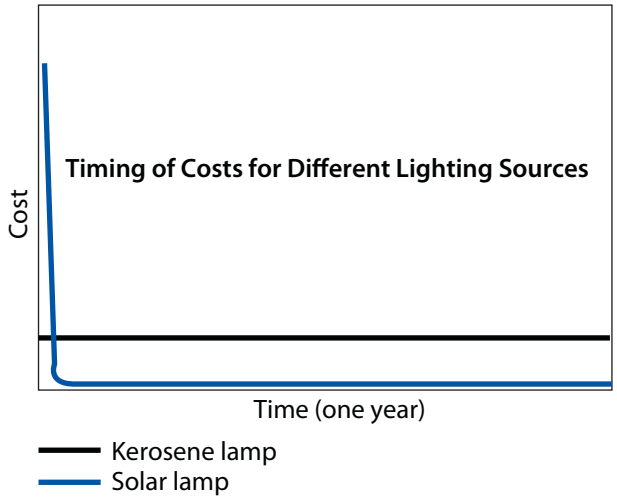
Or is it? While clean lighting and cooking solutions exist, they are not yet widely used, for multiple reasons on both the demand and supply side. Three top reasons include lack of awareness by potential buyers, poor distribution and financing channels, and the small capacity of the businesses, mostly SMEs, that produce and market these products. The Lighting Africa conference in May 2010 painted a surprisingly gloomy picture: 1.3 percent of off-grid families now have clean lighting, and present trends indicate that that percentage will increase only 2.3 percent by 2015. With a business-as-usual scenario from 2010 to 2015, the number of solar lanterns would increase from 500,000 to 2 million across the continent.[7]

The Energy Links Project entered this challenge with the idea that microfinance might be able to contribute to faster spread by contributing to distribution and financing. This idea was borne out; however, as the project proceeded, it found that this promise would only be realized once a range of additional issues were addressed.

There is an industry to be built, but it isn't going to build itself—at least not very fast.

Solar Lanterns: the Low-Hanging Fruit

Energy Links made several critical decisions early



4. Lighting Africa. "Solar Lighting for the Base of the Pyramid—Overview of an Emerging Market," 2010, figures 5 & 6.
5. Mills, Evan. "Global Lighting Energy Savings Potential." *Light & Engineering*. 2002. Vol. 10, No 4, pp. 5-10.
6. Calculations made with an average of $100 per barrel and 300 days per year.
7. Gaurav Gupta, et al. "Lighting Market Trends." Dalberg Associates, 2010, presentation at Lighting Africa Conference, Nairobi, Kenya, May 2010.

on, none more important than the choice to focus (not exclusively, but mainly) on *portable solar lanterns*. Solar lamps are the low-hanging fruit of clean energy products.

In order to light their homes and execute nightly tasks like studying, commerce, or household chores, many people, especially in Africa, use poor-quality lamps powered by kerosene or related fuels. The solar alternative is attractive because for lighting, unlike cooking, many people are dissatisfied with their current sources. While it is often difficult for people to adapt to new ways of cooking, improved lighting brings unambiguous benefits without the need for significant lifestyle changes (see Appendix 2).

The choice of solar lanterns, rather than solar home systems, resulted from the recognition that small solar lamps are a direct substitute for the ubiquitous kerosene lamps that are for many people the only source of light. Moreover, if purchasing costs are amortized across the product's lifetime, they are as cheap or cheaper than kerosene lamps. Thus, it seemed likely that demand for these devices would be easy to generate.

In Uganda, for example, only 4 percent of rural households had electricity as of 2005. Most rural households (79 percent) reported using an open-flame kerosene candle for lighting, while another 12 percent used a kerosene lantern with a glass chimney. The remaining 5 percent used a variety of lighting devices, from solar to firewood, or had no light at all.[8] But kerosene lamps give off soot and smoke. The indoor air pollution they create contributes to respiratory illnesses. They are also a source of fires, when open flames occasionally touch mosquito nets or grass roofs. If they tip and spill, they can cause burns. Finally, their light is barely adequate for reading or studying, a high priority for Ugandan parents who want to see their children do well in school.

In other words, because of poor lighting quality and secondary effects, families don't like traditional lighting sources. They would be willing to switch to new and promising technologies, if offered affordable alternatives. Energy Links learned this at the start of the project through informal interviews and focus groups with rural families, and it was an insight that proved sound as the project proceeded.

Until recently, solar lighting was too expensive to be a real alternative to kerosene for poor rural households. Lighting a home with solar energy required large rooftop panels, a lead acid battery as large as an automobile battery (but more expensive because it would be designed to withstand daily charging and discharging), and various regulators, transformers, switches, and cables. Even the least expensive solar home systems cost hundreds of dollars and incurred risk such as theft, misuse, failure, and lack of maintenance. A few microfinance institutions in Africa provided dedicated loans for such systems. However, only a few clients could quickly offset the high up-front costs of these systems, and thus the loans required were larger and longer-term than comfortable for either the MFIs or their clients.[9] Moreover, solar home systems required teams to install and maintain. Costs of operating a servicing infrastructure for sparsely populated areas were prohibitive.

The prospects for success began to change when a number of start-up energy companies developed solar

Solar Home System Installation

8. Uganda National Household Survey 2005–2006, Uganda Bureau of Statistics.

9. This conclusion is based in part on an interview with Robert Lule, Finca Uganda employee in charge of solar program at Finca Uganda, 23 March 2008. In its first three years of selling solar home systems, Finca sold about 150 systems. The company has since revised its financing and product lines, and sales have increased, but remain relatively modest. Interviews with the manager of Horonya in Mali, which until the arrival of Energy Links sold large installations, echo this experience.

products with the low-income market in mind, using an important technological breakthrough, inexpensive light-emitting diodes (LEDs). LEDs turn almost all of the energy they use into light. They use so little electricity that they require only a small battery, and the small battery in turn needs only a small solar panel. Engineers saw the possibility of making stand-alone lamps, purpose-built for conditions in the developing world. A number of small start-up companies, including Barefoot Power, d-Light Design, Greenlight Energy, Nuru, and ToughStuff, offer small solar-powered devices ranging from a lantern with a less-than-one-watt panel to larger solar home systems with 5- to 10-watt panels that can support a few light bulbs and charge cell phones.

With technological progress in East Asia, where most such devices are manufactured, these products constantly gain in performance while becoming cheaper. As of 2011, retail prices range from under $10 for the simplest lanterns to $100 for a very basic solar home system. Solar lanterns are rapidly becoming more desirable. While kerosene prices are on the rise, costs of solar lamps are falling, and quality is improving. Compared to just two years ago, today's lamps are significantly brighter and longer-lasting at the same price. And this trend is expected to continue.

Moreover, because they are portable, no installation is required, and maintenance can be carried out in rural workshops, not necessarily at a customer's home. As a general rule, anyone who can repair a mobile phone can repair a solar lamp, if he or she has the needed replacement parts. The rural phone repair industry has grown quickly in Africa, which could aid the spread of solar lanterns.

Solar Lamp

The products exist and the market is there. The challenge resides in reaching the dispersed, untapped market and bringing devices and financing solutions directly into the hands of the people who need them and can and will pay for them. Various market constraints, catalogued by Energy Links and others, are making adoption slower than it should be.

Solar Exceptionalism: The Attractions for Microfinance and Savings Groups

Microfinance institutions and savings group promoters that reach many off-grid clients may wish to become promoters of micro-energy solutions and, if so, they may wish to start with solar lighting.

- *Savings*. Energy-efficient devices are not like traditional consumer goods: switching away from kerosene to these clean devices actually generates savings—a "solar dividend." In the market research conducted with Energy Links at Finca Tanzania, the number one reason microfinance clients gave for purchasing a clean energy system was to save money. Many clients feel they are too poor to save. And yet, they may be spending $60 per year on kerosene and $120 per year on wood or charcoal. Energy Links measured a similar range in Mali, where households spend an average of $80 per year on kerosene for lighting. These costs increase as deforestation spreads and petroleum prices spike unpredictably. By switching to clean energy devices, such households can save half or more of this expenditure.

  For microfinance, a reduced energy bill creates an opportunity for client savings in an account or group. MFIs or savings group promoters that market an energy product in conjunction with a savings program can incentivize savings. Since MFI clients typically start to save money within a few weeks or months of taking an energy loan, quite a bit of capital can be unlocked through savings. For example, when developing its business model for energy loans, Finca Tanzania decided to couple the loans with a dedicated savings account to sensitize the population and promote the deposit of the expenditures saved.
- *Credit and Payments*. The acquisition cost of solar technology is high relative to kerosene, although

the total cost of ownership is lower over three to six months. Even affordable solar lanterns require an up-front payment that families cannot always afford. Therefore, buyers need to accumulate lump sums for their purchase. Savings groups allow members to save and borrow the small amounts needed for lamp acquisition, while MFIs can assist with loans or cash transfers from relatives.

- *Mobile Banking.* Small solar lanterns—and of course larger systems—can be used to charge cell phones, a currently expensive and often time-consuming activity, since it requires going to a phone-charging shop, sometimes in another village, and paying a fee per charge. Solar devices above a certain power often include phone-charging outlets, thus decreasing the cost of phone ownership and allowing for increased usage, and often providing an additional source of income: charging other people's phones for a fee. This phone-charging capacity also indirectly supports the development of mobile banking.
- *Financial Education.* Education programs could discuss the solar dividend, i.e., the savings generated by displacing kerosene or other expenditures, as a doorway to broader financial literacy topics.
- *Client Well-Being and Risk Mitigation*. A client switching to solar may reduce risk and become more prosperous, starting with the health benefits from reducing routine smoke inhalation. In addition, access to light in the evening supports education and can increase productivity by enabling work at night.

Of course, pursuing these opportunities requires a strategic decision from an MFI's or NGO's management, followed by identification of adequate products and careful program design, piloting, and roll-out. Product design and marketing are of course unique to a specific situation and population, but lessons from one area can be adjusted for another through experimentation. All this requires a significant initial investment, but prospects are good that a viable operation will result.

What Is the Role of MFIs and Savings Groups in Increasing Access to Energy?

There are several bottlenecks to developing the market for clean energy devices in rural areas. These include educating clients about the benefits and availability of clean energy products, making the products physically available, financing product purchases, and ensuring customer service. Networks of savings groups, and some MFIs, can bridge that gap. They are in an ideal position to undertake this when:

- They have wide outreach in rural areas, often more than any other distribution channel
- They hold a position of trust with families and communities
- They offer access to the financial tools that facilitate acquisition of new technologies (e.g., credit and savings)
- They have a broad mandate to improve the lives of their members or clients, and find that clean lighting contributes to that mission.

It is crucial to understand more precisely what MFIs and savings groups are best suited for in order to leverage them effectively. There are many possible financial needs to address in creating an off-grid modern energy industry, but MFIs and savings groups are not necessarily the best providers for all of them. At the same time, the ongoing regular contact with millions of households at the base of the pyramid offered by MFIs and savings group promoters represents a possibly unparalleled distribution opportunity.

Energy Links used the definitions in Table 1, below, to help classify energy use at the base of the pyramid, and from that starting point to categorize the types and sources of financing needed. The first four rows of the table address demand-side finance, while the last row addresses the supply side.

In the off-grid areas of Africa, the biggest demand is for products at the first level—basic household energy. These products are suited to all but the very lowest-income households in the rural areas, 90 percent of which are off-grid, and may also be purchased by better-off households in urban and peri-urban areas. This is especially true in areas of frequent electricity blackouts (consider the June 2011 electricity riots in Senegal). Energy Links chose to focus its action on the most basic energy needs. As the table notes, MFIs and savings groups are both relevant financing sources for devices at this level, but Energy Links found that savings group networks were often in a better position

Table 1. The Micro-Energy Sector: Levels of Usage, Products, Costs, and Financing

Market Level	Needs and Types of Systems	Costs and Financing	Finance Providers
Basic Domestic (0.3 to 5 watts in the case of lighting)	Lighting and (increasingly) cell phone charging Portable solar lanterns for task lighting with chargers Improved stoves	$10 to $60 Direct purchase by users Savings Microloans ROSCAs	Savings groups MFIs
Convenience and Home Improvement (5 to 100 watts)	Room light in the house, radio, TV Fixed panel solar home systems Solar water heaters Biogas digesters	$100 to $1,000 Savings Microloans	MFIs
Productive Energy (100 watts to 5 kilowatts)	Longer working hours, new products, faster/better production Even basic packages can improve productivity (through work after dark). Machinery (e.g., refrigerators, water pumps) requires more power Large solar home systems, larger biogas systems, solar water pumps	$1,000 to $10,000 Microenterprise loans Fixed-asset loans Leasing	MFIs Banks
Community Energy (over 5 kilowatts)	Microgrids at the village or multiple-village level allow households to tap into a common generation source Community services: water pumping or street lighting. Microhydro, solar or wind farm, biodiesel	Larger, longer-term project finance Utility payments	Banks Large established MFIs may be able to make such loans, especially if they set up specialized units. MFIs can also establish utility payment schemes to allow connection fees to be repaid periodically
Energy SME (the providers)	SMEs supply energy devices: manufacturers, importers, and distributors Microfranchising/Microconsignment	Equity Working capital Fixed-asset loans Import-export loans	MFIs can finance microfranchising and very small producers or distributors Most energy SMEs will require banks as partners

than MFIs to facilitate access to energy for the rural population as their outreach spreads wider and faster. Savings groups are made up of people (usually women) who come together to save and borrow. Savings groups are promoted by NGOs such as CARE, Oxfam, and others, generally with grant financing. Because savings groups reach deep into rural areas, a large percentage of their members come from off-grid, very low-income families. Savings group networks have regular contact with millions of families. There are now about 4 million savings group members in Africa alone and their expansion is rapid, with targets for membership in the tens of millions for 2020.[10]

The NGOs that promote savings groups see themselves primarily as promoting and enabling members

10. As reported on the Savings Group Information Exchange website, April 2011. http://savingsgroups.com.

to do something for themselves, rather than as service providers; thus, a model involving direct purchase of lamps (rather than loan financing) is possibly more compatible for them than it is for MFIs. The promoting NGOs do not participate in the financial transactions, but they do employ networks of community-based trainers (also called village agents) who assist in forming and monitoring the groups. Groups often stay in regular contact with their village agents, creating an opportunity for agents to educate members about clean energy products, assist them in identifying suitable products, and even distribute or sell the products. As Energy Links proceeded, it deepened its focus on savings groups, while continuing to connect with MFIs.

MFIs provide financial services, primarily loans, on a fully or largely financially sustainable basis. They may be NGOs, finance companies, or banks. Given that their core product is credit, they are best suited for the levels at which loan financing is an essential aspect of the system. This is why the first product most MFIs have explored is a solar home system financed with a microloan. Many of the micro-entrepreneurs that MFIs fund see solar home systems as an investment opportunity that will increase their production. MFIs also tend to be based around cities and market towns, so many of their existing clients are on-grid, although energy could be a way to connect with a pool of potential new clients in the close peri-urban areas. MFIs are also highly varied in scale and competence. The stronger MFIs that are regulated banks and finance companies can address a wider range of energy finance needs, even financing some small businesses that may play some role in the energy value chain, e.g., a provincial distributor or maintenance company.

Neither MFIs nor savings groups are the best partners for community-based energy. The required financing is too large and too highly tailored to be compatible with microfinance business models. Energy Links did not get involved at this level, though utility payment services and connection loans could be of interest to MFIs and their clients, as provided, for example, by Akiba Commercial Bank, a microfinance bank in Tanzania.[11]

11. See announcement of Akiba Commercial Bank's electricity loan product at http://allafrica.com/stories/201106070253.html.

At the energy SME level, however, involvement by Energy Links was unavoidable, even though this did not involve microfinance to any great extent. The supply chain for energy devices simply did not exist when Energy Links began. If products were to be brought to low-income households, the value chain would have to be built and supply-side financing needs would have to be met. The financing needs of this value chain are varied and require the support of a range of financial services providers—banks and others. The role of microfinance at this level is limited (though relevant for certain types of distributed models like microfranchising). Energy Links' experience with the financing needs of energy SMEs is treated below in the section on the broker role.

The next sections examine the elements leading to success with energy access through MFIs, and then through savings groups.

Engaging MFIs to Facilitate Access to Energy

Many MFIs recognize the need for their communities to improve access to energy and the consequences of fossil fuels or lack of lighting on their customers' health, environment, and economic opportunities. However, as financially sustainable enterprises, MFIs need a strong business case before they begin to lend for clean energy, and clean energy must align with their strategic direction.

Energy products can be a good strategic fit for MFIs seeking to grow in both urban and rural areas. In urban areas, MFIs face increasing competition. Clients may be attracted to MFIs that offer distinctive and relevant products and educational programs such as energy loans or energy retailer trainings. In addition, energy loans can deepen the level of engagement of existing clients in areas where competition makes it hard to attract new clients.

In rural areas, higher expenses and smaller loan portfolios mean that MFIs are constantly searching for high efficiency and improved capacity utilization. A rural MFI can build its client base by offering energy-related financial products; although not all households have businesses that need working capital, all households need energy access. And MFIs should be

attracted to a credit scheme that is self-repaying as a result of automatically generated energy savings. With energy savings programs, potential clients may start by opening a savings account, buy the energy product, and eventually enjoy other benefits of being "banked" such as the ability to take working capital loans for small businesses.

In building a viable business model, factors that need to be in place include:

- Sufficient market demand from clients (demonstrated by market studies)
- Financially sustainable returns (from interest, fees, supplier margin, and/or carbon credits)
- Institutional and operational capacity (knowledge and staff) to manage an energy program at head office and branch levels.

The Energy Links team provided technical assistance to develop business models and financial products that are being implemented in Tanzania and Uganda by MFIs today.

In Tanzania, Energy Links worked with a range of MFIs and found that most of them were interested in energy lending, but lacked the market studies, business plan, and trained human resources necessary to start them. In addition, there was a difference in the strategic imperative or urgency with which they were interested in pursuing energy. Most MFIs claimed interest in the medium to long term but nevertheless focused on their core business (working capital loans), particularly in response to growth pressure from funders. They also perceive risks associated with energy products. Energy Links worked intensively with one MFI, *Finca Tanzania,* to complete a market demand study. Based on the results, *Finca Tanzania* developed a full-fledged business plan and will launch its program in late 2011.

Specifically, MFIs were interested in offering the following energy-linked products:

1. *Microenterprise energy loan.* A dedicated loan product enabling new customers to purchase clean energy devices that allow them to expand their businesses or reduce costs.
2. *Home improvement energy loan.* An add-on loan product for existing clients who decide to improve their home by purchasing energy products. Savings from the displacement of kerosene or charcoal provides a source of repayment capacity. The loan term and interest are tailored to the actual savings generated from switching to modern energy solutions.
3. *Energy-linked savings account.* A product that incentivizes savings by illustrating how much clients can save by switching from traditional lighting and cooking sources. This product can serve both existing clients of the MFI and new client households, giving them a bank account for the first time.
4. *Energy retailer (microfranchise) loan.* A loan enabling micro-entrepreneurs to begin retailing energy products to their communities and become the *last* last-mile distributors for clean energy products. Sometimes, these small retailers already have stores, and simply buy inventory to expand into solar lanterns or efficient cookstoves. MFIs offering these loans could help link the best microretailers with the larger energy product distributors. Often these distributors are challenged to find and evaluate trustworthy, high-potential retailers in rural areas. MFIs can support and accompany these retailers through a microfranchising or microconsignment model.
5. *Carbon Credits.* As an additional income stream to make provision of such products economically viable, it is increasingly possible for an MFI to access the voluntary carbon markets and leverage carbon finance through MicroEnergy Credits (MEC) or other buyers of carbon credits (see below).[12]

MFIs benefit from providing energy loans and savings accounts by strengthening their reputation *vis à vis* donors and socially responsible investors as well as their clients. Their products can support the financial bottom line by attracting new customers and increasing loan portfolio with a limited exposure to credit risk, since clean energy devices pay for themselves over time. In addition, energy systems may subsequently serve as a form of collateral, increasing the future credit available to households.

12. http://www.microenergycredits.com.

Overcoming Challenges Associated with Clean Energy at MFIs

MFI involvement in the provision of modern energy services can be sound business, but MFIs are often reluctant to diversify beyond basic micro-enterprise credit. Energy finance is not a core competency of most MFIs, and the barriers to entry, though seemingly minor, have in fact limited MFI participation in the sector.

Some barriers are external: an unsupportive policy environment (as in India, where kerosene is heavily subsidized by government, or in African countries that have high import duties on foreign-made technologies), or a lack of capable energy companies to partner with. Others are internal. MFIs need to learn about the energy sector in order to select an appropriate energy partner and formulate a successful financial product. They may need to develop a special cadre of energy officers who assist clients in matching system choices with their needs and ability to repay. They may need to go through a period of testing and fine-tuning before they get the product and delivery right. All of this is expensive and requires scarce senior management time and attention. As a result, many energy microlending programs historically have been small and donor dependent.

Among the specific challenges some MFIs have encountered are the following:

- *Energy company limitations.* Nascent energy companies unable to provide sufficient quality, customer service, and steady product supply. Finca Uganda's first foray into solar home systems encountered these problems, given that the energy providers in Uganda at that point were quite nascent.
- *Clients unwilling to invest.* Especially with technical products that require a high initial investment, such as solar home systems, there was a lack of customer awareness of how the product functioned and what the potential benefits were from using the product.
- *Staff inability to market energy products.* There is often a lack of internal organizational capacity and incentives to market renewable energy products and recommend appropriate products to clients.
- *Term mismatch.* In the absence of tailored energy products, there can be a mismatch among the loan term, the repayment requirement, and the repayment capacity.

Successful models, while tailored to local communities and contexts, exhibit the following core characteristics:

- *The right products*. Careful selection of the products that clients want and can afford determined the success or failure of a program. An inadequate device can hurt the MFI, its reputation, and the market for clean energy devices. This requires (a) spending time discussing energy use with clients, (b) getting educated about the range of products on the market and their performance (e.g., life span, maintenance, failure rates), (c) doing some simple financial modeling of affordability, and (d) testing the acceptance and use of selected products with client families. When Energy Links applied this process in Uganda, it led to the selection of small solar lanterns as the product of choice, because of its ability to substitute for kerosene lanterns.
- *The right partners*. MFIs must carry out due diligence on the companies that supply energy products, given that many of them are small, fledgling efforts. They must assure themselves that the company has the management capability, systems, and financial standing to deliver the product at an acceptable quality standard, at an agreed-on time, location, and price. Maintenance and installation capability are key considerations. In many cases, these elements are missing, which is one area where Energy Links' brokering role came in. Energy Links partnered with Barefoot Power, at the time the most promising supplier in Uganda, even though not all the required capabilities were in place. Much of the project's effort was devoted to addressing value chain gaps (see section on the broker role). MFIs can help energy companies solve some issues, particularly finance for the end users, marketing, distribution, and understanding of client needs. Indeed, this is the reason such partnerships make sense. However, other gaps are beyond the scope of MFIs to resolve.
- *Clear agreements with partners*. Memoranda of understanding (MOU) or contracts between

MFIs and energy suppliers must spell out clearly the roles and responsibilities of the arrangement, with the starting point for collaboration based on common interests and objectives. For example, the MOU might obligate the energy company to install systems within a specified time after loan approval. It would spell out the commitments related to after-sales servicing, maintenance, and problem resolution. Energy Links developed MOUs among its partners that governed the relationships.

- *A strong distribution team*. The core challenge is to create a sales force that connects with clients and provides the product, financing, and servicing. These functions do not have to be performed by the same person or even organization; a variety of effective models have succeeded. Grameen Bank created a separate company, Grameen Shakti, as both energy supplier and lender with its own staff of loan officers. Similarly, an Indian solar power company, SELCO, integrated microlending into its activities in order to support sales and address a financing gap in the value chain.[13] Another possibility is for the MFI to develop a specialized loan officer cadre trained in energy products. FINCA Uganda, for example, created energy officer positions within the MFIs, responsible for educating customers and arranging financing. A third possibility is to train standard loan officers to offer energy loans, relying on energy company representatives for other functions. As discussed in the section on savings groups, CARE is experimenting with this last model: Its village agents will double as energy distributors.
- *Marketing and education about new products*. Clients may need education to use new energy products successfully, particularly in the early days. It is essential that early users have a successful experience, as rejection of a product or product failure, even if the result of client error, will ripple through a community. Solar lighting is relatively easy to use, but cooking changes are more difficult to promote, given the deep cultural associations with food preparation.
- *A viable business model, subsidies for initial set-up*. It should be possible for the sale, financing, and servicing of energy products to be a profitable business model for both energy company and MFI, after initial learning and set-up costs have been paid. Indeed, this is absolutely necessary if scale and permanence are to be reached. However, in much the same way that subsidies were used to establish many MFIs, subsidies are appropriate to finance the heavy initial investment in learning necessary to create scalable energy financing and distribution operations.

Savings Groups and Micro-Energy

Energy Links made a decision to focus most of its effort on outreach through savings groups, largely because of their prevalence in off-grid rural areas. These community groups provide very simple financial services to their members. They offer a set of refinements to the traditional models of accumulating savings and loan associations (ASCAs) that are already widespread in many areas around the world. The procedures have been somewhat standardized and are being propagated by international and local NGOs. Typically, groups are composed of 15 to 30 self-selected individuals, mainly women, who meet weekly or fortnightly to save, borrow, and often provide basic insurance services by creating a separate "social fund."

Savings groups have been spreading all over Africa in the past few years, primarily through the efforts of local NGOs working in collaboration with international NGO partners. The international NGO channels donor funds and technical support to its local partner to promote groups through a network of agents. The agents help communities to form and train groups. They work intensively with their groups at first, gradually tapering off to an intermittent monitoring role as groups gain know-how and confidence.

Energy Links worked with the promoting NGOs to involve these agents in the distribution of solar lanterns. CARE is currently leveraging savings group networks as a platform for energy product distribution in Uganda, Kenya, and Rwanda. Energy Links helped link an importer of solar lamps to two of

13. For more on Grameen Shakti and SELCO, India, see Alex Counts, "Towards Reinventing Microfinance Through Solving the 'Last Mile Problem': Bringing Clean Energy Solutions and Actionable Information to the Poor." Microcredit Summit Campaign, 2011.

CARE's local partners in Uganda; introduced lamps to a local entrepreneur forming SGs for CARE in western Kenya; and created an importation and distribution network in Mali involving both Oxfam and CARE savings groups. The lead Energy Links consultant, Paul Rippey, is drawing on the Energy Links experience to assist CARE Rwanda in what is hoped will become a massive effort to replace kerosene in Rwandan rural households. Energy Links also worked closely with Uganda Women's Effort to Save Orphans (UWESO), a Ugandan NGO, on solar lanterns and biomass briquettes.

The relevance of savings groups is that a huge proportion of their members are off-grid families in rural areas who are the prime clients for the smallest solar lighting devices. Whereas few MFIs have a primarily off-grid clientele, savings groups provide an excellent distribution channel with potential to reach millions of potential clients. Few other channels exist to reach people in this population segment. Moreover, savings groups' members have access to personal savings and group credit, which they can use to finance their purchase of solar lamps. Finally, savings groups and their communities trust their village agents and their promoting NGO, which helps the penetration of an unfamiliar technology in a new market.

In an effort to understand the utility of savings groups, Energy Links conducted a study (co-funded with Aga Khan Foundation) of group members who had purchased lamps through two programs in Uganda, UWESO and Community Organisation for Rural Enterprise Activity Management (CREAM), both partners of CARE.[14]

The group members revealed that they used a variety of funding mechanisms to purchase solar lamps, including cash out of pocket, loans from the group, and funds from the group's annual share-out. Researchers also found two unexpected financing methods: loans from the group's social fund and the creation of a rotating savings and credit association (ROSCA) within the group dedicated to having each member buy a lamp. The focus groups did not provide a large enough sample to determine the most common financing method; however, discussions strongly suggested that many lamp sales to men were done on a simple cash basis, and that the ROSCA was an excellent method of assuring that all group members acquired lamps. Similar innovative funding mechanisms were identified in Mali by the Energy Links team, during a field visit among savings groups organized by CAEB,[15] a local NGO and Oxfam partner.

Savings group promoters like CARE and Oxfam can benefit from a partnership with an energy provider: It helps advance their social mission and strengthens the reputation of their programs. Selling energy products can also help to retain the cadre of village agents on which the programs rely. Adding sale of energy products to an agent's responsibilities can generate an income stream that provides an incentive for field staff to continue visiting rural areas and forming new groups once donor funding ends. Savings groups networks are in an ideal position to become a distribution channel for introducing these new products as they have the trust of their members and can ensure them of their support in case of technical issues.

Developing the Supply Chain for Solar Lanterns

In the countries in which Energy Links has worked, the importers of clean energy products are small to medium-size local firms that have concentrated on solar home systems and that typically earn much of their income from installation of roof panels and systems or from donor-funded projects. While interested in rural bottom-of-the-pyramid markets, they have little idea how to reach that market and—after some initial skepticism—have welcomed Energy Links' introduction to rural networks.

In the past three years Energy Links has worked to understand the value chain for solar lanterns in East and West Africa, and has contributed to strengthening this chain at two points, as will be seen below. The model that emerged covered the entire value chain, from the factory in China to the end user in

14. Rippey, Paul, and Candace Nelson. "Marketing Solar Lamps through Savings Groups: Emerging Lessons from Uganda." Aga Khan Foundation, (forthcoming).

15. CAEB stands for Conseil et Appui pour l'Education à la Base.

rural Africa. The challenges were often circular: For instance, there is no consumer demand because there are no distributors in place. There are no distributors because consumers are not aware of the technologies or have experienced poorly constructed products. Energy Links worked primarily with Barefoot Power, a young Australian company rapidly building its capability to deliver in Africa and at the same time continually improving its products.[16] A simplified supply chain looks like this:

1. Products developed, tested and upgraded in Barefoot Power's labs
2. Manufacturing contracts with producers in China
3. Product shipping by air freight or sea container to Uganda, Mali, or other location
4. Importation and warehousing of products by local importer
5. Distribution up-country by local partner or a separate entity
6. Savings group sales and distribution by field staff of savings group project
7. Post-sale servicing and problem resolution.

Bottlenecks could occur at any point. Energy Links was involved in these steps in the following ways:

- Delivered user feedback to Barefoot for product upgrading.
- Secured assured market orders from MFIs and NGOs that were needed in order to place wholesale container orders. Overcame the initial chicken-and-egg problem of lack of demand because of lack of exposure and available supply.
- In Uganda, shortly after Energy Links began, Barefoot Power decided to create a local subsidiary to act as importer. In Mali, Energy Links worked to identify a company that was capable and willing to become the importer. In both cases, ability to navigate the customs process was essential.
- In Mali, also identified and helped build a local firm that is now working with the importer to distribute lamps.
- Importers must develop the capabilities to carry out the logistical functions, including inventory and accounting controls. Energy Links provided some advice in these areas.
- Brokered arrangements between Barefoot Power and MFIs and savings groups and NGO partners and organized market research, including product acceptance testing.
- Provided limited advising on quality control and client acceptance issues.

Financing is needed to grease the wheels at each of these steps, particularly at the early stage when little revenue is being generated. At the time Energy Links was working with Barefoot Power, it was actively seeking (and ultimately secured) equity financing from international social investors to grow its base operations. Energy Links worked with Calmeadow to help secure $250,000 of this financing. As a result, Barefoot Power created a Trade Finance Fund, managed by Oikocredit, to make it easier for local firms and MFIs to import lamps. The importer in Mali used this fund to cover 50 percent of the cost of the first container load of lamps.

In Mali, the local importer had a small network of retail stores in the interior of the country, but no means of reaching the widely scattered villages in that vast Sahelian country, so Energy Links provided encouragement, technical assistance, and a working capital grant of $7,000 to a local entrepreneur with contacts with two different savings group networks—those of Oxfam and CARE. The entrepreneur is buying lamps from the importer at near-wholesale prices, and then reselling through trainers and other channels to savings group members.

In fact, the experience of Energy Links showed that while there are common principles that are widely applicable in selling lamps through savings groups, structures will have to be tailored to each country and each program. Some of the principles that we believe apply in every country are these:

- The various actors need to get to know each other. Confidence engenders commerce. Holding a

16. Energy Links was generally favorably impressed with the quality of products and business ethics of Barefoot Power, and this confidence was reinforced when Barefoot Power won three of the four first prizes in the Lighting Africa Outstanding Product competition, awarded by the World Bank/IFC Lighting Africa Program in Nairobi in 2010. However, Energy Links did not endorse any particular product, and recommended to its partners only that they acquire the products best suited to their clients' needs and that promise the best quality/cost ratio.

roundtable discussion with the decision makers present was an excellent early step in entering a new country. People from the NGO world and from the business world frequently misunderstand each other and underestimate how much they have in common.

- It is essential to have a visionary champion who will keep the partners working together for common goals. Solar lamps are not likely to be the first priority of either NGOs or private concerns, and without a champion, lamps may fall off the back of the desk of busy people. Finding champions involves a bit of luck. In the case of CREAM in Uganda, the executive director showed a deep understanding for and commitment to the solar lamp market. In Mali, Energy Links was lucky to identify N'tyo Traoré, an experienced consultant who had a broad network in Mali of potential buyers and resellers of lamps. Traoré was described by other partners as "tireless" in his promotion of solar lighting.
- Solar lamps need neither huge mark-ups nor subsidy. Rather, they need enough mark-up that sales people are motivated to sell more. Solar lamp distributors vary widely in their practices, with some recommending a retail price almost twice the price in the capital city, while others scramble to find donor and contributor subsidies to knock the price down. Energy Links found that a margin of around $1 per lamp or $2 per solar kit (two lamps and a phone charger, priced at between $18 and $25) for the final retailer salesperson was a good place to start in developing an incentive structure.
- Lamps sell themselves. The hardest sales were the first one in a village; after that, people began to want their own. Energy Links suggested that early buyers talk about their experience with the lamp with their neighbors.
- There is a strong tendency to neglect putting a maintenance structure in place, but it is a serious mistake not to do so. The lamps are, after all, an inexpensive product made in China, and a certain percentage of lamps are bound to fail. Barefoot Power estimated that 3 percent of any order will fail during the guarantee period (six months for the lamp, one year for the panel). Many repairs are simple and can be carried out by local repair people, often those who already repair mobile phones. Suppliers of lamps are not highly motivated to sell spare parts, since they are low-margin items, but a lamp failure means a dissatisfied customer and can quickly contaminate the brand. Building an after-sale support network also allows for collection and recycling of used batteries—through small financial incentives—to avoid more batteries being discarded randomly, contaminating land and water, as the number of these products increases exponentially in the coming decade.
- Phone charging is the "killer app" for solar lamps. While everyone wants clean lighting, people want phone charging even more, including those for whom charging phones is an additional source of revenue. And if most women claim they purchase solar lanterns for the clean and efficient light they provide, their husbands see phone charging as the main benefit.
- Simplicity in the product line is a virtue, at least at first, as is the case for many start-up companies. Offering a single product meant fewer problems with stock and less confusion for the buyer. The strategy was to ensure that the introductory product would suit more than half of potential customers. Additional products, both above and below in terms of value and cost, were introduced later.
- Groups can figure out on their own how to finance lamps. They are ingenious, and if they want lamps, they will find a way to buy them.

While these principles are probably applicable in most countries and programs, the actual structure and incentives that link the capital city and the villages where savings groups meet depend on many factors, including the capacity and infrastructure of the importer, the willingness of the NGO partner to get involved in direct management of lamp sales, the interest of the NGO partner in promoting lamp sales as an additional source of income for their trainers, and the accessibility of groups.

Table 2 shows the sales and distribution structures that Energy Links staff encountered.

Accessing the Carbon Markets. A final link in the financing chain, increasingly available for micro-energy projects, is the carbon market, which can provide incremental funding based on the amount

Table 2. Sales and Distributions Structures among Energy Links Partners

	UGANDA UWESO	UGANDA CREAM	MALI	KENYA	RWANDA
Importer	BASE Technologies (subsidiary of Barefoot Power)	BASE Technologies, a subsidiary of Barefoot Power	HORONYA (Malian firm dealing in solar since 1996)	Smart Solar (subsidiary of Barefoot Power)	SECAM (French-owned local firm)
Up-country distributor	A former trainer from UWESO	CREAM buys in wholesale from BASE Technologies	EPIC Ankilais (a Malian firm incubated by Energy Links)	Entrepreneur L. Bironga, who originally formed savings groups with CARE	Small shops in market towns (to be identified)
Retail sales	Present trainers	About 30 trainers who, when their funding expired, continued as fee-for-service trainers	EPIC Ankilais sells to a network of 80 retailers, including many SG trainers who resell to members	Beronga sells some lamps directly from her shop; her group trainers also sell lamps	Village agents, fee-for-service trainers of CARE (planned)
Energy Links' Role	Introduced concept into Uganda; introduced Barefoot and UWESO; pilot-tested lamps with UWESO members; produced training materials	Introduced concept into Uganda through series of events and workshops	Introduced concept into Mali; gained Ministry of Energy support; identified key actors; financed trial shipments; gave small working capital grant to EPIC Ankilais	Energy Links consultant informally introduced solar lamps concept to distributor Beronga	Energy Links consultant is assisting CARE to replicate and scale experience of Energy Links in Uganda and Mali
Comments	The former UWESO trainer became BASE Technologies' leading sales person. UWESO did not support his business, andAhe moved to salaried employment. Customers were disappointed when they had no way to repair failed lamps.	Considered by Energy Links to be a promising model. Lamp sales provide CREAM with some revenue, bolster its reputation in the community, and help it retain field staff, who made about 40% of their income from lamps, 60% from fees collected from groups.	Mali is apparently successful because it draws heavily on informal networks to sell lamps. The actual business plan aims to sell 40,000 kits in 2011 and 100,000 in 2012.	There is some anecdotal evidence that distributor is selling lamps at relatively high prices.	This project is in start-up, and is now addressing logistical and administrative issues.

of carbon emissions estimated to be saved by client use. Solar lighting systems, efficient stoves, and other clean energy products in developing countries qualify for carbon credit certification, if their use can be efficiently monitored and communicated to the market. For example, MEC purchases the carbon credits created when clients or group members use clean energy products. It aggregates these credits and sells them into the carbon markets. The majority of the proceeds are returned to the MFI or NGO. Carbon revenues can be used in a range of ways, such as in marketing, client education, after-sales service, or price reductions. Carbon revenues could provide incentives for energy savings accounts. For example, if a solar lantern user stores money saved from switching to clean energy for a period of time, the MFI could provide a bonus or match using carbon revenues. To qualify for MEC's services, MFIs or NGOs must be able to reach 12,000 households within two years. Currently, 16 MFIs in 11 countries have signed up, and approximately 45,000 households have been reached to date.

From Broker to Industry Builder

Greater access to clean energy for low-income people requires the creation of functioning value chains and ultimately the development of a competitive market. Unfortunately, as we observed through experience, progress will be very slow if the task of creating access at scale is seen only through the current lens of impact investing or energy SME development. An industry-building vision is needed. And for ideas about how to create an industry that serves low-income people, there is no better place to look for lessons than microfinance. This section describes how Energy Links acted as a project broker on a limited scale, then considers how such efforts could be scaled into an industry-building approach, with comparisons to the growth path of microfinance.

Energy Links' Experience as a Broker. Energy Links was created to address the following problem: Although a functioning value chain requires cooperation among several players—device provider, importer, finance providers, government, MFIs, and ultimately clients—these players are not necessarily ready to cooperate. Barriers stand between them, particularly in terms of knowledge, understanding, and trust. Overcoming them requires an investment in time and learning. A large and profitable market would provide incentives to overcome those barriers, but for a new product that requires buyers to change behavior, the uncertainty and risk may appear large and the potential market is uncharted. The broker works to reduce these barriers so that players can come together more easily. It primes the pump.

This role *could* be played by any number of entities, from energy companies to government agencies, NGOs, or MFIs. The energy companies, however, face many challenges for which they need assistance. They look to MFIs to provide the market access, distribution, and financing they lack, while they themselves focus on the absorbing tasks of building the supply chain's back end. In the case of Barefoot Power, for example, had it been an established multinational it could have set up its own unit to do all the things Energy Links did. However, as a small start-up, its ability to work on such a wide range of challenges at once was highly constrained. The same goes for the other solar energy companies we examined.

MFIs, for their part, see that there might be a business case to get involved in the provision of modern energy services. But they are typically under significant pressure from investors and funders to grow their main credit and savings operations while maintaining sound financial performance. They often conclude that the energy sector is a potentially expensive detour, requiring a great investment in management time and possibly money, with uncertain prospects of ending up with a viable, scalable product. Only a few highly motivated MFIs, like Grameen Bank with its creation of Grameen Shakti, have seriously taken up the challenge on their own.

Similarly, the promoters of savings group networks can be skittish about getting involved in solar lamp distribution.

- Some savings group facilitators are philosophical minimalists, who think it inappropriate to "use" savings groups for nonfinancial services of any sort. This point of view is disappearing as the number of successful experiences of linkages grows.

- There is an understandable aversion to the risk in promoting an unknown product, which, if it failed, could damage their members' financial security and their own brand.
- Some are afraid that commercial sales could distract field staff from their principal occupation of forming, training, and supporting groups.

All of these concerns are legitimate, and all can be addressed by careful planning and good communication.

Energy Links involved a small grant from USAID and the Wallace Global Fund to the Center for Financial Inclusion at ACCION. The Center's Energy Links team operated independently of any other market participants. Its major resource was the team of two and at times three or four people, who operated in an entrepreneurial manner to identify opportunities, persuade and organize partners, and solve problems. A small amount of funds was available for specific efforts such as market research, shipping of test batches of lamps, and workshops and training sessions. Throughout the project, the team constantly adjusted its role to work first on one and then another aspect of the challenge (e.g., developing client educational brochures, negotiating agreements with importers). Much of the work involved trial and error (for example, approaching partners that later decided not to participate) and fine-tuning (for example, determining that the market was there for a $25 package of two LED lamps and a phone charger).

This work was largely catalytic. Most of the accomplishments were actually carried out by the players with whom Energy Links worked. For example, initial work in Uganda on market testing, design of educational material, and development of a microfranchising model influenced the decision of Barefoot Power to place one of its founders in Uganda and invest in its first African market by setting up a subsidiary, BASE Technologies. From that point on, Energy Links' assistance was not needed: With a strong local presence, Barefoot Power could solve problems on its own. In Mali, much of the work centered on finding a suitable importer and developing the trust necessary for that importer to secure agreements on both the supply and demand sides. As a result, Energy Links secured a few air shipments of about 2,000 units, but the actual shipment of a full container load of lamps occurred only after Energy Links had officially closed. Since then, the Center for Financial Inclusion has been following the progress in Mali unofficially, and, as shown in Table 3, our partner reports increasing orders and shipments.

As a broker, Energy Links had one characteristic that was both its greatest asset and in some cases a shortcoming: Its complete independence from any

Table 3. Energy Links-Related Lamp Shipments in Mali

SHIPMENT	NO. OF KITS	DATE	FUNDING AND REMARKS
Air shipment	430	March 2010	Demonstration and pump priming with ACCION funding
Air shipment	780	August 2010	Half used ACCION funds recycled from previous order; the rest used local funding
Container	2,000	January 2011	Imported by Horonya with own funds, Barefoot Power supplied credit, and NOTS Foundation, a Dutch NGO working with Energy Links' partner
Container	10,000	March 2011	Imported by Horonya with own funds + Barefoot Power supplier credit
Container	10,000	August 2011	Imported by Horonya. Lights supplied by dlight design as product test. Financing from NOTS Foundation
Container	10,000	August 2011	Imported by Horonya. SunKing lights supplied by Greenlight Planet with NOTS financing
Container	10,000	Ordered	Barefoot Power lamps, financing from NOTS

Note: Barefoot Power kits contain two lamps and a panel; dlight kits contain one lamp and panel.

of the parties involved. As a project of the Center for Financial Inclusion, a Washington-based organization, Energy Links had no ties to any of the key partners in the countries in which it worked. This did have the great advantage of allowing flexibility to work on whatever was most needed and to take up or abandon avenues of action on their merits rather than because of previous agreements. With little leverage beyond the power of persuasion, partners got involved when and only when convinced that involvement would result in a workable operation benefiting them and their clients. The biggest shortcoming was the inability of the project to locate its team in the region officially, which made it difficult to maintain contact over time, monitor progress, open local bank accounts, and execute contracts with local parties. Building a coalition among busy people by email and phone calls to Africa is challenging! That is why Energy Links ultimately hired a full-time consultant in Mali to set up and expand distribution networks. He then moved on to start his own company and distribute solar lanterns across the country.

Stepping back from the specifics of the Energy Links experience, a partial list of functions that a broker in this space can usefully carry out include the following: market testing, input on product design, product vetting, partner vetting, creation of public goods such as educational materials, project design, problem solving on specific value chain issues, convening for awareness raising, training, supporting the securing of finance, facilitating contract negotiation, maintenance of project momentum, and interface with policy makers. In all these functions, the role is critical in the start-up phase, but time-limited, and the expectation is that, once established, operations can continue without further broker presence. USAID recognized that building a market is too expensive an investment for a local SME or MFI and would require dedicated donor funding. (The situation may be quite different for established technology firms trying to expand their operations, conquer new markets, and reach new customers, e.g., Philips or Schneider Electric.)

Learning from Microfinance. If micro-energy were approached as an industry development challenge, it could grow faster to serve the masses of people who experience energy poverty and use damaging fuels. This work should be driven by the vision of a massive off-grid energy industry that becomes as widespread as cell phones or microloans are today.

The current prospects are similar to the challenge of building microfinance from a few scattered experiments in the late 1980s into a worldwide industry serving over 150 million people. It is highly instructive to look at the role of donor funding and eventually commercial funding in driving that movement forward.

We can divide microfinance evolution into four periods.

1. *Proof of product; proof of demand.* In the 1980s, the lending models were developed for lending small amounts, with confirmation that low-income people wanted the loans and were responsible repayers.
2. *Institutional development (late 1980s and 1990s).* The small NGOs that launched microfinance were helped to become larger, more capable institutions that operated on business principles and covered costs.
3. *Early commercialization (mid-1990s to mid-2000s).* Donors helped the sector build the elements needed to qualify for commercial funding, including transforming NGOs into regulated financial institutions.
4. *Maturity.* The microfinance sector currently uses little donor funding for routine operations. It is increasingly embedded in local financial systems.

During its first two and part of the third stages, microfinance was largely supported by donors. Commercial investment began to be available only during the third stage. The major investment in MFIs that now takes place is largely a phenomenon of the past 10 years. In order to build an industry with commercial funding as the main driver, a great deal of work was needed in areas including institutional performance standards, transparency and availability of information, and regulatory adaptation. This work, too, was supported by donors. Similarly, the mobile banking sector, which is believed by microfinance experts , banks, and telecom companies alike to have an extraordinary future, emerged only through substantial donor funding.

Turning back to micro-energy, we can place the sector at present well into stage 1 (products people want and can afford, though this still needs further proof). It is starting to work on some of the stage 2 issues (building the capability of the energy companies). If it is to succeed, there are a large number of institutional development and industry building tasks to be undertaken. Energy Links worked on some of these on a very small scale, which merely points to the larger need.

It is our contention that the micro-energy sector is not yet ready to be driven by commercial capital. At present, most of the capital flowing into the sector is commercial, social investment, or quasi-commercial. At this stage, the returns to such capital will be small and unpromising in the short to medium run. Too many tasks remain undone, and growth will be stunted: seeds cast on unprepared soil. This is not to say that the sector should operate on a subsidized basis. The mantra of the microfinance movement was "scale and sustainability." The drive to create a sector operating at scale on a financially sustainable basis helped to focus the use of subsidies on industry building rather than end-user financing.

Because the donor community regarded microfinance as a tool to address poverty, it was willing to invest in creating the sector. It created possibly dozens of national industry development projects that played a similar brokering role as Energy Links, but on a larger scale. Just to single out East Africa, for example, USAID's SPEED project in Uganda, coupled with GTZ's project of working with the Central Bank of Uganda on the regulatory front, paved the way for the transformation of MFIs from nonprofits into deposit-taking institutions. The Financial Sector Deepening Fund of the UK's Department of International Development, in addition to catalyzing many experiments across East Africa through direct grants, also financed efforts in the areas of standard setting, transparency mechanisms, national associations, and client research, among others. These functions have their analogues in micro-energy.

This same industry development logic applies to micro-energy, but so far, with a few exceptions, the support has not been forthcoming. Why not? Energy poverty and the use of damaging fuels are challenges that development organizations and charities should have an interest in tackling. It may be that micro-energy development is seen through the lenses of SME development and impact investing. Neither of these lenses is sufficient for the challenge or for the stage of industry development. The SME lens focuses too narrowly on the energy companies, and is too restrictive in terms of willingness to provide support (because donors are more reluctant to support for-profit businesses than nonprofits). The impact investing lens also focuses too narrowly on the energy companies, and because investment funds are risk-averse and require a financial return, many market-making activities cannot be funded this way.

One other impediment may also be that thinking about energy tends to start from the electricity grid and move out, while the small distributed model of off-grid provision is not taken seriously among energy policy experts. This is in some sense analogous to the thinking that commercial banks constitute the financial system, relegating MFIs to the periphery of the financial system, with savings groups often considered outside that periphery. This thinking has taken years to overcome, but ultimately it was recognized that MFIs and savings groups constitute viable models that serve millions of people whom commercial banks were going to continue to ignore for a long time.

In the case of micro-energy, the shift to a commercially driven sector can perhaps occur more quickly than it did for microfinance, but if the sector is to realize an audacious vision of providing energy to all who lack access, it must go through a more deliberate precommercial stage than donors have so far been willing to support.

Final Thoughts: Overcoming Bottlenecks to the Growth of a Micro-Energy Sector

This section summarizes some of the most important lessons from Energy Links.

Demand and Supply. There is a large and growing demand for small-scale household off-grid energy products. A number of small energy start-up companies have set up shop in the past five years, from India to Africa to the Pacific islands. Market demand

has driven growth and increased competition. But the number of actual users is still tiny compared to the size of the potential market. Supply is needed in order to generate demand, and it must be a reliable supply to overcome people's reluctance to change. Ensuring continuous supply is quite a challenge, however essential it is for product uptake. Thus the sector needs to improve reliability in its value chain.

Awareness. Both in the developed and developing world, few recognize energy poverty as a serious problem with dramatic cascading consequences in health, education, income, economic opportunities, and economic growth. Despite a global focus on climate change with its resulting attention to energy, few multilateral organizations or NGOs focus their energy programs on individual household energy solutions. NGOs, MFIs, and other development organizations that work closely with rural off-grid households often don't comprehend the scope of the problem or feel the urgency. Solid statistics on energy uses and costs are often scarce and seldom well known or shared. Worse, while the environmental costs of deforestation or pollution can be visible, the social and economic costs (health, education, income generation, savings) of burning fossil fuel are poorly documented and far from obvious to many, possibly including end users who are unaware of alternatives. The opportunity to benefit millions of people with solar lighting and other modern energy is new, and not fully understood. Sensitizing decision makers about energy poverty and demonstrating the development impact and the business potential is necessary to allow the market to gain traction.

Lighting vs. Cooking. In the developing world, 1.4 billion people use fossil fuels for lighting and 2.4 billion for cooking. These two tasks are their main energy consumption and may consume as much as 30 percent of their income. Both have dramatic health consequences that need to be addressed urgently. But the cultural significance of lighting and cooking is extremely different. For lighting, moving from a fuel-based kerosene lamp to a modern alternative (solar lantern or solar home system) requires few behavioral changes in the household. Instead of striking a match, users flip a switch. On the other hand, cooking is a central cultural pillar, and cooking methods are highly resistant to change, especially those involving food preparation methods. For example, some of the relevant questions to ask a family might be: Do you cook indoors or outdoors? Do you boil or grill your food? Does your family like to sit around the glowing coals of an open fire in the evening? Do you believe smoke and open flame repel mosquitoes? Answers vary by country, region, and sometimes religion or ethnicity. Therefore, replacing existing cooking solutions by modern energy devices is far more complex and needs to be tailored to the specific target population: Unfortunately there is no one-size-fits-all fix to today's energy problems.

End-User Financing Needs. Switching household energy fossil fuels to modern devices requires an upfront investment, initially singled out as the heart of the financing need in the clean energy value chain. Early projects focused on loans to end users to enable them to purchase solar home systems. But alternative solutions also exist, from use of personal savings to borrowing from family or the community, since the price, particularly of smaller portable devices, is affordable and often generates immediate savings. These alternatives need to be well understood by savings group promoters or MFIs in designing their support services.

Financing the Value Chain. End-user finance alone has not been successful in increasing outreach substantially because it turned out not to be the most restrictive financial bottleneck at this time. At present, the most urgent finance need occurs one step back in the value chain. The SMEs that are producing and distributing modern energy devices to serve bottom of the pyramid markets are generally young or start-up companies, which are only now growing to the point in size and management sophistication to qualify for substantial outside equity and some long-term debt, such as from impact investors. This still leaves a gap. In order to expand locally, the energy value chain needs to provide a ready and reliable supply of products to those who will distribute and market them to end users. Local investment and working capital are essential for facilitating this movement within the supply chain.

The Industry-Building Vision. An industry-building perspective is needed, in which donors work toward a vision of scale and sustainability and put

the elements in place that will turn a few scattered projects and energy SMEs into a massive industry. This will require pre-commercial, grant-based efforts and involves support to both individual projects and companies, and to the architecture of the industry. A platform for peer learning and documenting the many different decentralized approaches, program successes, pitfalls, and lessons learned will increase the knowledge base on renewable energy microfinance and energy microenterprises. Knowledge sharing will also make it easier for MFIs and energy providers to find each other and form successful partnerships.

The experience of Energy Links as a project broker points the way to the need for larger and more deliberate vehicles to create a vibrant micro-energy sector that can significantly address energy poverty and contribute to more environmentally friendly energy use by millions of low-income people.

Appendix 1. Biomass Briquettes: A Credible Alternative to Charcoal?

In the developing world today, charcoal and firewood are the primary cooking fuels, followed by fossil fuels. But as forests shrink and as the prices of fossil fuels keep rising, cooking fuel expenses are a growing burden on low-income households, monopolizing on average 8 percent of a family income, much more than people pay in high-income countries. Imagine the average American household paying a $300 bill every month just for cooking.

Producing charcoal requires wood, which increases both deforestation and the stress on ecosystems, emits large amounts of CO_2, and regularly ends up burning down entire chunks of forests. And it is estimated that 10 to 20 percent of that charcoal is lost in dust and fines along the distribution process. What a wasteful system!

After looking into small-scale lighting for more than a year, the Energy Links project decided to explore alternatives to traditional cooking fuels.

There are several ways to reduce or displace wood and charcoal:

- *Improve stoves that use traditional fuels.* Many universities, research centers and development organizations are trying to design an affordable and efficient stove that can significantly reduce fuel inputs and reduce smoke and particles while remaining affordable and requiring minimal behavioral changes with respect to cooking habits and preferred food. The Aprovecho Research Center in Oregon has been a worldwide leader in introducing new stoves, and their management acknowledges the large number of promising products and projects that have almost worked, only to fail because of small details.[17]
- *Promote alternative fuels that substitute for wood, charcoal and fossil fuels.* Some of these could be used with existing stoves, while others, such as solar cookers, would require different devices.

Energy Links decided to focus on the second approach, given that many players with greater resources and expertise were tackling the first question. This bought us to consider the environmental and economic development potential of biomass briquettes made of agricultural and other organic waste (fruit peels, tree leaves, grasses, paper, sawdust, and charcoal dust). Briquettes made of such materials have been used around the globe for at least 20 years. They are attractive as a quasi-free resource that substitutes for charcoal and wood and thus helps prevent deforestation. But these approaches have remained scattered and small in scale.

The fact that biomass briquettes protect the environment is hardly enough to convince users to choose them over other fuels. Additional advantages over charcoal or firewood include the following:

- *Saving money*: Since briquettes can be made of almost any dry organic waste—tree leaves, cereal husks, scrap paper, banana peels, sawdust, or charcoal fines—input materials are free or quasi-free (the cost might be that of collection). Producing one's own briquettes to replace charcoal or firewood purchase can bring substantial savings.
- *Improving livelihood and time use:* Women traditionally collect firewood, and in many locations they transport heavy packages over long distances every day. Making briquettes is an alternative to this painful, time-consuming, and sometimes even perilous activity, allowing women to dedicate their time to other productive tasks.
- *Generating income:* An individual or a small group of two or three people, with limited capital for a start-up investment (tools and a press start at $30), can easily produce fuel for their own use and for sale to neighboring families. Selling briquettes provides income for the producer and substantial savings for buyers compared to charcoal or wood.

But despite these clear benefits, only a few communities use this green fuel source, while most pay a rising price for charcoal or struggle to collect free firewood even as forests shrink. Energy Links sought to understand why this was the case. What was the limiting factor in what seemed to be a brilliant idea for environmental protection, household costs reduction, and income generation? Is this activity too

17. "Hearth Surgery." *The New Yorker*. December 21, 2009, pp. 84-97.

time-consuming? Is the know-how missing? Are raw materials unavailable to scale up production? Or is this "technology" ill-adapted to urban areas that are growing at unprecedented scale?

Together with two partners, the Legacy Foundation and UWESO, we developed a viral replication program to sensitize Ugandan households to the need for a cost-effective, eco-friendly fuel source, and to train them to produce and use biomass briquettes. The purpose of this training was ultimately:

- To provide individuals with ways to produce low-cost environmentally friendly fuel
- To develop a turnkey income-generating activity "in a box"
- To promote a "planned spontaneous" replication of the know-how and of small-scale local businesses.

The Legacy Foundation's promotion, training of producers, and research into technological improvements worldwide spans two decades, and UWESO is an NGO that, among other programs, organizes savings groups. These savings groups, with a total membership of around 75,000 members (in 2010) offered a ready channel to promote the spread of biomass briquettes.

Energy Links organized a training of trainers by the Legacy Foundation for 25 staff and community-based trainers (CBTs) from UWESO. In addition to learning how to produce briquettes, the training focused on demonstrating the advantages of briquettes as cooking fuel and showing the business opportunities they offer. Trainers were encouraged to share their newly acquired knowledge with their communities, passing on the technology to their contacts, encouraging the emergence of micro-entrepreneurs, and spreading techniques virally.

Mastering the briquette-making technique and having access to credit are both requirements for this activity. Since briquette making is not automated and requires a high level of effort, the scale of production is limited. One producer can only serve up to 50 families. In order to replace charcoal on a wide scale, a large number of producers and entrepreneurs are needed to flood the market with briquettes. Thus, briquettes are also a great opportunity to create jobs and generate income.

After the workshop, UWESO worked to establish and spread the use of briquettes. Using regular meetings of community savings groups, UWESO staff and CBTs exposed their fellow members to the concepts of using briquettes and producing them for home use and sale. In over a year, more than 4,000 UWESO members had been trained. However, only 35 had undertaken briquette making as a commercial operation. There are several factors that begin to explain this low uptake:

Technology. The Legacy Foundation first introduced a large wooden tool, a pressing device called the "Mini-Bryant." The high acquisition cost (around $250) and requirement for at least three people at the same time to operate the press were major constraints to household production. The press itself is also quite complicated to design and assemble. Local carpenters had trouble supplying functioning presses.

Energy Links quickly identified another suitable model, the "Peterson Press," a much smaller and simpler machine, propelled by a car jack and only needing one person to function. Acquisition cost for the Peterson Press is substantially lower, at $30-35. It can be acquired by a single individual or shared among two or three people and can produce 300 briquettes (about $15 in sales value) on average per day. It can also easily be made locally.

A number of motivated entrepreneurs saw a great opportunity in biomass briquettes and began to create their own pressing devices. Unfortunately, most hand-made presses produce low-quality briquettes that dry slowly, come apart, and produce a lot of smoke. It was necessary, therefore, to encourage micro-entrepreneurs to purchase only presses made to exact specifications.

Marketing, education, and business acumen. Replacing a product established for generations is not an easy task: motivating a switch between charcoal and briquettes is clearly a challenge. Charcoal prices fluctuate seasonally, making price comparisons better at some times of the year. Moreover, potential

clients don't trust this new fuel. The best marketing was the proof of example: using briquettes on the market in simple tasks such as boiling water for tea or grilling meat, or by distributing high-quality free samples for home trials.

Overall, the lack of previous business and particularly marketing experience among rural families quickly became a bottleneck. More than typical marketing, sellers must educate their potential customers on the use and benefits of this new fuel, since it requires them to change habits. The rising price of charcoal compared to the much cheaper alternative offered by briquettes incentivizes users to change, but they need to understand fully the added value before making a switch.

Finally, there is a small geographic discrepancy between where the briquettes are produced and potential demand. Briquettes can be produced in inner cities using semi-industrial waste (paper, wood dust, charcoal fines), but most producers associated with UWESO operate in rural areas where agricultural waste is plentiful. Yet, they need to target urban markets because rural communities often have access to free firewood and do not regularly pay for cooking fuel.

Product quality and storage. Often product quality was a hurdle. When introducing a new product, poor quality can have a definitive effect on whether or not it will be accepted. Briquette making is quite an art, and until the briquettes are properly manufactured and well dried, they produce smoke that can be a deterrent to new users while defeating the health purpose of moving away from traditional biomass. At first, many new producers reported that their briquettes' combustion generated too much smoke, but within a few iterations, they improved.

Storage of briquettes was also a hurdle. During Uganda's rainy seasons, with massive rains and high humidity, it is hard to dry biomass products and keep them dry. Producers of briquettes thus need access to a protected space if they want to sell quality briquettes. Pooling production and storage in one location at the village level proved a good way to address this issue.

Among the lessons Energy Links learned from its work with briquettes are the following:

- Briquettes, as a cooking product, require a real change in mentality. At first, the work will be seen as a burden because net savings only appear once the user has amortized the cost of equipment, and that can take awhile.
- There are various press models. Energy Links found the smaller press it worked with to be better, both because it is cheaper and because it can be made locally.
- Briquette-making enterprises can work with a model of using hired labor.
- Attention to the price and quality ratio is essential. Energy Links found that at $0.05 briquettes were too expensive, but that the market would be much larger at $0.03 or $0.04, which would still allow for a suitable margin. Promoters should not overpromise likely returns to prospective briquette entrepreneurs.
- Promoters are tempted to focus on the use of the press itself, but should pay more attention to what comes before and after, such as getting and preparing materials, drying, and marketing. They have a clear support and guidance role to play with these individual enterprises. MFIs could envision playing such a role, as they could finance the necessary material to start a briquette-making business, while supporting micro-entrepreneurs through business training.
- The briquette-making process continues to require fine-tuning. For example, drying is a big issue, as is smoking briquettes. Several theories are advanced about why briquettes smoke: too much moisture (solution: longer drying), smaller particles (like fine sawdust), more charcoal, hotter fires, and incomplete combustion because of inadequate secondary air source in stove. Users should not be discouraged, listen to clients, and keep experimenting.

Appendix 2. Rationale for Action: Why Reducing Energy Poverty Matters

Although absent from the Millennium Development Goals, energy poverty has recently been recognized by the United Nations as a major challenge impeding social, economic, and human development that needs to be addressed urgently: the UN declared 2012 as the International Year for Sustainable Energy for All.[18]

Accelerating the access to clean and modern sources of energy for low-income households in Africa has a huge multiplier effect in terms of impact. According to the International Energy Agency, access to energy is an "indispensable element of sustainable human development. Without access to modern, commercial energy, poor countries can be trapped in a vicious circle of poverty, social instability and underdevelopment."

Thus, a dollar spent in increasing energy access will induce many benefits.

- Potential health, productivity, and quality-of-life benefits for consumers (e.g., less respiratory illness, time savings, and use of technologies in business operation as well as primary and secondary education)
- The increasing cost-effectiveness of renewable energy sources with substantial savings induced for households
- The need for developing countries to chart a low-carbon development path to sustain economic growth without contributing to global climate change
- Potential for very large-scale impact with limited budgets compared to other development initiatives (especially traditional infrastructure for energy generation)
- Also, it is estimated that kerosene lamps release 190 million tons of CO_2 into the atmosphere annually, an equivalent of 30 million cars and an amount greater than Australia and UK combined.[19]

The potential market for renewable energy at the base of the pyramid is huge: The example of solar lighting is illustrative, with almost $40 billion spent in 2010 on fuel-based lighting (equivalent of 1.7 million barrels a day). Africa, with its 110 million households off the electricity grid, today accounts for close to 40 percent of that, that is to say $16 billion, a share that will keep rising.[20]

Overall most poor households would switch to better, cleaner, and more efficient energy sources if they could afford alternate fuels or efficient devices. As important as the market potential is to achieve a large-scale project, there are tremendous social benefits associated with displacing kerosene lighting and fossil fuel burning for cooking.

Health. Lighting homes with kerosene or cooking in the house using firewood or charcoal produces smoke and other health-damaging particles (soot or dust, also called black carbon, that finds its way into the lungs). The resulting indoor air pollution increases substantially the risk of respiratory diseases, especially among children and women who are most exposed. If ventilation is not appropriate, as in most poor dwellings, the concentration of pollutants can reach a level 100 times above what is tolerable.[21] Research from Humboldt University shows that the intake of particulate matter from indoor use of kerosene lanterns is 5 times higher than in ambient air and more than 10 times above the EPA limit.[22] The World Health Organization estimates that indoor air pollution results in 1.6 million premature deaths per year[23]—1.5 times more than malaria![24] Most of these deaths are caused by biomass cooking stoves but also by kerosene lanterns.

18. United Nations Secretary-General Ban Ki-Moon called for "A global clean energy revolution—a revolution that makes energy available and affordable for all," adding that this was essential for minimizing climate risks; reducing poverty; improving global health; empowering women; and meeting the Millennium Development Goals. http://www.unido.org/index.php?id=7881&tx_ttnews%5Btt_news%5D=850&cHash=f160cd2d5384f734eb5b44efae2ee2a9.
19. Radecsky, Kristen, Peter Johnston, Aren Jacobson, and Evan Mills. 2009. "Observed minimum illuminance threshold for night market vendors in Kenya who use LED lamps." Lumina Project Research Note #3. Cited in Overview of the Solar Portable Lighting Market for the Base of Pyramid, Lighting Africa 2010 Conference Report 6 June 2010. Dalberg Global Development Advisors.
20. Lighting Africa: Overview of Off-Grid Solar Portable Lighting in Africa, p. 11
21. World Health Organization. http://www.who.int/mediacentre/factsheets/fs292/en/.
22. Research by Dustin Poppendieck from Humboldt State University presented at the 2010 Lighting Africa Conference: http://lightingafricaconference.org/fileadmin/user_upload/Conference_2010/Day2/DAY2_PDF/Dustin_Poppendieck-Lighting_Africa_2010_-_Poppendieck.pdf.
23. World Health Organization. http://www.who.int/mediacentre/factsheets/fs292/en/.
24. http://www.who.int/features/factfiles/malaria/en/index.html.

Solar lanterns and efficient stoves provide a safe, healthy, and affordable alternative to fossil fuels. Although health impacts have not yet been thoroughly documented, users of kerosene lights we have talked with are conscious of the danger of toxic fumes and worry about their adverse effects. Women especially fear for their children's health and their own.

Education. Kerosene lighting is too dim for children to read and study by at night, which limits school performance and literacy levels. In an early market acceptance test in Mali, Energy Links found that the primary beneficiaries of solar lanterns were children who gathered at the homes of test users in the evenings to study. Anecdotal evidence from Africa and India supports the idea that children study longer hours when they have access to an efficient source of lighting.[25] Overall, WHO's and UNDP's research tends to show that household access to electricity, as well as to modern fuels, is positively correlated with school enrollment ratios. Another study showed that, for example, in India study hours per household increased from 1.5 to 2.7 with the introduction of solar lighting.[26] Besides, wood collection is a time-consuming burden that in many societies falls on women and children. Time savings from reduced collection can then be used by children to read, study, and attend classes.

Environment. Kerosene burning releases greenhouse gases. It is estimated that kerosene lighting worldwide emits 190 million tons of CO_2 in the atmosphere every year, the equivalent of 30 million cars. These emissions could be displaced by existing solar technology. These figures only measure off-grid lighting externalities. The impacts are all the more dramatic when cooking is added to the equation.

Cooking with firewood or charcoal adds another level of stress on the environment: The demand for fuel wood is greater than the supply, which is often not replenished through sustainable land management policies. Hence, it contributes to deforestation, which in turn leads to depletion of soil quality, a decrease in agricultural yields, and erosion.[27]

Household savings. Kerosene, charcoal, and firewood (except when gathered for free) have not been exempt from the rising prices of commodities and energy sources. Basic energy tasks have become extremely costly for poor and remote households that spend a growing part of their income satisfying these needs. Switching to a clean or renewable energy source generally incurs up-front costs but it also generates automatic savings. With a solar lantern or a solar home system, there is no need for kerosene or candles. An improved stove used correctly can allow a family to cut charcoal or firewood use by at least half; homemade biomass fuels or biogas can even fully displace the use of charcoal. Thus, families' energy bills drop substantially, freeing that large share of income for savings or other household needs.

Safety and security. Better lighting displaces the risk of fire from an open flame in the house. A well-lit street or house offers greater security, in discouraging aggressions and assaults. Alternative cooking fuels allow women and children to avoid collecting wood in remote areas, which is both a burdensome, time-consuming task and may put them at a physical risk, especially in conflict zones or violence-prone areas.

Income generation and economic opportunities. At the turn of the 20th century, the mass phenomenon created by the spread of electric power allowed for a profound change in the productive systems of the Western world. Similarly, accessing off-grid power can offer a range of new opportunities for micro and small businesses. First, a better, cheaper, and more reliable light source allows for longer working hours and better working conditions, thus increasing productivity. Second, access to power allows the emergence of new microbusinesses offering services that were not available before, such as charging battery-powered devices such as cell phones. Finally, it allows improvement of production processes and increased productivity by adding new machinery or electric tools, allowing businesses to expand their activities and producers or cooperatives to process raw materials.

25. Lighting Africa: Overview of Off-Grid Solar Portable Lighting in Africa—p. 14. http://lightingafricaconference.org/file admin/user_upload/Conference_2010/16.5.2010_Lighting_ Africa_2010_Conference_Report__FINAL_DRAFT_.pdf.
26. Dalberg. Op. cit. p. 13.
27. On March 1, 2010, heavy precipitation caused landslides in the Mount Elgon region of Uganda, resulting in the death of more than 100 people. The Uganda government and other organizations have stated that deforestation might have played a role in preventing trees from holding these steep hills together.

Cover Photograph
Photographer Credit: Paul Rippey
Caption: Malian women with solar lamps.

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