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Abstract: Energy poverty is a major problem in the developing world, with nearly 1.3 billion people lacking household electricity. Strikingly, the electrification rate is not only low, but is falling in many countries as population growth outpaces efforts to give more people access to electricity. Seizing the opportunities presented by rapid changes in technology and the availability of renewable energy at continually falling costs, social enterprises have begun to light the darkness and fill in the gap between public and private provision of electricity. We review the extent of energy poverty and explain why neither the public, nor private sector has successfully addressed this problem. We also discuss institutional factors which have created an environment conducive to solar power. To illustrate the social enterprise response, we explain the sector's three most common approaches to solar electrification. Since the potential benefits of any social innovation revolve around its scalability, we discuss various paths to scale before outlining A.T. Kearney's Social Enterprise Accelerator model as a template for scaling up individual social businesses. To enable greater consistency with an institutional economic framework, we suggest an adaptation of the model. We conclude by highlighting potential benefits and challenges facing solar electrification, including the limits of social enterprise as a stand-alone solution to utility provision.

Keywords: Africa, development, electricity, entrepreneurship; innovation, social enterprise, solar power, sustainable development

JEL Classification Codes: Q01; Q42; Q56; B52; O13; O35; P48

Energy poverty is a major problem in the developing world, with nearly 1.3 billion people lacking household electricity (IEA 2015). Strikingly, the electrification rate is not only low, but is falling in many countries, as population growth outpaces efforts to give more people access to electricity. Energy poverty exacerbates existing inequalities, impacting people not only as consumers and producers, but also as social beings (Chester 2014). As institutional economists explain, several factors (including habits and values) can lead to institutional rigidities and "lock-in" of current systems and technologies, impeding progress in tackling pressing challenges (Caballero and Soto-Oñate 2015; Lacasa 2014). In this paper, we examine a disruption to the energy sector in developing

countries. With solar power solutions, social enterprises have begun to light the darkness and fill in the gap between public and private provision of electricity.

We first review the extent of energy poverty and explain why neither the public, nor private sector has successfully addressed this problem. We then discuss institutional factors which have created an environment conducive to the spread of solar power. To illustrate the social enterprise response, we explain the sector's three most common approaches to solar electrification. Since the potential benefits of any social innovation revolve around its scalability, we discuss various paths to scale before outlining A.T. Kearney's Social Enterprise Accelerator model as a template for scaling up individual social businesses. To enable greater consistency with an institutional economic framework, we suggest an adaptation of the model. We conclude by highlighting potential opportunities and challenges facing solar electrification, including the limits of social enterprise as a stand-alone solution to utility provision.

Energy Poverty and the Rise of Solar Power

Where are the Energy Poor?

The issue of energy poverty is most critical in Africa. This region has the lowest electrification rates, with 26 percent in rural areas, 68 percent in urban areas, and 43 percent overall. Electrification rates are even lower in Sub-Saharan Africa, with 17 percent in rural areas, 59 percent in urban areas, and 32 percent overall (IEA 2015). Outside Africa, the region with the lowest electrification rate is developing Asia, with 78 percent in rural areas, 96 percent in urban areas, and 86 percent overall (IEA 2015). The populations lacking access to electricity can be categorized in two groups. The first group, predominantly in urban areas, includes people who are (or can be) connected to the grid, yet do not have electricity. Despite reforms over the last three decades, state-owned monopolies have failed to bring electricity to this group for various reasons, including affordability, supply shortages, and deteriorating network and equipment (Williams and Ghanadan 2006).

The second group, concentrated in rural areas, is completely excluded from the grid. Bringing conventional electricity to this group requires costly grid extension to remote, underpopulated villages. Economically, weak electricity demand in these areas does not justify the high costs of extending the grid. Even where the energy sector is open to private capital, energy-related investment remains unattractive, given financial impediments, regulatory hurdles, capacity issues, and high risk factors in developing countries (Aseidu 2002; Muzenda 2009). The large gap between private and public sector provision of electricity — with millions of people literally left in the dark — has created opportunities for new actors and approaches.

Why Solar Power? Sustainable Development

In recent decades, notable institutional changes have paved the way for successful solar electrification. Widespread focus on the UN Millennium Development Goals from 2000 to 2015 increased recognition of the linkages between modern energy access and development outcomes, such as poverty reduction, nutrition, education, healthcare, gender equality, and environmental sustainability. This spurred several public sector initiatives to provide access to electricity to more people around the world (Arouri et al. 2014; Modi et al. 2005). One of the new Sustainable

Development Goals (approved in 2015) specifically targets the attainment of affordable, reliable, sustainable, and modern energy for all.

Solar electrification supports all three dimensions of sustainable development: economic, social, and environmental.[1] As discussed in Warnecke (2015), the economic dimension focuses on long-lasting economic growth and augmentation of physical, social, human, and natural capital. The social dimension focuses on human security and equality, including poverty rates and social inclusion, while the environmental dimension involves the ability to serve future generations with existing resources.

Solar lighting facilitates education, as children can study and complete homework at night. Studies show that installment of solar lighting improves student attendance, teacher motivation, and test scores (Kent 2015), benefiting human capital and employment outcomes. Over the long run, solar products cost less per day than alternatives such as kerosene lanterns, directly impacting the poor. Solar energy also creates an economic environment in which local businesses can thrive. Small shops can extend their business hours and satisfy more customers, schools and healthcare centers can offer better service, and the proliferation of solar power can diversify job opportunities. As economic activities pick up, the quality of life in rural communities would be improved along several dimensions, which can potentially reduce rural-to-urban migration and urban unemployment.

Solar energy impacts social inclusion by connecting isolated rural communities, facilitating societal participation, satisfying basic needs, and supporting gender equality. Because women and girls in developing countries perform the majority of unpaid household labor, they face disproportionate health risks from exposure to indoor air pollution, created by kerosene lamps and inefficient cooking and heating devices (WHO 2014). Lack of electricity leads to time poverty for women and girls, who must spend considerable amounts of time collecting alternative fuels, leaving little time for paid employment or education. Not only can access to solar energy free up time and money, but solar power production and distribution systems can also support women through the creation of jobs and social networks.

Growing concerns about climate change highlight the environmental impact of solar power. Solar power contributes to energy efficiency. It can reduce the energy impact on water supply, decrease human health hazards from air pollution, and cut down on greenhouse gases emitted by fossil fuels. Greenhouse gases contribute to temperature increases, adversely impacting agriculture, flora, and fauna. These temperature increases also contribute to less predictable weather patterns and more frequent natural disasters. Thus, as coastlines erode, climate migration is increasing. Through solar power uptake, 990,000 tons of greenhouse gases have been avoided around the world — the emissions equivalent of 190,000 cars (Lighting Global 2015).

Why Solar Power? Investment and Technology

All of these linkages help to explain why a variety of domestic and international sources have increased funds to simultaneously promote clean energy and fight energy poverty. The International Energy Agency (IEA) estimates that $13.1 billion in capital investment was directed toward improving energy access in 2013, a $4 billion increase from 2009 (IEA 2015). New public policies involve "de-risking" renewable energy investments and shifting their risk-reward profile to make them more attractive to private companies (CCIR 2011). In addition to direct financial incentives, public sector efforts cover areas such as institutional capacity building, streamlining permit

processes, training programs, and information campaigns (CCIR 2011). These efforts have encouraged research and development in renewable energy and led to rapid technological advances.

In the last two decades, rapid innovation boosted solar electrification in two distinct ways. First, both initial and operating costs of solar products are lower and continue to fall. Second, the overall quality and reliability of solar products have improved. Apart from affordability, quality factors such as durability and length of battery life are essential to the adoption of solar energy products by low income households, some of whom must give up several months of savings to make the initial purchase.

Another noteworthy technological change is the rise of mobile payments in the developing world (Hughes and Lonie 2007). These payments are relatively accessible to the poor and help facilitate the implementation of small-scale solar electrification projects by social entrepreneurs. New "pay-as-you-go" (PAYG) business models enable customers to use their mobile phones[2] to pay for electricity based on their needs and usage. Some even enable households to own a solar device outright after a certain number of payments. Such developments better enable communities to take ownership of their energy needs, switching from consumers-only to new roles of producers and owners.

Social Enterprise Response

The combination of increased institutional support, advances in technology, and drive for community ownership has opened the door for many social enterprises to take on the challenge of electricity access. Social enterprises may be for-profit, non-profit, or hybrid-model organizations, but they have one thing in common: the creation of social value, not wealth (Warnecke forthcoming). Solar-based social enterprise solutions to electrification vary along several dimensions, but in general, there are three distinctive approaches: (i) independent micro-grid projects, (ii) solar home system kits, and (iii) pico-solar systems.

Micro-grids are the most sophisticated and complex type, and the closest alternative to traditional on-grid electricity. They involve large fields of photovoltaic collectors and storage units, and a small-scale network to distribute the solar energy to subscribing households and businesses. One example is the Sharedsolar program, initiated by the Millennium Village Project in 2009. The system centrally generates solar energy and uses underground cables to connect up to twenty customers located within a one-hundred-meter radius (Hinsdale 2012). Customers can pay via their mobile phone, using prepaid scratch cards and text messages. The Sharedsolar program started as a pilot with the Pelangala Millennium Village in Mali in 2010 and spread to other Millennium Villages in Mali, Uganda, Kenya, Tanzania, and Haiti (Hinsdale 2012).

Solar home system kits are complete off-grid systems, independently installed for each customer. These systems typically include the solar collector (installed on the rooftop), a power storage unit (batteries), and several energy-efficient LED lights. They can also support small appliances like radios, televisions, fans, and mini-refrigerators. Solar home system kits tend to have the highest initial cost for the user, while micro-grids have the highest initial costs for the community. However, a number of social enterprises have developed innovative business models to meet the spending patterns of rural communities. For example, Mobisol offers Rwandan and Tanzanian customers a 36-month installment plan with the option to freely sell excess energy to help pay the bill (USAID 2015).

Pico-solar products are much smaller and cheaper systems. They consist of individual battery-operated devices that recharge through a small portable solar collector. Common pico-solar products include stand-alone LED light systems and chargers for portable devices. For the millions of low-income off-grid households, pico-solar products are the most attainable alternative. Thanks to their light weight and portability, they are relatively easy for non-specialist shops to carry and sell, even in remote communities. Hence, distribution and staff training are easier for social enterprises taking the pico-solar route.

Together, the three types of solar-based solutions have brought electricity to many off-grid rural communities in recent years. According to the World Bank Group's Lighting Global program, nearly fifty million people across the world have benefited from improved energy access through modern solar lighting products, and more than twenty million meet their basic lighting needs this way (Lighting Global 2015).[3] Entrepreneurs are reaping the financial reward of their innovative products as adoption and demand continue to grow. Navigant Research estimates that the pico-solar and solar home systems market will grow from $550 million in annual revenue in 2014 to $2.1 billion by 2024 (Gauntlett and Lawrence 2014).

Scalability

How can we extend the benefits of solar power to as many people as possible? This question leads us to consider issues of scalability.[4] As Madeline Gabriel (2014) explains, there are four common paths to scaling social innovation. The path that most people consider first is growing the organization: creating new branches or stores, or enabling the core team to reach a broader consumer base. However, several other paths to scale exist. Social innovations can be scaled through strategic partnerships (collaborations with private companies, governments, NGOs, foundations, and intergovernmental organizations). The establishment of new delivery networks (franchising, licensing, or micro-consignment) can enable social innovations to reach new populations. On a broader level, social innovations can be scaled through the spread of ideas, "know-how," and influence. This often provides an environment for new social enterprises to emerge and introduce the social innovation in their own areas.

Table 1 presents an overview of the four paths to scale and an example of an organization using each approach to scale the reach of solar power. However, a given social enterprise may use more than one path. An example can be found in M-Kopa Solar, an asset finance company facilitating "pay-as-you-go" solar power for households. Although M-Kopa Solar grew its organization and established new branches, it also formed a strategic partnership with Safaricom, a mobile network operator; this enabled M-Kopa Solar to benefit from Safaricom's brand recognition, its M-Pesa mobile banking system, and its large customer base (Wills 2015). The path to scale a given social innovation may change over time or include complementary strategies at a particular time.

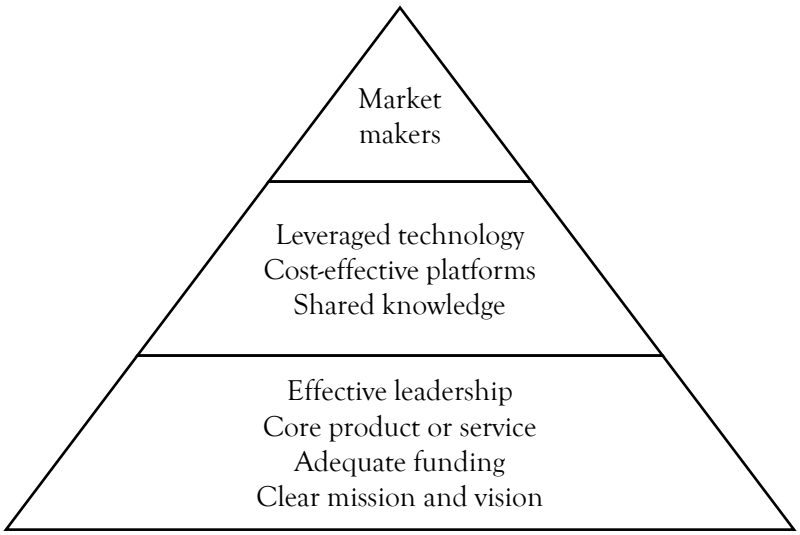
A.T. Kearney's Social Enterprise Accelerator model provides a template for scaling up social businesses, detailing required enterprise characteristics and the steps involved. As Figure 1 shows, the model includes three layers: (i) foundational elements, (ii) growth levers, and (iii) market makers. Foundational elements include a clear vision and mission, exceptional leadership, a core product or service, and adequate funding. Growth levers include leveraged technology, cost-effective platforms, and shared knowledge. Market makers revolve around changed attitudes and behaviors (A.T. Kearney 2015).

Table 1. Potential Paths to Scale for Solar Power Innovations

Path to Scale	Potential Strategies	Example	How does it work?
Spread knowledge, "know-how", and Influence	Campaigning; consulting; training	Saha Global	NGO trains local women to start profitable social enterprises in Ghana, including solar charging stations; each household in community receives battery-powered lamp; households pay to charge devices
Build a delivery network	Franchising; licensing; micro-consignment	Solar Sister	"Avon Lady" approach sells multiple brands of solar lamps; micro-consignment model operates in rural Uganda, Nigeria, and Tanzania; saleswomen receive initial inventory on loan and pay back loan with sales proceeds
Form strategic partnerships	Collaborating with public/NGO interventions; creating business alliances or joint ventures	D.light	Collaboration with Unilever corporation and UK Department for International Development; Perfect Solar Store Initiative in Kenya places solar lights in small stores stocking Unilever goods
Grow the organization	Establishing new branches; increasing delivery scope of core team	M-Kopa Solar	Focus on asset finance; "pay-as-you-go" solar system operation is linked to daily mobile-enabled micro-payments; based in Kenya with branches in Uganda and Tanzania

Sources: First two columns adapted from Gabriel (2014); Saha Global information from McNally (2015); D.light information from Acumen (2015); Solar Sister information from Heuër et al. (2015); M-Kopa Solar information from Wills (2013).

Figure 1. Social Enterprise Accelerator Model



Source: A.T. Kearney (2015, 4).

We can better understand the components of the Social Enterprise Accelerator model by considering how they relate to a successful social enterprise in the solar power realm — M-Kopa Solar. This deepens the discussion of M-Kopa Solar from Table 1, moving beyond a general path for scaling and considering concrete steps for growing the organization. As Table 2 reveals, M-Kopa Solar has been able to capitalize on each aspect of the accelerator model. Leveraging technology via mobile banking has played a particularly large role in M-Kopa Solar's scalability.

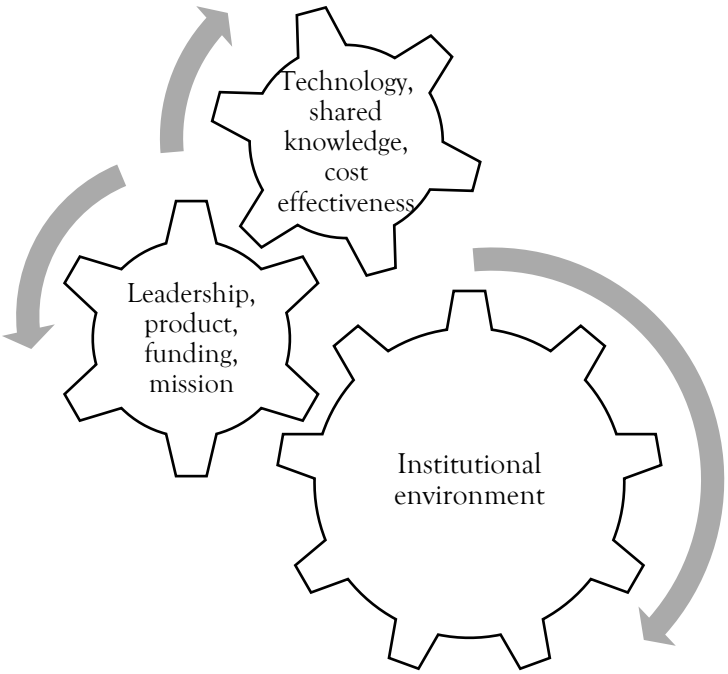
Although it is helpful for conceptualizing scalability, the Social Enterprise Accelerator model is missing a broader institutional perspective of social enterprise operations. The current model places the institutional environment at the top of the pyramid. In reality, all pieces of the model are embedded in a complex institutional system, including (for example) the regulatory environment and cultural environment. The regulatory environment impacts all stages of business operations, and the ambiguous legal status of social enterprise in many countries presents a major challenge (Warnecke 2016). The cultural environment refers to values and beliefs about entrepreneurship and social entrepreneurship in a particular society (Urban 2013). Not all countries have positive perceptions of entrepreneurship, and the social and environmental contributions of social entrepreneurship may themselves be undervalued (Creech et al. 2014). Figure 2 presents a more institutionally grounded model of scalability. This model includes the components of A.T. Kearney (2015), but shows that the entire business operation is impacted by (and will impact) the broader institutional environment.

Table 2. Application of Social Enterprise Accelerator Model to M-Kopa Solar

Component of Social Enterprise Accelerator Model	Application to M-Kopa Solar
Clear Vision and Mission	"Make high quality energy affordable to everyone" (M-Kopa Solar 2013). Provide "pay-as-you-go" solar energy for consumers lacking electricity.
Exceptional Leadership	M-Kopa Solar's three co-founders bring an array of complementary skills, including development of the M-PESA mobile banking system; experience with technology-based ventures; directorship of a mobile development fund; and management of a microfinance investment fund.
Core Product or Service	The M-Kopa IV Home System includes: • 2 LED lights with switches and multiple brightness settings • 1 LED portable solar torch light • Phone charging USB with 5 standard connections • Solar radio • 8W solar panel
Adequate Funding	M-Kopa Solar has received investment since 2010, and won the African Enterprise Challenge Fund competition for renewable energy in 2012. It has several equity investors, lenders (e.g. Commercial Bank of Africa), and grant providers (e.g. UK Department for International Development). In December 2015, M-Kopa Solar concluded a $19m financing round.
Leveraged Technology	Uses mobile payment systems to disrupt payment and service delivery for household solar power. This eliminates a large up-front payment for a solar panel. The "pay-as-you-go" system enables a smaller initial payment with incentives to pay regularly to continue receiving solar power benefits.
Cost-effective Platforms	M-Kopa Solar increases consumer demand through its partnership with Safaricom (a telecom operator); this also "reduced pricing for mobile payments by sharing promotional costs, distributing products in Safaricom stores, and sharing revenue" (Groe 2015).
Shared Knowledge	M-Kopa Solar has cultivated relationships with a wide variety of foundations, governments, private lenders, and other social enterprises. In January 2015, the company was honored by the $1.5m Zayed Future Energy Prize for small and medium enterprise. This prize is funded by the United Arab Emirates.
Changed Attitudes and Behaviors	M-Kopa Solar's fast growth and relationships with institutions in a variety of economic sectors have increased awareness and support for the diversity of solar power options for off-grid customers.

Source: Compiled by authors.

Figure 2. Institutional Model of Social Enterprise Scalability



Source: Compiled by authors, based on A.T. Kearney (2015).

Moving Forward: Challenges and Opportunities

On December 12, 2015, a landmark climate change accord (the Paris Agreement) was approved by 196 nations, committing developed and developing countries alike to reduce greenhouse gas emissions. The stakes are high, but renewable energy sources such as solar power can help countries achieve their individual targets. Social enterprises are already taking advantage of opportunities to bring light to millions around the world, and the demand for solar electrification is steadily growing. A variety of solar products exist, and there are multiple paths to scale these social innovations and bring the world closer to universal electricity access. In so doing, solar power contributes to the economic, social, and environmental dimensions of sustainable development.

However, solar products still face significant challenges that may hamper adoption goals. Access to finance is a natural obstacle, especially for the poorest. Quality assurance is also a challenge. The availability of poor quality competing products on the market can slow adoption by increasing the risk of financial losses associated with switching to solar solutions. Other challenges include lack of technical skills, administrative barriers, political instability, and property rights issues, especially land rights.

Much needs to be done. Social enterprises alone cannot solve any development problem, including energy poverty. As one type of actor among many political, economic, and social actors, social enterprises need to work in concert with and be supported by those actors and the broader institutional environment, particularly where public sector energy policy and investments are concerned.

Footnotes

[1] This conceptualization of sustainable development follows the UN Development Programme (UNDP 2012).

[2] In Sub-Saharan Africa, mobile phone penetration is rapidly growing (GSMA 2014). Infrastructure for telephone landlines is often absent or underdeveloped.

[3] Lighting Global is the World Bank Group's program initiated in 2007 to support the development of modern sustainable energy solutions for off-grid populations. It has three regional affiliates: Lighting Africa, Lighting Asia, and Lighting Pacific (Murphy and Sharma 2014).

[4] See Christiana Weber, Arne Kroger, and Kathrin Lambrich (2012) for a literature review on scaling social enterprises.

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