SUMMARY REPORT

REACHING THE LAST-MILE: WOMEN'S SOCIAL AND SUSTAINABLE ENERGY ENTREPRENEURSHIP

FEBRUARY 2018

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SOLAR SISTER

wPOWER
PARTNERSHIP ON WOMEN'S ENTREPRENEURSHIP IN RENEWABLES

About Us

CITE, the Comprehensive Initiative on Technology Evaluation at the Massachusetts Institute of Technology (MIT), is a program dedicated to developing methods for product evaluation in global development. CITE draws upon diverse expertise across MIT and globally to evaluate products and build an understanding of what makes different products successful in emerging markets. The United States Agency for International Development (USAID) had funded much of the work CITE has completed to date. For more information, see http://cite.mit.edu.

Solar Sister, a social enterprise with operations in Nigeria, Tanzania, and Uganda, works to eradicate energy poverty while also empowering women with economic opportunity. A deliberately woman-centric direct sales network that brings clean energy technology to remote communities in rural Africa, Solar Sister's vision is to provide light, hope, and opportunity for everyone, everywhere. Since its inception in 2010, Solar Sister has recruited and trained over 2,600 women entrepreneurs, reaching an estimated 877,000 beneficiaries. For more information, see http://solarsister.org.

wPOWER, the U.S. Department of State's Partnership on Women's Entrepreneurship in Renewables program, seeks to shine a light on and expand the role of women in clean energy entrepreneurship and in addressing climate change through the diffusion of clean energy technologies and services. By 2018, the wPOWER program aims to empower 8,000 women in clean energy entrepreneurship to deliver clean energy access to 3.5 million people. Research for this report was made possible through a grant from wPOWER. For more information, see http://wpowerhub.org.

This summary report and the full report can be accessed online at http://bit.ly/LastMileEvaluation.

INTRODUCTION

Throughout rural Sub-Saharan Africa, grid electricity coverage remains sparse. In Tanzania, the site of this study, 33% of the population and only 4% of rural areas has access to electricity. Even where available, expensive connection fees and monthly utility bills make grid electricity too expensive for many low-income households. Several organizations are trying to fill this energy gap by providing rural households with affordable off-grid energy options, such as solar lighting. But are organizations really reaching last-mile customers? In addition, are these customers' preferences being taken into account?

This report addresses these questions through analysis of the social enterprise Solar Sister. Solar Sister recruits and trains a network of women entrepreneurs—Solar Sister Entrepreneurs, or SSEs—to sell solar lanterns. The focus on local women aims to serve two purposes. First, it aims to promote gender empowerment through economic opportunity. Second, it aims to invest in locally embedded SSEs who can, in principle, use their social networks to reach customers that other types of business models cannot.

The findings reveal that, first, based on a three-indicator last-mile index (LMI) Solar Sister is indeed reaching remote households. Second, rural customers in the areas where Solar Sister operates have few alternative options for clean energy. Solar Sister thus plays a crucial role in bringing clean energy to communities that other organizations are not reaching. Third, some indication exists of a bias against saleswomen, underscoring the role gender-conscious interventions may play in combatting such prejudice. Finally, rural customers appear to place considerable importance on the social aspects of a purchase, such as whether local after-sales service is available and whether a salesperson is someone familiar and trusted. This preference far exceeded even the financial consideration of paying for a product in installments, validating Solar Sister's approach to champion locally-embedded entrepreneurs.

More broadly, most research on the relationship between gender and clean energy measures the effect of energy technology access *on* women: women as beneficiaries. Instead, this report describes the impact *of* women on energy access: women as facilitators. It thus addresses an important research gap and builds the evidence base for integrating women into the clean energy value chain.

RESEARCH OBJECTIVES AND DESIGN

Table 1 shows the research objectives and design. These were developed through an iterative process with MIT-CITE researchers and Solar Sister staff in Washington, D.C. and Tanzania. The research took place in 28 villages in four regions throughout central and western Tanzania.

To meet the first objective, 260 SSE customers were surveyed to collect data on their poverty level, grid infrastructure access, and physical remoteness.[1] This information was used to calculate an LMI based on three indicators, as shown in Table 2. This approach captures the multi-dimensional nature of being last mile. The indicators and LMI, all on a scale of 0 (least last-mile) to 1 (most last-mile), determined the "last-mileness" of each surveyed customer.[2] In order to understand the relative availability of clean energy, respondents also identified where they could buy solar lanterns, other than through SSEs.

[1] While sampling was purposive, effort was taken to survey diverse households in order to achieve "as if" random sampling.
[2] More detailed explanations of the indicators and how they were calculated can be found in the full report.

Objective	Research question	Sample population	Sampling method	Research instrument	Measure[3]	*N*
(1) Efficacy of social enterprise	Is Solar Sister reaching last-mile customers?	Solar Sister customers	Purposive	Survey	LMI, solar lantern access	260
(2) Preferences of rural residents	What sales options do rural customers prefer?	Rural households in Solar Sister-adjacent villages	Random walk stratified by sub-village	Survey with embedded experiment	AMCE	350

Table 1: Overview of research objectives and design

To meet the second objective, SSEs identified villages near their own where they had not attempted any sales. Researchers randomly selected households to survey in these non-Solar Sister villages. In addition to collecting data to measure their last-mileness and clean energy access, the 350 non-customers participated in a conjoint experiment. Respondents were presented with two salespeople who had been assigned randomly varying characteristics, or attributes, that could take on one of two values, or levels (see Table 3). They were then asked to choose from which salesperson they would prefer to buy a solar lantern. This process was repeated four times, for a total of five rounds. The four attributes chosen represent characteristics of Solar Sister's business model (familiar saleswomen who can offer local assistance), as well as of other organizations selling household solar lanterns (multiple payments over time). In administering the conjoint experiment in Solar Sister-adjacent villages, the intent was to find respondents similar to those that SSEs are reaching but who have no direct contact with Solar Sister, so that their preference choices would not be influenced by such interaction.

Indicator	Code	Explanation
Poverty level	P	Inverse of Progress out of Poverty Index® (PPI) score[4]
Grid access	G	Self-reported proximity to a grid connection
Remoteness	R	Self-reported distance from nearest highway
Last-mile index	LMI	Mean of P + G + R (equal weighting)

Table 2: Last-mile index (LMI) and its component indicators

Conjoint experiments elicit respondents' preferences for a certain product or service without asking them about each attribute-level directly. This has the benefit of avoiding social desirability bias, where respondents provide researchers with answers they think the researchers want to hear. It also has the advantage of being a more realistic choice: that is, selecting between two salespeople rather than between two attributes.

[3] LMI: Last-mile index, discussed further in the Reaching Last-Mile Customers section. AMCE: Average Marginal Component Effect, discussed further in the Understanding Rural Customers' Sales Preferences section.

[4] PPI is an asset-based measure of a household's wealth, based on a 10-question survey specific to each country that computes the likelihood that the household is living below the poverty line. A higher PPI score indicates greater progress out of poverty.

Attribute	Level
After-sales assistance	Assistance available via phone, local assistance unavailable In-person local assistance available
Familiarity	Do not know the salesperson Know and trust the salesperson
Gender	Male salesperson Female salesperson
Payment	Single payment of 15,000 TSh ($6.70) Multiple payments, 6 of 4,000 TSh ($1.80) each (24,000 TSh, $10.80 total)[5]

Table 3: Salesperson attributes and levels for conjoint experiment

REACHING LAST-MILE CUSTOMERS

Figure 1 contains boxplots of the distributions for each indicator and the LMI. Values closer to 0 indicate less last-mile along that dimension, while values closer to 1 indicate more last-mile. Boxplots whose distributions are skewed toward 1 indicate that the sample population is more last-mile: poorer, less access to grid infrastructure, and more physically remote.

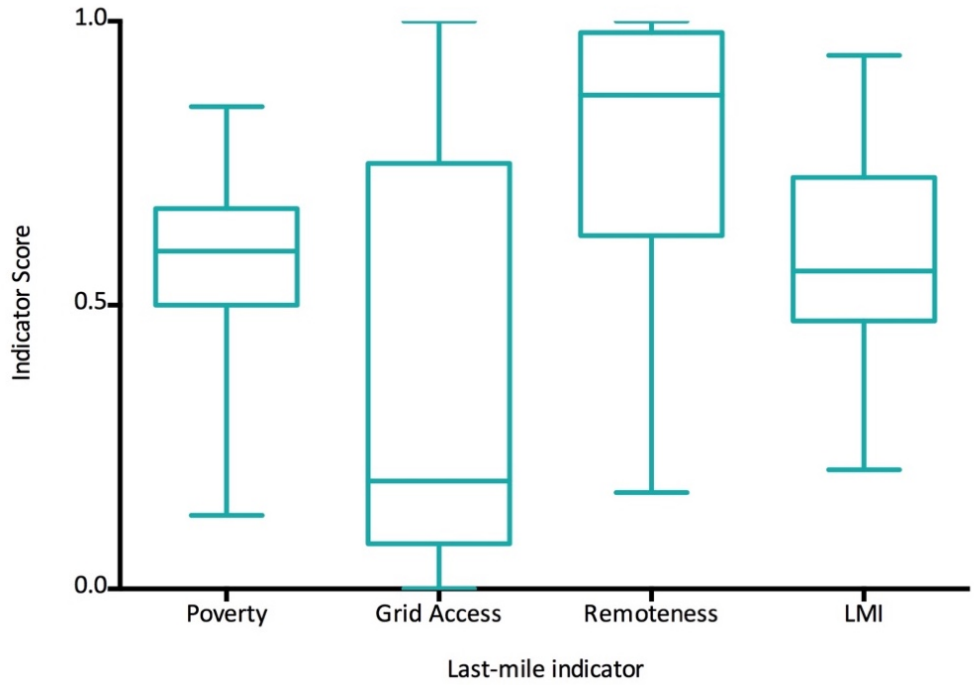

Figure 1: Last-mile indicators and LMI for SSE customers. Boxplots show minimum, 25th percentile, median, 75th percentile, and maximum.

For poverty level, the customer distribution has a median of 0.6. Relative to the $2.00-a-day poverty line (2005 PPP), this means the median customer's household has between a 64% and 77% likelihood of living

[5] Additional mark-up for payment in installments based on figures reported in Gong et al. May 2017. "Pay as you go solar as a means to combat energy poverty." School of International and Public Affairs, Columbia University.

in poverty. That is, the median customer is more likely than not to be living in poverty. Grid access scores are generally low, indicating relative proximity to grid infrastructure. Further, quartile three (50th-75th percentile) covers a wide score range, from 0.2 to 0.7. This may be due to the fact that 62% of customers reported that a grid connection existed in their village. The distribution of the remoteness score shows significant variation in distance from the highway. However, the median is 0.87 and more than half of the customers surveyed are relatively physically far removed from the highway, with scores greater than 0.5.

Taking the three indicators above and combining them with equal weighting generates the LMI score. Notably, the LMI median is 0.56. At just above 0.5, this indicates that most Solar Sister customers in our sample are more last-mile than are not.

In addition to the LMI analysis, customers and non-customers were asked about their alternative sources for solar lighting products. This included whether they had heard of, have access to, or have purchased solar lighting from any individual or organization other than Solar Sister. Monthly and weekly village markets and traveling salesmen were the main sources for household solar lighting products, accounting for 80% of purchases.[6]

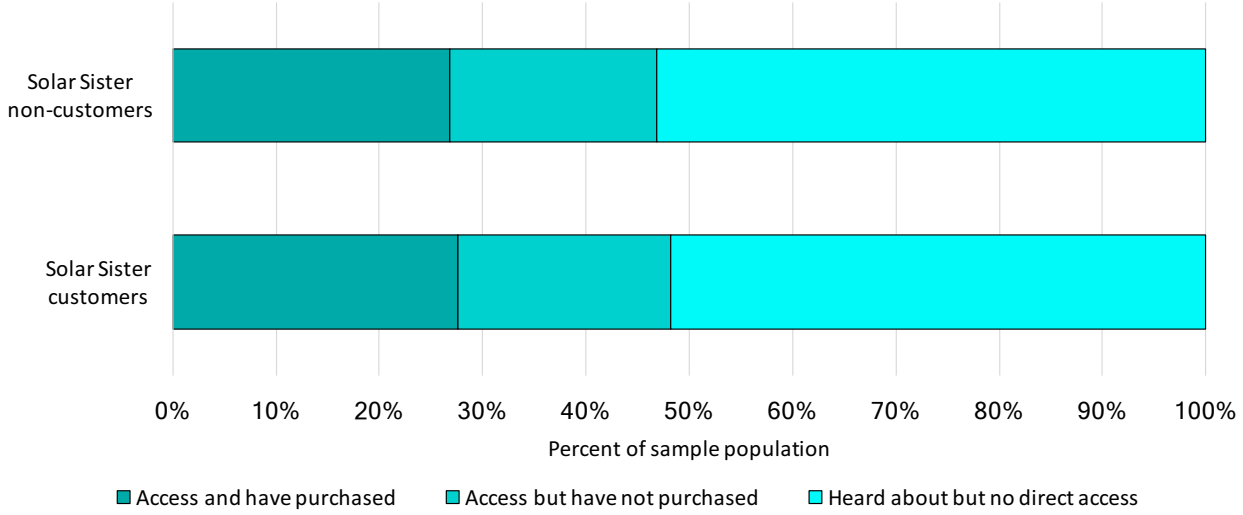

Figure 2: Differing levels of access to solar lighting. For Solar Sister customers, access is to solar lighting sources other than Solar Sister.

Figure 2 reports the results across all solar lighting providers mentioned. The majority of customers and non-customers had only heard about alternative lighting sources, without direct knowledge about where to purchase them. Few people said they had purchased anything from an individual or organization offering solar products. The providers mentioned the most, both in terms of purchases and hearsay, were M-Power/Zola and Mobisol. Both of these private companies sell large solar home systems and so do not offer a direct alternative to Solar Sister, whose primary product focus is household solar lanterns.[7]

[6] However, some respondents noted that the quality of products is often poor or questionable from these sources. Further, the nature of traveling salesmen also means that in-person after-sales assistance is unlikely.

[7] Further, several respondents noted having installed these systems, or having known someone who had, only to later discontinue use after the recurring monthly cost became too expensive.

Taken together, the LMI analysis and data on access to alternative lighting providers offers evidence that Solar Sister's women entrepreneurs are penetrating into last-mile markets and communities that have few alternatives for reliable and affordable clean lighting products.

UNDERSTANDING RURAL CUSTOMERS' SALES PREFERENCES

Figure 3 shows results from the conjoint experiment. The average marginal component effect, or AMCE,[8] represents the average difference in the probability of one attribute level being preferred to a baseline attribute level. These probability differences can be interpreted as preferences for an attribute level as compared to the baseline. The AMCE for the Assistance attribute, therefore, shows that there is a 31-percentage point preference for a salesperson who provides local assistance over an otherwise identical salesperson who cannot provide such assistance. Similarly, a salesperson who is known and trusted is preferred by 24 percentage points over one who is unknown to the customer. Both of these preferences, for local assistance and for a salesperson who is familiar, are large in magnitude and statistically significant,[9] inspiring high confidence in these results.

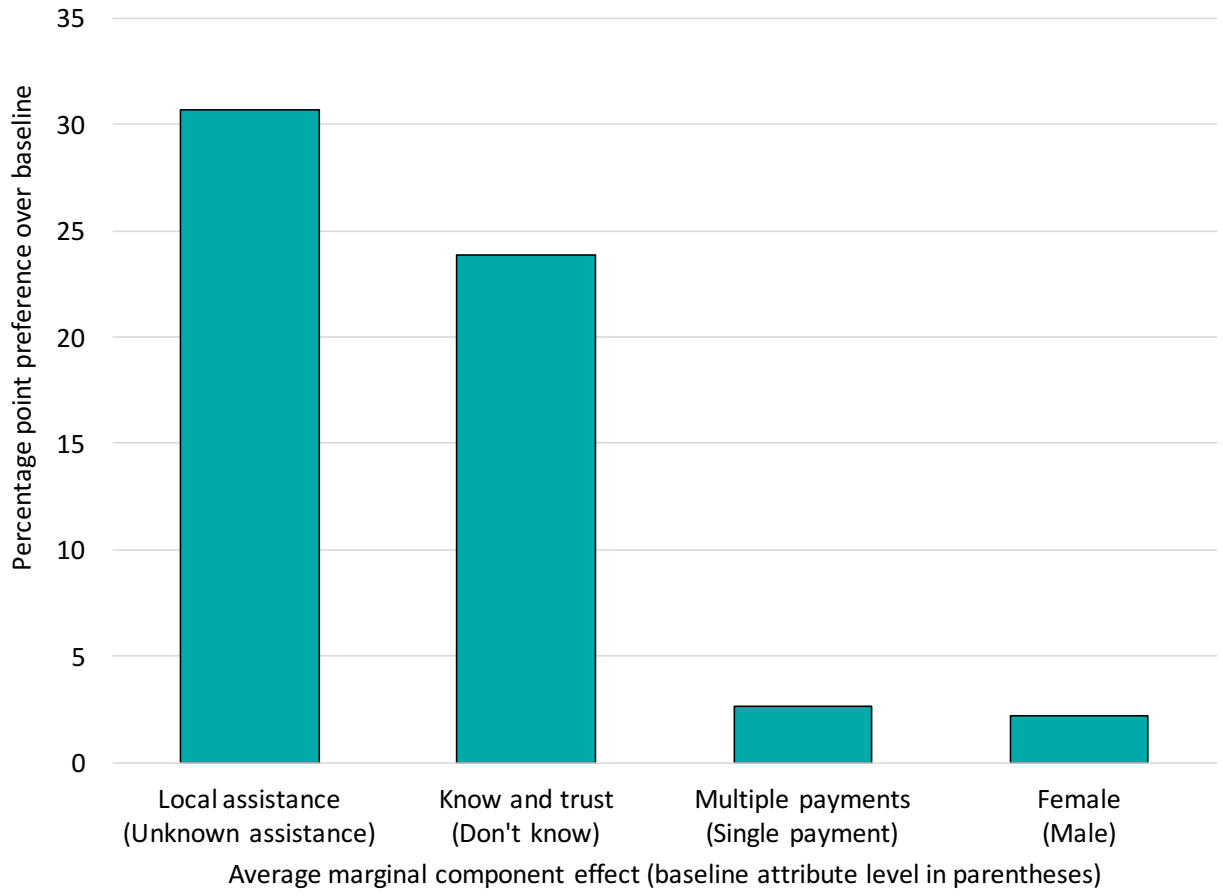

Figure 3: Rural customers' sales preferences

[8] The AMCE analysis follows the method developed by: Hainmueller J, Hopkins D, and Yamamoto T. 2014. "Causal Inference in Conjoint Analysis: Understanding Multidimensional Choices via Stated Preference Experiments." Political Analysis 22(1): 1–30.
[9] $p < 1.10E\text{-}64$ for assistance and $p < 2.00E\text{-}40$ for familiarity.

In contrast, the preference for multiple payments over one lump sum payment (5 percentage points) and that for a female salesperson over a male one (3 percentage points) are relatively small in magnitude and not statistically significant.[10]

The AMCEs can also be analyzed for different respondent subgroups, such as by LMI score or by gender, as well as for six possible two-way interactions between attributes.[11] The conjoint results for respondent subgroup suggest that as LMI increases—that is, as respondents become more last mile—preference for local assistance and a familiar salesperson remains stable. In contrast, as LMI increases, the gender preference of the salesperson switches from female to male, and the preference for multiple payments over a single payment increases slightly.[12]

Categorizing the results by respondents' gender shows that females preferred local assistance 33 percentage points more than unknown assistance; for males, the preference was 27, or 6 percentage points less than females. Female respondents had a slightly greater preference for female salespeople (3 percentage points) than did male respondents (0.6 percentage points). Familiarity was equally as important for male and female respondents at about 24 percentage points, while females had a slight preference for multiple payments (5 percentage points) and males had a small preference for single payment (0.6 percentage points).[13]

In terms of interaction effects, all six were small in magnitude and statistically insignificant. With that caveat in mind, however, they suggest a pattern of bias against women salespeople. All three interactions with the gender attribute reveal a slight preference for males over females. More specifically: a male offering no local assistance is preferred over a female who can offer local assistance; a male who is unfamiliar is preferred over a female who is known; and a male who can offer a single payment scheme is preferred over a female who offers multiple payments. While perhaps discouraging, this result also points to the importance of empowering women through entrepreneurial activity, which may help dissuade such pervasive bias.

Taken together, these results indicate that rural customers value social considerations above and beyond financial ones. Organizations that aim to reach the rural poor should take social context into account when crafting their business models. Solar Sister's model, which trains and recruits local women entrepreneurs, fits the preferences of rural customers, who strongly favor local assistance from someone with whom they are familiar. Moreover, Solar Sister may be helping to fight against a gender bias that views men as more suitable businesspeople.

[10] $p < 0.28$ for payment and $p < .22$ for gender.

[11] An interaction measures the differential effect that the value of one variable has on the value of another variable. For instance, does local assistance matter more when choosing a male salesperson? The six possible two-way interactions are between: assistance and gender, assistance and familiarity, assistance and payments, gender and familiarity, gender and payment, and familiarity and payment.

[12] The results for gender and payments are not statistically significant and so should be interpreted with caution.

[13] These results for assistance and familiarity were statistically significant at $p < 0.01$, while those for gender and payment were not statistically significant, with $p > 0.1$.

CONCLUSION

This study finds that Solar Sister appears to be meeting its goals to reach rural last-mile customers and to operate in underserved communities. Further analysis shows that, when considering a purchase of a solar lantern, certain social considerations prevail over financial ones by a factor of at least five. Rural villagers thus place great importance on local, in-person after-sales assistance and close familiarity with a salesperson, much more so than the flexibility of being able to pay in installments over time. Yet, not all salespeople may appear equal in the eyes of rural villagers, who may possibly discriminate against women when it comes to their involvement in social entrepreneurship. Based on these findings, Solar Sister's focus on supporting women entrepreneurs in their local communities proves well-founded—not only as a socially appropriate model, but also as a means to counteract an enduring gender bias.

This study provides new empirical evidence on the relationship between gender and clean energy promotion in developing contexts. As meaningful as the findings are, additional research could build on them to elucidate further insights. Replicating the methods used in this study, whether the last-mile indicators and LMI or the conjoint experiment, in other countries and contexts will offer several advantages. For one, doing so would help achieve a more nuanced and robust understanding of how women-centric social enterprises perform, exposing both strengths and weaknesses of such a business model. Further research along these lines would also reveal the extent and nature of biases against women salespeople. Finally, it would help gain insight as to whether the findings regarding rural customers' preferences presented in this report are universal or whether they are conditional on additional context-specific characteristics.

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Front cover: A Solar Sister Entrepreneur walks to visit one of her customers in rural Tanzania.
Photo credit: Jonars B. Spielberg