Preliminary Impact Analysis:
Kuyere Solar System Distribution,
MChinji, Malawi

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Summary

Kuyere! is a social enterprise dedicated to the distribution of efficiently subsidized solar electric systems to accelerate poverty reduction in rural Africa. To evaluate the potential cost-effectiveness of its approach, the enterprise conducted a small, preliminary impact study to measure the impact of its current solar system design on household economics. In the survey, itemized data was collected on total household consumption spending both before and after acquisition of the solar system, along with data on changes in spending on the energy-related items: disposable batteries, candles, and cell phone charging. Sixteen of seventeen households reported that spending on batteries, candles, and cell phone charging dropped to zero after acquisition of the solar system because the system provided for all of their major lighting and cell phone charging needs. In addition, some households reported providing cell phone charging to family or neighbors who lived outside of the household. The cell phone charging services were usually provided for free, but sometimes households earned a monetary fee (i.e. 50 MWK per charge or approximately $0.07) from their neighbors. Average total monthly savings was reported to be approximately $5/month or 6.5% of total household spending. Given a total all-in cost for the solar system (including marketing and subsidy solicitation and processing) of $50, this represents a 10-month simple payback time for the total solar system investment.

Introduction

Kuyere! (Kuyere.com) is a social enterprise dedicated to the development of a solar system production and distribution network in Africa that can accelerate rural African poverty reduction. The enterprise began work in Malawi in early 2015, when it conducted a pilot project of a preliminary system design for over 100 households in Sept/Oct of that year.

Since that time, the enterprise has innovated on the system design and the distribution and sales model to the point where it launched a version 2.3 system that consists of:

- Three 150 candela Malawi-made LED light bulbs with individual Malawi-made wall light switches and master dimmer switch
- Two 3300 mAh LiFePO4 batteries in a Malawi-made battery pack with voltage display and over-voltage control
- One 5W solar panel, Malawi-hacked to provide analog voltage control
- One fast phone charger connection that can deliver >1A charging rate to smart phones and more than 10 Wh/day of phone charging energy
- 15 meters of wiring and custom home installation

This system is designed to provide most of the major household lighting and phone charging needs for a typical rural Malawian household.

The sales and distribution model consists of group distribution to villages with different levels of subsidy corresponding to the different willingness to pay levels of the customers. Systems are offered at deep discounts but only a limited number of systems are offered. The opportunity to buy the solar systems at a discounted price are allocated via lottery with the chance of a purchase opportunity decreasing with the size of the discount. Villagers who want to buy the system at a price of $7 have a 1 in 10 chance of being able to make a purchase. Villagers wanting to buy a system for $14 have a 1 in 3 chance of being able to make a purchase. Meanwhile any villager that does not win their respective lottery can buy a system at a moderately subsidized price of $21 if they sign up at the day of the lottery. The purchase price of the system is due on the day of the installation. If the villager does not have the cash ready on the day of the installation, the system is not installed and they lose their purchase opportunity. Typically, if villagers do not have the money on the day of the installation, they give their purchase opportunity to a neighboring friend or family member that then purchases the solar system at the discounted price.

Data Collection

Approximately 100 Kuyere solar systems were installed in November 2017 in multiple villages. To collect data on household economic impacts, on two days in January 2018, economic survey data was collected on randomly selected household in two villages: Village A and Village B.

The survey asked households regarding the number of adults and children in each household, and asked a number of detailed questions regarding spending on different food and consumption items in November 2017 before the household obtained the solar system. After detailed data is recorded regarding spending before the solar system acquisition, the household is asked if spending is the same in the present time (i.e. January 2018). Spending sometimes changed due to changes in prices, or to changes in quantities purchased. The final question—assuming that they noted savings from the solar system--was what they thought the monetary savings from the solar system (typically decreased battery expenditures and cell phone charging spending) were now spent on.

Results

In this section we present the results of the preliminary impact survey. First we provide a summary of the data collected, and then we perform some tentative statistical analyses.

Data Collected

Table 1 summarizes the spending data collected in the survey. The sample size is very small, but the data may still provide useful data if the variability in the data is sufficiently small.

First, it is notable that the size of the surveyed households is quite different in the two villages. Village B has a couple of very large households, and Village A has a relatively large sampling of small households. The anecdotal observation is that Village A had more households that consisted of young couples that had one small child or no children, while Village B had a sampling of households with older parents with many children.

On most items, spending appears to be relatively consistent between the two villages, but with Village B spending more on corn, sugar, cooking oil , salt and onions. Village A appears to spend more on goat/pork and fish.

Table 1: Household spending in surveyed villages

(N=9 for Village A, N=8 for Village B)

	Village A	**Village B**	**Before**	**After**
Adults	2.00	1.88	1.94	1.94
Children	1.75	4.63	3.19	3.19
Spending Item	$/month	$/month	$/month	$/month
corn	$5.36	$19.04	$11.48	$12.03
beans	$11.79	$9.85	$10.18	$8.24
oil	$3.32	$5.44	$4.12	$4.26
sugar	$5.21	$7.66	$6.06	$6.90
salt	$0.59	$1.44	$0.95	$1.04
onions	$0.64	$1.12	$0.83	$0.79
tomatoes	$2.48	$3.53	$2.83	$3.06
other veg.	$3.31	$4.17	$3.52	$3.31
milk	$1.88	$2.51	$2.07	$2.82
eggs	$7.98	$7.35	$7.22	$6.59
fish	$4.16	$3.65	$3.68	$4.73
chicken	$5.99	$6.22	$5.74	$6.01
goat/pork	$10.08	$4.87	$7.04	$6.70
batteries	$2.60	$3.41	$2.83	$0.37
candles	$1.56	$0.46	$0.95	$0.00
phone credit	$1.90	$3.57	$2.36	$3.64
phone charging	$0.79	$1.79	$1.21	-$0.26
soap	$3.14	$3.55	$3.15	$3.61
medicine	$1.86	$4.26	$2.88	$2.11
other	$1.22	$2.28	$1.83	$2.50
TOTAL DAILY	$2.53	$3.06	$2.67	$2.57
TOTAL MONTHLY	$75.87	$91.79	$79.97	$76.99
INCOME/CAP	$20.23	$16.70	$17.79	$17.16
Income $/cap/day	$0.67	$0.56	$0.63	$0.57
Energy Spending	$4.95	$5.66	$4.99	$0.11
% Electricity/light	7.74%	6.47%	6.91%	0.37%

The difference in spending between the two villages may be consistent with the differences in household composition where households in Village A spends more on higher quality more expensive food because there are relatively more adults per household on average, and Village B spends more on basic foodstuffs because of the larger number of children in the household.

The average data for before vs. after also shows the large drop in energy related consumable spending of disposable batteries, candles, and phone charging. Note that when after obtaining a solar system a household gave phone charges to family and neighbors, this was recorded as negative expense (i.e. effective income) at the value of the phone charges given to others.

What can also be seen in the average spending numbers is that the drop in energy spending of $4.9 which corresponds to an average of 6.5% decrease relative to total consumption spending.

While it is not statistically significant given the small sample size, we note that the averages reported in the table indicate that average spending per household dropped $3, or 3.8%, while some items have potential spending increases. Notable amongst these are increases in spending on phone credit of $1.28 per month, increases in fish spending of $1.05/month, increases of spending on sugar of $0.84 and increases in other spending of $0.67 (e.g. scones). A much larger sample size would be needed to measure such spending changes with any precision.

In the next section, we analyze some of these changes and discuss their potential statistical significance.

Analysis

To test the significance of any measured spending changings, we fit the data to a very simple regression model:

$$\textit{Spend} = A + B * \textit{Adults} + C * \textit{Children} + D * \textit{Binary}$$

Where spend is the amount of spending, B is a coefficient that says how much spending increases with the number of adults. C is the same coefficient, but with regards to spending relative to the number of children, and D is the coefficient that indicates how much spending changes from before to after the installation of the solar system (i.e. from November 2017 to January 2018).

We examined total spending, spending on basic food items (corn, beans, cooking oil and vegetables), spending on protein food items (milk, fish, chicken and goat/pork), spending on energy consumption items (batteries, candles, and phone charging), and spending on other items (soap, medicine and other).

Only for one category of spending did the coefficient of *D* have a statistically significant non-zero value, i.e. energy spending. The regression model showed a $5.19 drop in energy spending with a 95% confidence interval between $3.51 and $6.58.

Other spending categories showed statistically significant correlations with either the number of adults or children in the household but not with the time period. For example, basic food item spending correlates with the number of children with spending $4.18 per child with a 95% confidence interval of $1.96 to $6.39. This result is interesting in that it means that the amount of energy savings from the solar system is approximately equal to the spending needed to support basic food for one child.

Protein food spending shows a positive correlation with the number of adults with greater meat and protein spending with more adults in the household.

Other spending (soap, medicine and other) shows a statistically significant correlation with the number of children with $1.13 in extra spending per child with a 95% confidence interval between $0.45 and $1.81.

Conclusion

In this study, we examine the impacts of the latest version of Kuyere solar home systems on household economics in rural Malawian villages. The Kuyere solar systems provides between 10 to 20 Wh/day of delivered solar electricity in the form of lighting and phone charging for a total, all-in cost of $50 per household.

A preliminary survey of before and after expenditures of 17 village households in two villages (9 in Village A and 8 in Village B) indicates that households save on average $5/month in energy expenditures in the form of decreased disposable battery, candle, and phone charging expenses. The 95% confidence interval for this preliminary estimate is $3.51 to $6.58 dollars in monthly savings.

A statistical analysis of the survey data also provides an indication of the marginal spending that households in rural Malawi villages make when they have additional children to support. This spending appears to consist of $4.18 per child on basic foodstuffs, and $1.13 per child on additional soap, medical care and miscellaneous expenses. This apparent marginal spending for one child appears to be approximately the monthly savings on energy-related expenses that the household experiences when it obtains a Kuyere solar system.

Given the $50 total cost of the Kuyere solar home system, the savings corresponds to a 10 month payback time on investment, and appears to be a highly cost-effective investment that can substantially help reduce poverty in rural Africa.