Energy and Economic Growth
Applied Research Programme

Letter of Intent

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(Max 3 pages)

UKaid from the British people

Oxford Policy Management

Introduction

To maximize the cost-benefit of investing in solar energy, a load should be kept on the panel so that it is producing the maximum amount of power at all times. Our 100 W Solar-powered insulated electric cooking system cooks dinner for a family of four to eight and provides electricity for household use and local grid.

We have developed and are introducing in Malawi and Uganda, a low-cost method to cook using solar electricity, (Insulated Solar Electric Cooking - Tomorrow's Healthy Affordable Stoves?, T. Watkins*, et. Al., Development Engineering 2 (2017) 47–52. See associated video). More recently, we added capability allowing the user to share the electricity for the cooker with other domestic purposes, or sell excess electricity to a neighbour or the grid.

We currently estimate that a solar home system with the cooker, lights, phone charging and AC (inverter) electricity can be assembled and sold in Malawi for approximately $150 for a 100 Wp system and $200 for a 200 Wp system. If the initial purchase price can be spread over 10 years (without interest), this corresponds to an electricity cost of $0.20/kWh to $0.14/kWh (for the 100 Wp and 200 Wp system respectively), assuming only 2 hours/day of average rated panel output, with a lower cost in places with better solar exposure. For the past 50 years, the price of solar panels has roughly halved every five years, and our costs per kWh will continue to decrease with the decreasing price of solar panels. For much of rural Africa, these costs are lower than the marginal cost of the utility-supplied electricity. Thus, under the least-cost principle of utility regulation and policy, rural customers with these low-cost solar home systems should be providing electricity to the utility as much as consuming electricity flowing from the utility. But most rural Africans do not have access to capital financing and up-front cash for the purchase of such least-cost electricity systems. This provides potential for creating mutually beneficial arrangements between the utility and low-income rural households that want to own a low-cost solar home electrical system.

In fact, creating models where low-income distributed customers can sell relatively small amounts (e.g. 1 kWh/day) of their unused low-cost electricity back to the grid in a least-cost fashion would be a great benefit toward efficient regulation of utility monopolies. Creating such models will become more urgent over the coming years, as distributed solar costs continue to decline, and as nearly 100 million new rural African customer households get access to electricity over the next decade: with or without the help of the national utility.

In this research, we test scenarios by which subsidizing these solar home systems for low income rural households can become profitable investments for African electric utilities. Specifically, we analyse a model where utilities provide subsidies to new customers that are interested in purchasing solar electricity systems for their homes that include a solar electric cooker or solar electric water heater. The solar panels in these systems are sized somewhat larger than the minimum needed by the average household including cooking, but much larger than necessary without cooking. The user can choose to sell the excess electricity from the subsidized solar electric system back to the electric utility that provided the initial subsidy to the household system. The sell-back prices are non-zero to give the household a motivation to maintain the system, but still relatively low per kWh so that the utility can make a profit when redistributing the electricity. The low-priced solar electricity from distributed solar electricity customers is then resold by the utility to other customers at a profit that is used to pay back the original utility investment in subsidizing the household solar electric system purchase.

If such a model can be designed to be profitable for African utilities, then this may allow such utilities to rapidly increase electricity access for low income households using solar electricity. Because solar electric cooking largely replaces biomass cooking, our system should reduce deforestation and the combustion emissions associated with climate change and mitigate the 4 million annual respiratory deaths from indoor air pollution.

Principal Investigator

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Research team

Pete Schwartz, Cal Poly Physics Professor; Nathan Heston, Cal Poly Physics Lecturer, Robert Van Buskirk (CEO, Kuyere!)

Title

The future of Africa's green electricity grid: Can subsidies for low income household solar capacity be profitable over the long term?

EEG theme

Our project seeks to increase grid resilience and reliability through distributed generation of renewable solar electricity by independent families and businesses. Our area of focus is to empower the poorest communities to build and maintain their own reliable electrical infrastructure, supporting small electricity businesses in FCAS of Malawi and Uganda. The primary beneficiaries are women and children, who constitute the majority of deaths related to indoor fire emissions.

Country/countries

Malawi, Uganda

Research question

Can the cost of residential rural solar electric systems be reduced by fully utilizing the produced electricity with solar electric cookers, and can this justify subsidies for solar home systems in rural African households?

Total budget estimate[1]

£200,000

Time frame

July 2018 – December 2020

Summary of approach/method

In our engineering design study, we will support and subsidize local businesses in Malawi and Uganda to build, install, maintain, and monitor our solar home electricity / cooking prototypes. Our contractor will also monitor the electricity production and collect research data on the community and family in terms of health, firewood use, and economic well-being for academic impact analysis.
The first electric/cooking prototypes are presently being installed and collaboratively optimized by technical researchers at Cal Poly and local merchants in Malawi mentored by our contractor, Kuyere!. At Cal Poly, the laboratory research is leveraged by research and development in service learning classes where students address technical and societal challenges faced by the poor.

Methodology:

Step #1: Make and test solar home systems with electric cookers/water heaters.

Step #2: Distribute solar home systems with varying levels of subsidy via lottery and simultaneously select control households via lottery.

Step #3: Perform baseline socio-economic surveys of both treatment and control households.

Step #4: Install monitored dump load in households with solar home systems to simulate electricity that is sent back to the grid. These households will be paid for the electricity delivered to the dump load.

Step #5: Perform after-treatment socio-economic surveys of all households.

[1] Fees and reimbursable costs are allowable costs; overheads cannot exceed 15% of the total budget.

Step #6: After 4-12 months install systems in control households (time period is selected based on discussions with communities).

Step #7: Continue monitoring and collecting periodic surveys of all households.

Step #8: Analyse data, write papers and present at conferences.

Step #9: Organize meetings with communities, Chiefs and Members of Parliament to discuss methods for scaling up results (e.g. commercially) or creating supportive national policies for accelerated rural electrification with partially-subsidized distributed household solar assets.

Research Uptake (stakeholder engagement/local partnership/ capacity building/dissemination)

The research is being implemented in collaboration with an existing social enterprise, Kuyere, that has already installed hundreds of solar-electric systems to very low income rural communities in Malawi. The contractor actively engages communities in its solar distribution system. Specifically, Kuyere currently distributes partially-subsidized solar home systems through community-based lotteries organized through the existing traditional government structure in rural Malawi. Through village chiefs, village meetings are organized and lotteries are conducted to decide which households can purchase solar systems at which level of subsidized discount. In collaboration with local communities and regional rural distributors, the systems being studied in this proposal will be distributed using similar methods.

Unfortunately in Malawi, the main utility stakeholders are largely disengaged from the majority of the people where less than 12% of the country's population has access to electricity. It may never work in Malawi to build electricity infrastructure only from the utility out to the rural villages. Thus, it is also necessary to build electricity infrastructure from the villages back to the utility.

One can see how dire the institutional situation is with the Malawi electric utility by reading:

https://www.mcc.gov/blog/entry/blog-100417-malawi-utility-turnaround

Expensive top-down approaches to electricity out-reach have often failed to reach the rural poor. Therefore, we will begin by engaging the villages and the chiefs in rural Malawi because they represent the more than 88% of Malawians that remain without access to electricity infrastructure. After the villages accept and support the results of the project, the next step will be to organize meetings with the Chiefs and their respective Members of Parliament. This way we will engage and approach the government and the utility from the bottom-up rather than using a top-down approach.

Our engagement hypothesis is that when the villages have the means of solving the electricity infrastructure problem themselves and have in hand a profitable means of engaging the utility, then the utility may be willing to engage with them. Faced with the problem of barely being able to serve the existing 12% of Malawians with electricity access, the utility is unlikely to strongly engage with the majority of Malawians without access unless the utility can do so in a profitable way. Creating such a scheme that can be profitable for the utility is the objective of this research project