How to Help Solve Climate Change and African Poverty at the Same Time in the Most Cost-Effective Way Possible

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The Problem

While huge progress on clean energy has been made over the last decade, the world is still not on a path that is projected to avoid some of the most catastrophic consequences of climate change. Recent NYT articles[1] and opinion[2] pieces highlight how a key reason for this is that the technologies that need to be adopted for a climate-friendly clean energy transition are not being adopted fast enough—particularly by the world's poor majority for whom emissions continue to grow. There is a very simple reason for this. For lower-income populations, adopting clean energy technologies is not yet affordable or accessible.

Consider the example of Esther.[3] She lives in a village in rural Malawi and provides for a family of five—including a husband and three children—on a monthly budget of $30. The family grows its own food, makes the bricks that compose the walls of the house and collects the grass each year that provides thatch for the roof. Esther helps her husband hoe their one-acre field by hand, and plants, weeds and harvests throughout the growing season. She also spends 3 to 5 hours per day collecting fuel and cooking five dishes per day: two pots of maize porridge, a pot of boiled sweet potatoes, greens, and a protein of fish, soy, eggs or beans. Even though she works without pay, every hour of her time is precious, especially during the 6-month growing season where each hour not spent cooking means more time in the field and more food for herself and her family after harvest.

The Solution

This clean energy affordability problem is not easy to solve, especially for the 400 million people in rural Africa currently without electricity. Largely this is because the world's poor majority lack access to capital. Because of this, they can afford to invest in only the most beneficial household investments. For most people in lower income communities the most urgent investments pay back in less than a year—i.e. after harvest—yet most clean energy investments pay back in more than 3 years.

Thus, to make their clean energy investments economically beneficial, most people in the world need co-financing to help pay for clean energy technologies. This means that to make clean energy accessible and affordable to the world's low-income majority, two things are needed: (1) Technology that is optimized to be as cost-effective as possible at serving the needs of low-income households, and (2) Co-financing that makes clean energy investments by low-income households feasible.

With 10 years of volunteer work and innovation, one scientist—myself—along with many volunteers and organizational collaborators (solar4africa.org, solarkumidzi.org) has created an optimized cost-effective clean energy solution for rural Malawians who are some of the lowest income people on the planet. If this solution can be distributed at scale with co-financing that enables easy affordability, then this solution can be a clean energy access solution for much of rural Africa's 800 million people who either don't have electricity or who rely on fossil fuels.

Specifically, the technology solution is an off-grid solar home system with electric cooking that can provide more than 1 kWh/day of electricity for 10 years and that can have an initial investment cost of less than $300.

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[1] https://www.nytimes.com/2024/09/25/climate/climate-change-environment-planet.html
[2] https://www.nytimes.com/2024/09/22/opinion/clean-energy-electricity-poverty.html
[3] "Esther" is an amalgam of several women interviewed in a solar electric cooking impact survey in Malawi

Ester is one of the people who has invested in the system. This saves her more than 2-hours per day in cooking and fuel collection labor which is valued at $0.50/day at the Malawian minimum wage. Instead of collecting wood, starting and tending a smokey fire to cook on a blackened pot, most her cooking is now just putting the food in an electric multi-cooker, pressing a button and coming back an hour or two later and finding the food cooked. THIS is empowering and poverty-reducing clean energy.

We have tested what price households can afford to pay by offering the system at different prices at different times. We find that rural Malawians can afford to purchase this system up-front if aid and/or donors can help pay for about 50% of the initial system investment cost.

In this note, we request a grant to demonstrate scale-up of this solution. The objective is to show the details of how to efficiently and effectively reach all of Malawi and hopefully the rest of Africa.

A Solution Created from 10 years of On-the-Ground Innovation

I began working as a part-time volunteer on electricity access in Malawi in 2015. I was motivated in part by the fact that in 2012 the US Government gave the Malawi government a $325 million grant for increasing electricity access,[4] yet more than 80% of the 20 million people living in Malawi today remain without electricity access.[5] Wasn't this budget enough to provide solar home systems for virtually all 80% of Malawians living in rural areas who have the greatest difficulty getting electricity?

By 2017, I took early retirement and started working with Malawian colleagues on an accelerated innovation process to make electricity affordable to rural Malawians within a decade. In 2017, off-grid solar electricity at a cost of $2/kWh was too expensive for many Malawians whose cash incomes are less than $1/capita/day. The cost of electricity had to drop by >10X to be affordable to rural Malawians.

Two innovation strategies were pursued: (1) Efficiently use solar panel electricity directly, using a minimum of expensive batteries, so that the cost per kWh of electricity declines rapidly over time as the cost of solar panels declines, and (2) Find or create energy storage that lasts as long as solar panels, i.e. 10 to 20 years, so that battery costs can be minimized by spreading them over as many kWh as possible.

Pursuit of these two strategies after 8 years, has created a $300 off-grid solar system that can provide a kWh/day for 10 years or more. This means that the per-kWh cost of off-grid electricity in rural Malawi is now <$0.10/kWh, or **>20X LESS EXPENSIVE** than it was in 2017: Innovation Mission Accomplished!

But because Esther and her family have less than $400 per year of cash income, they need help getting the cash to pay for the initial off-grid solar system investment. The system can save her and her family more than 500 hours of labor per year. This means that Esther and her family can afford to invest between $100 and $200 in the system after a good harvest when they have some extra cash, but they cannot afford to pay the full $300 system cost. They definitely need investment assistance to make the system affordable.

About the Innovator

I received a Ph.D. in computational physics from Harvard in 1991. I have worked on clean energy and technology projects in Africa and the US for 30 years. From 1993 to 1997 I was an assistant professor at the University of Asmara in Eritrea where I set-up the email system for the country and helped establish the country's clean energy research programs. In 1999, I joined the Energy Efficiency Standards group at Lawrence Berkeley National Laboratory where I developed and advanced the group's energy efficiency policy cost-benefit analyses for 16 years. From 2010 to 2014 I worked to assist the Department of Energy

[4] https://www.mcc.gov/where-we-work/program/malawi-compact/
[5] https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=MW

to accelerate progress on energy efficiency policies. This culminated in a paper co-authored with Energy Secretary Steven Chu[6] that elucidated how energy efficiency policies that focused engineers' attention on designing appliances that minimize the life-cycle ownership cost can accelerate technological learning in ways that minimize consumer costs over the long-term.

Since 2015, I have applied my knowledge of clean energy economics and technological learning processes to develop practical technologies that demonstrate rapid declines in the per-kWh cost of off-grid solar electricity for rural Africans. (See: https://www.researchgate.net/profile/Robert-Van-Buskirk/research)

Technical Details of the Solution

How is our system designed? First, our solar electric system focuses on cooking because more than 90% of energy consumed by rural African households is used for cooking. Also, solar panels are substantially cheaper than batteries per unit electricity output. Thus, one key to our solution is a solar-electric cooking system that can operate with or without a battery. This consists of a solar panel, a maximum power point tracking (MPPT) controller and an insulated DC multi-cooker that can operate at a wide range of voltages and power. This subsystem costs $0.20 per peak watt of capacity.

We also radically improve the solar battery that goes with the system. In low-income rural Africa, the dominant battery technology is lead-acid batteries, which have a lifetime of 500 cycles. Such short-lifetime lead batteries also pose an extreme toxic hazard to rural Africans when the lead is not disposed of properly. In contrast there is one battery technology that stands out above all others: this technology uses Lithium Titanate (LTO) chemistry and can charge and discharge for more than 10,000 cycles: i.e. it lasts 20 times longer than lead-acid. Our system therefore uses a custom LTO solar battery with a programmable battery management system (BMS) and built-in data logger that is designed to last more than 10 years and that costs less than $0.5/Wh. Added to the cooking subsystem, this creates a $300 off-grid 1 kWh/day solar home system with cooking that can log energy use data for long periods on a $2 data chip inserted into a slot in the custom battery.

The Urgent Need—A Donation to Demonstrate Co-Financing Impact:

A "philanthropic investment" is now urgently needed for $150,000. This will enable 1000 households to purchase a solar cooking unit (with the other $150 per household coming from the Africans). It is anticipated that this will generate 750MWh of off-grid solar electricity use within five years. This will demonstrate that even the lowest income rural households can get off-grid solar electricity—including cooking—for a subsidy of $0.20/kWh. We have just distributed 300 systems over the past four months, but we need to demonstrate this at larger scale.

Why is this urgent? The World Bank and other international funders are about to spend billions of dollars on clean energy investments that are much more expensive than our solution, and which will not reach lower income rural Africans.[7] We need funding now, so that we can demonstrate both the financing and technology for getting affordable clean energy access to rural Africans in the most cost-effective way possible. We will then use this demonstration to get the World Bank and other development agencies to spend their money 2X to 5X times more effectively and get clean energy to many millions more people over the next 5 to 10 years.

Esther, and millions of rural African women like her, are counting on it.

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[6] https://iopscience.iop.org/article/10.1088/1748-9326/9/11/114010

[7] See: https://www.worldbank.org/en/news/press-release/2023/11/28/100-million-people-in-afe-eastern-and-southern-africa-poised-to-receive-access-to-sustainable-and-clean-energy-by-2030