KUYERE!*

How to get the lowest-cost solar electricity to the lowest-income communities in rural Africa?

Answer: SOLAR HOME SYSTEMS WITHOUT BATTERIES

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*Kuyere! means “Let there be light!” in Chichewa, the language of Malawi

The Problem: SHS electricity can cost >$10/kWh

For example, the standard 8Wp Mkopa system costs $0.48/day
For about 24 Wh/day = ($0.48/0.024kWh) = $20/kWh.

PRICING

Paying for your M-KOPA 5 device					
Products	**Deposit**	**Daily Payment**	**Number of Days**	**Total Price**	**Cash Price**
M-KOPA 5 Classic	Ksh 2,999	Ksh 50	420 Days	Ksh 23,999	Ksh 18,999

What is in the box

- 1 8W Solar Panel
- 1 Rechargeable FM/USB Radio
- 1 M-KOPA 5 Control Unit with Lithium Battery
- 4 Bright 1.2W LED Bulbs
- 1 5-in-1 Phone Charge Cable
- 1 Custom Charge Cable
- 1 Rechargeable LED Torch

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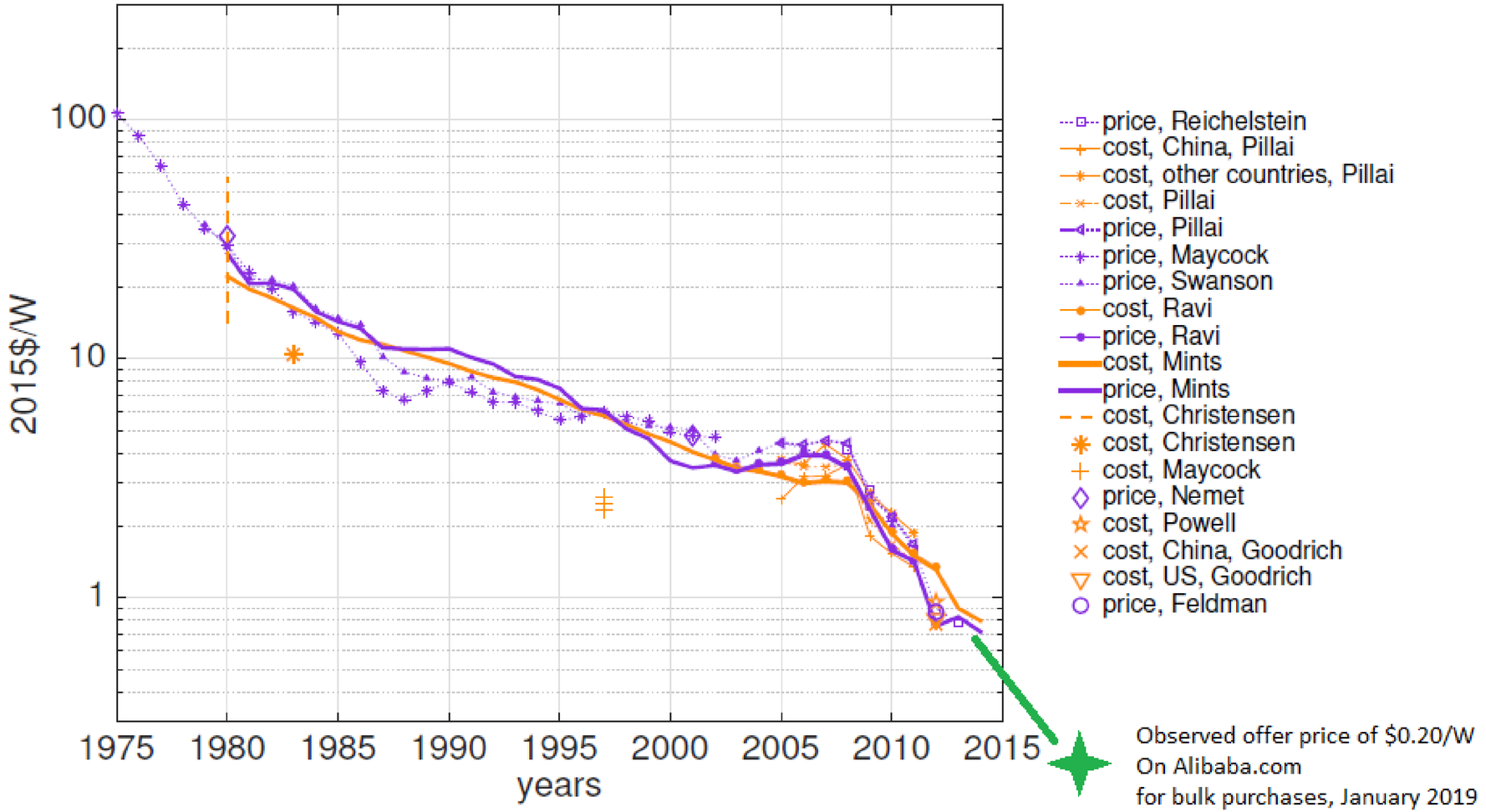
And Yet: Solar Panels are Really Inexpensive!



$0.20/Wp

=

$0.02/kWh

Amortized Over 10 years of Electricity Production

(Original figure copyright: Massachusetts Institute of Technology, 2018)

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Why are low-income Africans paying Solar Electricity Prices that are 100 to 1000 times the minimum Cost?

1. ***Economies of Scale:*** *Very small systems spread system costs over very few kWh*
2. ***High Overheads and Mark-ups:*** *Import, sales and distribution in rural Africa can be expensive for imported products*
3. ***Short-lifetime Chemical Batteries:*** *Batteries last only a few years, so system costs are spread over fewer kWh*

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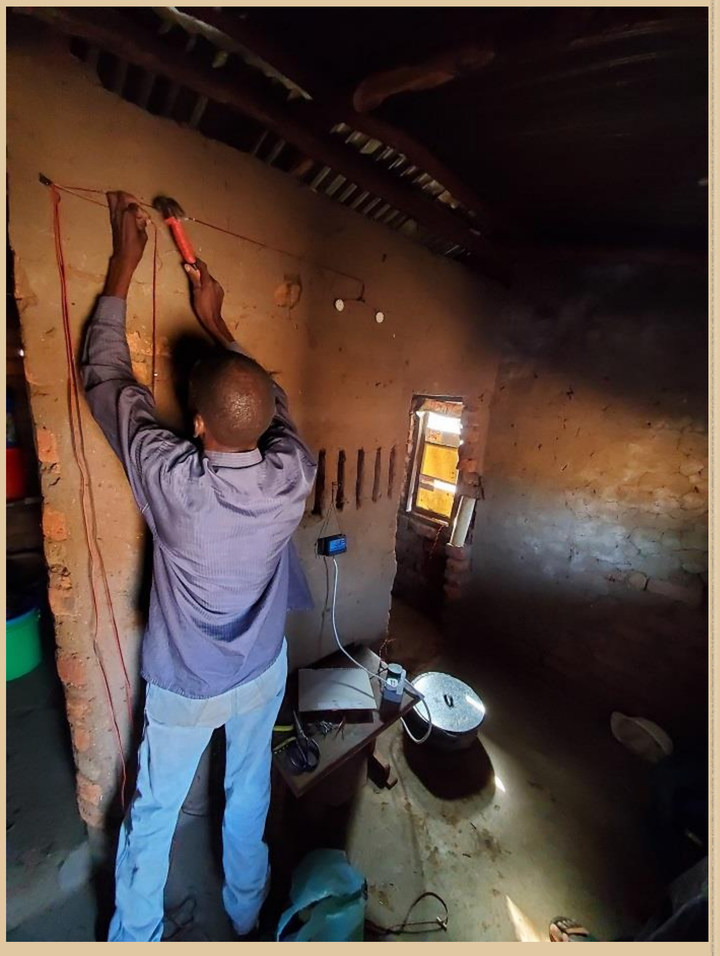
How to Solve the High-Solar-Electricity-Price Problem:

1. ***Include Cooking for Solar Home Systems:*** *90% of African household energy use is for cooking. Including cooking increases electricity output by 10X*
2. ***Africa-assembled Solar Systems and Components:*** *Importing components and assembling in Africa avoids many import, and distribution costs, overheads, and mark-ups*
3. ***Use super-capacitors and thermal materials for energy storage:*** *Super-capacitors and thermal phase change materials can last 10 to 20 years allowing solar costs to amortized over many more years of electricity production*



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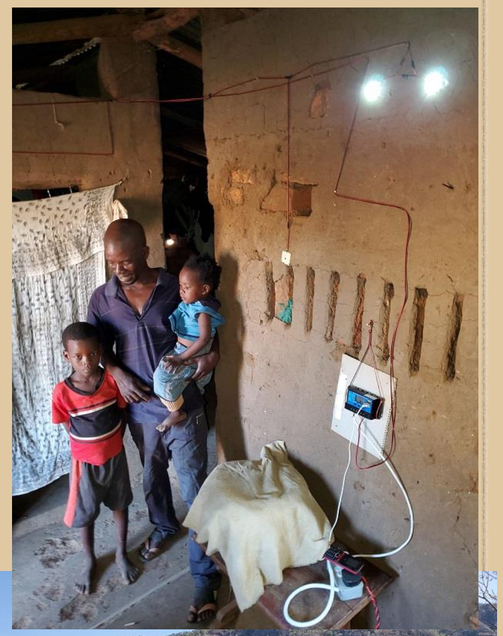
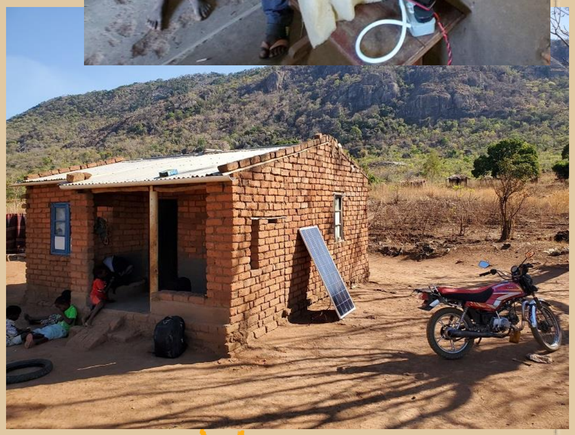
A 150W SOLAR SYSTEM WITH COOKER IS NOW AVAILABLE IN MALAWI FOR A COST OF ~$200

150 Watt solar panel	$ 65
Solar electric cooker with accessories	$ 25
Charge controller	$ 5
Super-capacitors (15 Wh)	$ 25
Lights, switches and wiring	$ 20
Installation	$ 20
Overhead and profit	$ 40
Total Cost	$200

(Note we should soon be able to upgrade to a 250W system at no incremental cost)





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“Thermal Batteries” have the same first-cost as Sealed Lead-Acid Batteries (but last longer!)

Sealed Lead-acid Battery

Price: *$0.70/Ah at 12V*

Energy Density: *43.2 kJ/Ah at 12V*

Storage Capacity Cost: *$23/MJ at 70% cycle efficiency*

Erythritol:

Price: ***$****3.55/kg delivered to Malawi*

Energy Density*:* *316 kJ/kg*

Storage Capacity Cost: *$22/MJ at 50% cycle efficiency*

Magnesium Chloride Hexa-hydrate

Price: ***$****1.60/kg delivered to Malawi*

Energy Density*:* *167 kJ/kg*

Storage Capacity Cost: *$19/MJ at 50% cycle efficiency*

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Per-Cycle, Super-Capacitors can have costs comparable to Sealed Lead-Acid Batteries

Super-Capacitor:

Price: *$4.50 ea delivered to Malawi*

Energy Density: *9 kJ/ea*

Cost/kWh: *$0.18 for 10,000 cycles*

Sealed Lead-acid Battery

Price: *$0.70/Ah at 12V*

Energy Density: *43.2 kJ/Ah at 12V*

Cost/kWh: *$0.12 at 500 cycles*

(But businesses won't pay to put supercapacitors in an SHS because customers won't pay for the extra 5 to 10 years of lifetime)

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No-Battery Solar Home Systems with thermal storage and supercapacitors: Key Points

1. *Non-battery energy storage can be as cheap as lead acid batteries, but lasts much longer.*
2. *Solar panel electricity is VERY INEXPENSIVE. Therefore; we minimize the electricity cost with system designs that maximize direct-use of solar panel electricity.*
3. *There are little or no toxic chemicals in no-battery systems.*
4. *Solar Home Systems can now last 10 to 20 years or more if built right!*

Many potential funding sources could support development of long-lasting no-battery systems

- ***GEF: Global Environment Facility***
- ***GCF: Green Climate Fund***
- ***Beyond the Grid Fund for Africa (e.g. funding for Burkina Faso and Liberia)***
- ***ROGEP: Regional Off-Grid Electrification Project***
- ***...***

Innovative Value-Chain Idea: Solar-Electric Kitchens w/ Workshop

Commercial solar-electric kitchen/restaurant:

Has 0.5 to 3 kW of solar panels and cooks 5-25 meals/day

Solar panels paid for with climate credits:

Because each kWh of cooking electricity saves a kg of wood

Next door is a workshop that pays the kitchen for electricity:

Workshop can use equipment that requires >1kW of power because it stores electricity in long-lasting capacitors that can discharge energy rapidly supply high-power equipment the during the day

Win-win-win-win-win-win proposition:

This a win for the environment, a win for women's empowerment a win for the shop-owner, a win for the solar panels supplier, a win for the national economy and a win for donors

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