Farmers' Electrification Needs in Rural Off-Grid Ethiopia

In rural off-grid Ethiopia, the electrification needs and demands of farmers have been observed with the aim of understanding their role in improving living standards. Solar Home Systems (SHS) have been installed and their social impact on farmers has been closely monitored. Another main objective of this mission was to do an adequate SHS system sizing which fits the needs and demands of typical farmers' households in rural Ethiopia

Lighting Needs	Mobile Charging Needs	Expectations of System Users	Social Impact
500 – 1000 lumen per household	5 – 10 mobile phone charges per 24h day, no charge time restrictions	System must adequately fit their rural living conditions	Farmer's meeting point after dark Children's homework Farmer's productive use

Off-Grid Location and Way Description

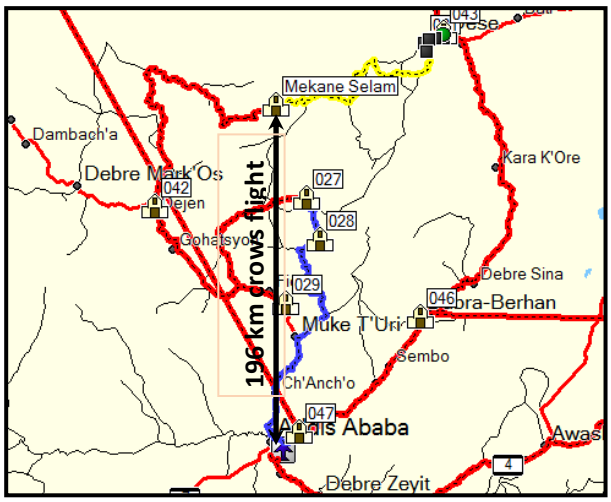
The observed off-grid area lies in the vicinities of Mekane Selam. Mekane Selam is the district capital of South Wollo, 196 km north of Addis Ababa and 30 km east of the river Nile, 2700 meters above sea-level.

Mekane Selam is connected to the national power grid. There are plenty of scattered villages and farms around but none of them are grid connected.

A low voltage power line, running along the main road between Dessie and Mekane Selam is currently under construction (Nov 2014) and will provide power to larger settlements along the road.

The newly constructed, second grade asphalt road connects Mekane Selam with Dessie to the east and with Bahir Dahr to the north-west. The Nile crossing is still under construction but it is possible to cross by car. Daily bus services run in both directions.

Before road construction, Mekane Selam was very difficult to access due to the country's mountainous topography. The local airport is out of operation since the mid-nineties.



Though the air distance between Addis Ababa and Mekane Selam is only 196 km, the driving distance counts 570 km (!) [Garmin GPS Image]

Lighting Needs

Rural households require a minimum lighting standard. Though lighting standards for Africa are far from those set for European households, figures should not be totally compromised for the sake of super-small or inefficient SHS systems.

The following luminary values have been tested and proved to be adequate to allow "normal" work and living conditions after dark:

Farmer's living room (5mx5m):	600lm
Farmer's kitchen (2mx5m):	300lm
Farmer's bedroom (2mx5m) :	100lm
Farmer's veranda (outside light):	100lm

Because of the high luminary efficiency (efficacy) of latest LED lighting technology it is very easy to provide 1000 lumen per small SHS. 1000 lumen can be powered by 8 Watts only.

But SHS systems need to adapt the latest technology in order to achieve high efficiency and use quality components to provide system reliability.

Farmer's living room illuminated with 600 lumen high efficient LED lights

100 lumen LED veranda light

Mobile Charging Needs

Mobile phone charging is a vital part of SHS system functionality. To restrict the number of charges per day/night has proved to be impractical. Systems should therefore be configured to allow at least 5 to 10 charges per 24 h.

Why so many charges per one household?
Neighbours who do not have access to SHS but own mobile phones will want to come to charge their mobiles. This demand is difficult to refuse.
On another note, to restrict mobile phone charging would impair the positive social impact because mobiles play an increasingly important role in modern rural communication. By providing 'one-mobile-charge-outlet-only' per SHS the numbers of possible charges are automatically limited.

Here mobile phones are charged 12 km away from the next grid-connect point

Pattern of Farmers' Lighting Usage

Lights will be switched on at dusk; usually around 6 pm. Farmers normally go to bed at around 9 pm or at latest 10 pm. The availability of electrical lighting will not immediately change this pattern.
Reason: farmers need to get up at 6 am in the morning in order to feed livestock. The hard working day does not allow an extension into night life.
All available lights will remain switched on from 6 pm to 9 or 10 pm. The teaching of energy saving, e.g. switching kitchen-lights off when not in need, does not work.

As a result of these findings, the full lighting load has to be considered to be in operation 4 hours per day, every day.

Expectation of System Users

System users (users), usually farmers and their families, have no previous experience with electrical systems. Once they have light, they want to make good use of it, and they expect their electrical system to work as well as that of their friends in grid-connect areas.
After basic requirements have been met, namely providing lighting and mobile phone charge, farmers ask to connect radios and TV's.

Social Impact

The social impact has only been monitored for ten days after system installation. A much longer duration would be needed to make fundamental statements.

Summary of the immediate visibly impacts:

(1) Electrified households become a farmers meeting point where many friends gather
(2) Children do their homework after dark
(3) Cooking and preparing food is easy after dark
(4) Farmers treat crops indoor after dark

Farmer's kitchen sufficiently illuminated with 300 lumen LED lights

Adequate System Configuration is Key Factor

To configure a truly adequate SHS system for farmers' use one has to combine technical considerations with social factors on the ground.
In order to minimize system costs (and to maximize profits) poorly configured systems are flooding the market. Such systems often have very small PV generators and inadequate storage batteries (often of poor quality).
A lack of understanding of the importance of social factors has directed the SHS market into the design of undersized, super-small SHS systems, and called them to be adequate. In reality, systems with low

luminary output (< 300 lumen) are not the desired choice of SHS.

600 lumen LED lights are sufficient to work indoors

In order to overcome this problem, a purpose designed system to fit a typical farmer's house in Ethiopia has been introduced and its suitability has been tested on the ground.

This system comprises the following technical guideline parameters:

PV Generator:	14 – 18 Wp /12V DC
Storage battery:	12 – 16 Ah / 12V DC
Charge controller:	4 A – 8 A / 12V DC
Lighting system:	≈ 8 – 10 W / 12V DC
Luminary output:	≈ 800 – 1200 lm
Mobile charge:	250 mA / 1 outlet only

Detailed component description

Purposely oversized PV generator

→ Accommodate for harsh system over-usage
→ Enable full daily recharge even in rainy season
→ Reduce autonomy demands on energy storage: SOC mostly > 75% under normal cycle use (Partly cloudy charge conditions – 4PSH)
→ enhance lifetime of battery

LED lights of high quality

→ Luminary efficiency above 100lm/W
→ Usage of high quality LED products (e.g. Samsung, Osram, Philips, Cree, Solarox)
→ Design over-sized heat sink to enhance lifetime of LED under tropical conditions => keep LED temp below 50° C

High quality charge controllers

→ Usage of high quality charge controllers to guarantee long system lifetime

Batteries identified as bottleneck to SHS quality

In the chain of SHS components batteries form the weakest part of all. They therefore require very special attention. It would exceed this report to go into detail.

The (somewhat understandable) trade-off between battery sizing, quality and battery prices puts rural Africa automatically at a disadvantage (as compared to richer economies), with no immediate solution in sight.

PV modules of only 16Wp provide enough power to lighten up the entire building with 1000 lumen and to provide 5 – 10 mobile phone charges per day

Role of Solar Lanterns

Solar lanterns play an important role, and they perfectly complement SHS systems. Farmers are in need of some kind of light, in order to walk in the dark, and to do necessary works, such as monitoring live stock after dark.

Ethiopia's rural countryside is very challenging to walk through after dark, with no roads and difficult topographic terrain.

Up to now, farmers mostly use small battery torches (of poor quality, which are widely available), and they have to replace the batteries. Solar lanterns are virtually unknown to the majority of farmers. The reason is that such lanterns are simply not yet available in the remote countryside.

Once solar lanterns have been introduced, farmers are keen to acquire them; and farmers on low budgets or small families will prefer solar lanterns to SHS, because they can afford solar lanterns.

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