

The Small Computing on Solar (SCOS) Handbook — 2018 Edition



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Picture: The site where "first contact" in 1870 occurred in Papua New Guinea. Mikloucho Maclay, the Russian Anthropologist, lived near the point to the left and also left a diary translated from the Russian language into English. There is still no electrical power in this part of the world. -Brian Chapaitis, CC-BY-SA

Tools for National Language Workers

News:

- Added the new Lenovo IdeaPad 320 model with 15 inch anti-glare screen, and still maintaining a low power consumption in the Notebook section. There's no longer a need to be cramped under an 11 inch screen, and the Intel N-series "turbo" mode is plenty fast when needed for Paratext work.
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Please send your comments to: brian_chapaitis@sil.org Direct edits to this Wiki are welcome by others. Please don't hold back on any ideas or knowledge you might have, and please do contribute to these pages. The greater solar community thanks you. This site wants to become a "live document" -- so edits and additions are welcome. At any point in time, please print a section of the document and carry away for your purposes. See options on upper right "down wedge" icon. However to print the entire Handbook in all it's glorious detail, then see the "Print this Manual" item now in the sidebar to the right.

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Summary:

For the first time in recent memory, advances in solar technology and computer notebook technology have converged such that the goal of language work performed by Mother Tongue Language Workers (MTLW) can be realized in a relatively cost-effective manner by themselves and for themselves — with minimal oversight. This work primarily concerns itself with hardware issues, on modern platforms where useful language software tools can work, created by SIL and other agencies. It is meant as a “handbook” or a guide to collect in one place all the relevant technical issues and potential hardware suppliers useful to SIL administrators who want to set up somewhat independent, long term, national coworker projects with limited or minimal mentor/ advisor contact. In short, it is an effort to outline the application of technologies for a sustainable MTLW programme and represents the present “state of the art.”. This is a constantly moving target since technology changes so rapidly. This document supercedes an original work created in 2010. Since we are now electronically publishing this on a wiki site, the authors welcome contributions from others to make the content more accurate and more up-to-date in a rapidly changing technology environment.

Note: It is possible now to print the entire Handbook to .PDF format. Look for instructions in far right column under "Search Wiki". Some readers do not see this column because they are in "full screen" mode. To exit this mode click the double-arrow icon in the far upper right corner of this page. An excellent free add-on for Firefox and Chrome would be "**Print Edit**", but there are others.

Introduction

The year 2016 was an amazing year for low-power consuming notebooks and laptops. Intel pushed hard on it's process technology called "Bay Trail" and that produced a new family of processors that showed up in various manufacturer's lineups in this year. The power-saving effects were astounding. Processor speeds also improved steadily since 2010 and nowadays an inexpensive notebook is more than able to perform well with Word Processors, Spreadsheets, Paratext (SIL/UBS), Email, and Web Browsing activities. These are today's computers commonly found in stores like amazon.com in the \$250 to \$400 range, with screen sizes from 11 inches to 15 inches.

At the same time huge advances occurred in new thin-film and poly-crystalline solar technologies within this same year. It is not uncommon to find old monocrystalline solar panels in the \$0.60 per watt range. Portable and very light weight, thin-film technologies are also available in the US\$ 3 per

watt level. This might still seem to be expensive, but when one considers that a modern notebook only requires a mere 30 watts to be sustained in the field in rainy weather, then even the relatively more expensive thin-film technologies are now much more affordable. One new application is socio-linguistic survey work, where excursions in the remotest part of the world necessitate portable and light-weight solar equipment. Yet powerful computers are still involved for data collection and possible field analysis.

This paper represents the state of the art for the merging of these two powerful trends in the industry for new Third-World applications. We are actively developing significant “laymen” tools that, once placed on sustainable hardware, would empower national citizens to consider doing portions of the language development task. And this includes, the Bible Translation task.

Summary: SCOS Goals and Objectives

“Define a complete system of solar powered hardware; an overall tool, suitable for third-world national coworkers to consider doing language development work for themselves and by themselves. To build reliable, self-contained, and low maintenance hardware systems, where there is no readily available mains power.”

"To educate laypersons, in support of others, as to basic solar principles and adequately maintain future solar systems in the field."

“SCOS defines a sustainable equipment platform by which suitable national language software tools can be implemented in the field”

Beyond the scope of this “handbook” is the requirement of suitable national training programmes for a successful implementation within a Branch or Entity within SIL. That exercise is the subject of another paper and also would be integral to a far larger, comprehensive, entity strategic plan.

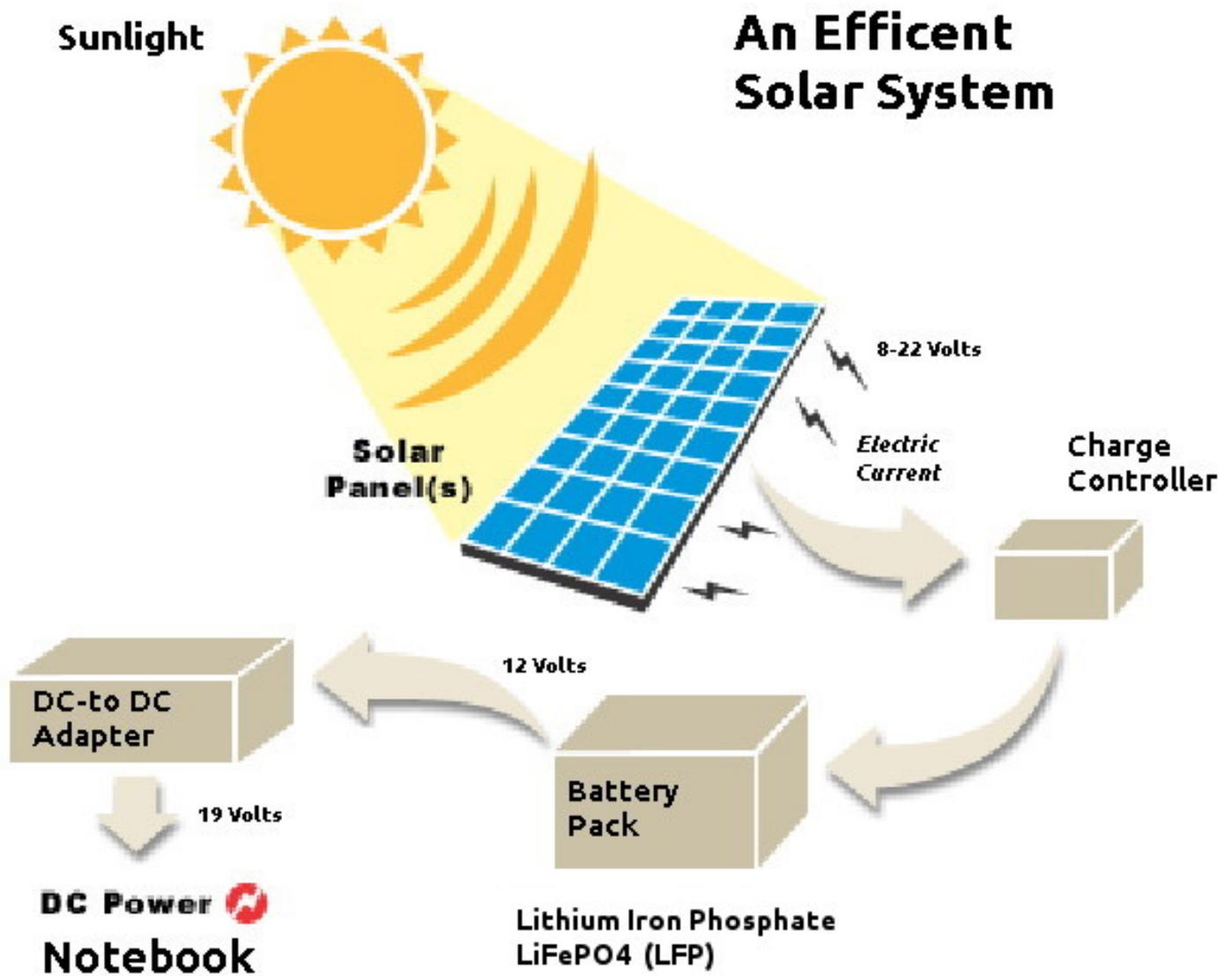
Note: No technology, not even the use of mobile phones to call out to people, will work without adequate training. Technology by itself, never works. It is the same with even the simplest of solar systems.

Table of Contents

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- 1 *Choosing a low powered notebook* : [Notebooks](#)
 - 2 *Using tablets with solar* : [Tablets](#)
 - 3 [Solar Panels](#)
 - 4 [Controller Battery](#)
 - 5 [Battery Technologies](#)
 - 6 [Solar Controllers](#)
 - 7 [DC-DC \(Auto\) Adapters](#)
 - 8 [Fuses](#)
 - 9 [Wiring Principles](#)
 - 10 [Tools](#)
 - 11 [Basic Electricity](#)
 - 12 [Advanced Topics](#)
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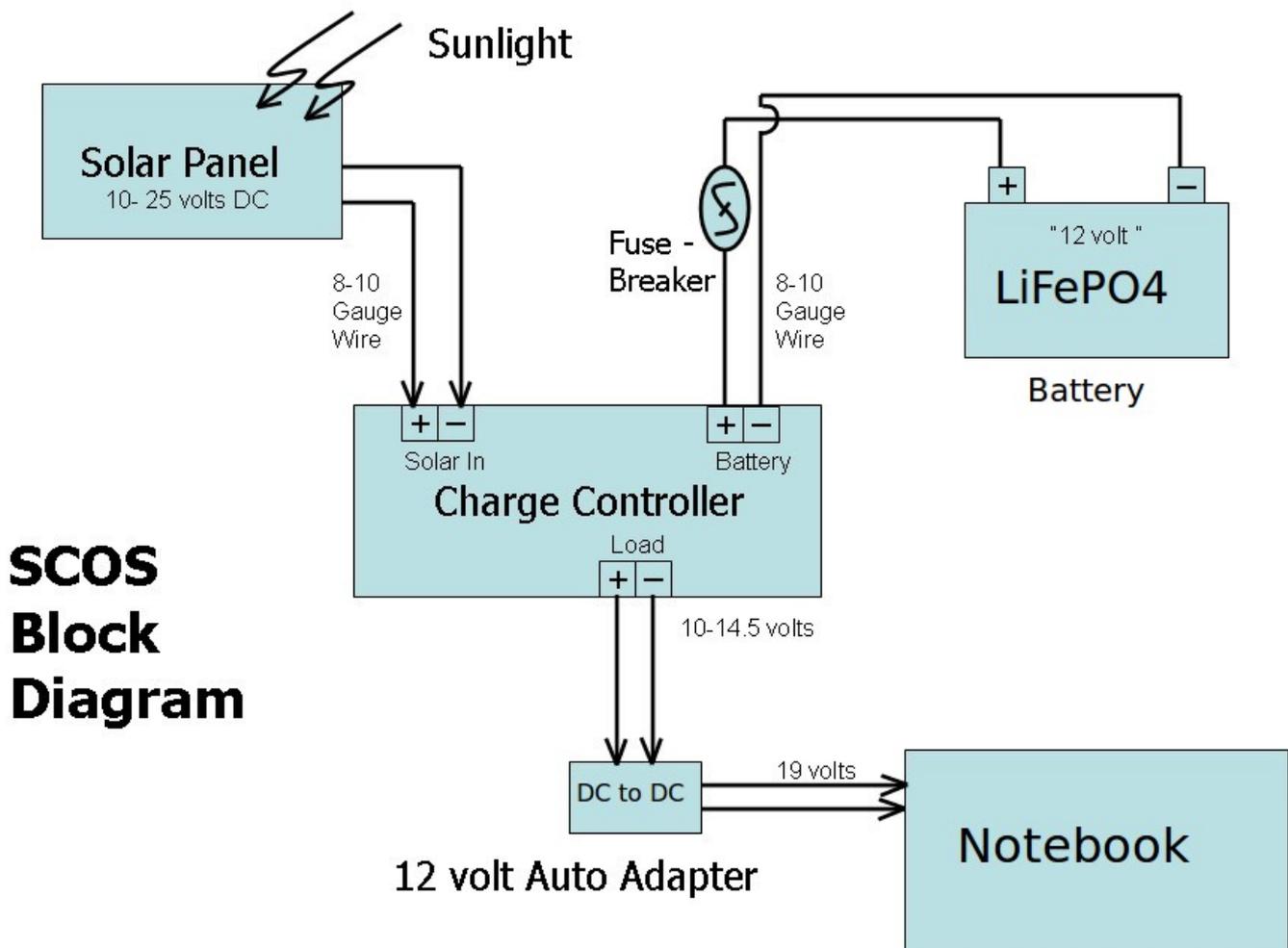
Click on Section Above for more Details on that Topic.

The Village System



These are the major components of a village system that desires to be **energy efficient**. Note that there is no inverter here, but rather the DC-to-DC auto adapter in the sub-systems that make for a more energy efficient operation. In a cost sensitive situation (local level churches and communities in the third-world) every joule of energy conserved is important per unit cost. Such communities struggle with resources; practical costs are very important.

Block Diagram of a Complete Solar System



Description of Components

Note: Although the manufacturers of the solar controllers mentioned here, say the order of connection of parts does not matter — the general wisdom says that under full sunlight, the converted energy of the sun's radiation should have a good place to go. Therefore always connect the battery first, or disconnect the battery last during assembly/ disassembly of the parts.

Click on Topic Below for more Details.

Notebook / Laptop:

A new class of notebook computer that can run a major Operating System like Linux or Windows OS. These range in size from the Lenovo 11 inch models such as the Lenovo 11e all the way to the Asus Vivabook line at 14 inches wide. 11 inch is about optimal. Popular makes of notebooks come from Asus, Acer, Dell, Lenovo, Samsung, HP, and others. Asus is considered the most reliable by far, only to be rivaled by Apple Computer.) (see more details)

Tablet:

2016 started to see many common 8 inch and 10 inch tablet offerings available for approximately \$150. Some were classic Android OS, however, a new breed of Intel tablet hit the marketplace

opening possibilities for a future with ultra low-power consuming devices. A product of Intel's "Bay Trail" efforts. The term "Tablets" in this paper *include a Bluetooth keyboard added*. For data entry chores one would not normally be expected to use the on-board touch-screen interface on most tablets, although in a pinch this would work. Unlike notebooks, **tablets do not require an external battery pack to run well all day**, and can rely upon their internal batteries, reducing per seat costs further. The required solar panels are quite small, even to sustain these 2.5 watt devices in rainy weather conditions. In the so called, "direct connect" scenario, a solar panel is directly connected to a mobile phone or tablet, usually by a standard USB port, but implied is a 5 volt regulator device, still necessary to condition the solar panel power output. (see more details)

Solar Panel:

A flat panel device, sometimes called a photo-voltaic panel, that converts incident solar radiation into electrical energy. Manufacturers include Solartec, Global Solar, Bioenno, and SunPower mentioned in this wiki. This report focuses on small 12 volt micro-solar systems, and doesn't address the issues of major, Western-style residential systems, where names like *Canadian Solar* and *First Solar* would be common place and systems would be 48 volts or higher. SCOS is about small, inexpensive, 12 volt systems. (see more details)

Combo Units: Controller with Battery

Recent advancements, mainly in the adoption of LFP batteries, has allowed smaller, complete units to be created that combine both the solar controller, fuses, batteries, and monitoring displays, **all in one box**. This simplifies the overall assembly of the system and doesn't tax the user's understanding of the system, simplifying installation in the field. Standard modular plug-type connectors are used to connect cables and no screw-drivers are required. This is easily the future of micro-solar systems, which is the subject of this report. If you want "**simple**" and "**reliable**" then this is the topic you want to read about. (see more details)

Battery:

An electro-chemical energy storage device. Many battery chemistries exist including **Lithium Ion** used in mobile phones, and laptops and **Nickel-Metal Hydride**, often used in LED flashlights and hand-transceivers. All can be re-charged. **Lead-Acid** is a relatively old technology, and well understood. It is sometimes favored in solar applications primarily due to common local availability and (assumed) low cost, compared with the other, newer technologies which often have to be imported. Certain Lithium chemistries are totally safe and will not overheat, such as the safest form: Lithium Ferrous Phosphate (LiFePO₄). As the report hopes to illustrate, LFP technologies can actually be **less expensive** technology to deploy than Lead-Acid over the lifetime of the language project. And LFP so far, is more robust and far less fragile, while being far more compact and light weight to transport (see more details).

Solar Charge Controller:

Due to rapid changes in solar radiation possible (think: a cloud drifts by), the solar panel voltage fluctuates dramatically. The purpose of the controller is to condition the power coming from the solar panel and make this power acceptable for storage batteries to store electrical power, and without premature damage to the batteries, shortening their useful life. Some people like to connect solar panels directly to batteries, without a controller and then permanently damage the batteries. (see more details)

Automotive DC to DC Adapter:

Actually a voltage conditioner and regulator, notebooks would normally use these to condition the transients found in automotive 12 volt electrical systems, saving the internal notebook power supply from undue stress. In solar notebook applications these devices allow the up-conversion of 12 volts to the more common 19 v and 20 v power required by most notebook computers. These adapters are very energy efficient and superior for use over an AC inverter using the normal "power brick" supplied by the manufacturer for typical mains power use in a town or city. Typically these DC-DC adapters are not expensive, however, care must be taken to purchase one with the correct DC plug arrangement for the given notebook. Reliable automotive DC adapters can be purchased for as little as \$15 in some situations. (see more details)

Fusible Link:

A circuit component, that is designed to break, or burn, or time-delay-off, when a relatively high current is applied and thus save further damage from equipment attached to a power source. Examples are an automotive in-line fuse (which must be replaced when used once) and a mechanical circuit breaker which can be reset by the user. For national coworker settings the better systems have fuses that "reset" themselves and are hidden from the end user, thus saving the user from painful mistakes (such as electrical arcing leading to a house fire), while not troubling the user with the education required to maintain these devices. In time, these special fuses reset themselves, much like a circuit breaker. (see more details)

Wiring Principles:

Choosing the appropriate wire diameter has a big effect on performance, however, too large a wire diameter greatly increases the cost of a system, especially if the solar array is very distant from the home office where work is accomplished on the computer. Long distance here means 50 meters or greater, but effects can be seen for a run as short as 10 meters. (see more details)

Tools:

If you are maintaining a solar system you might be interested in a few basic tools to help beyond a mere hand-held DVM (Digital Voltage Multi-Meter). In this section there will discussion of useful measuring instruments for various experiments in the lab, and would be very useful in rural settings if one were assigned to manage and repair very remote micro-solar systems (even very large ones, too).

Basic Electricity:

Many of us learned all the necessary solar principles for electricity in our secondary education, but since there was no practical application at the time, we have forgotten the basics. This section is to refresh our memories on basic concepts of electricity. This has a bearing on the language worker, when alone, and he/she is faced with figuring out what is wrong with a broken solar system, while attempting to repair it, "on their own", and without neighborly assistance. (see more details)

Advanced Topics (Technicians Only):

This is the technicians corner and most readers should stay away from this part (their eyes will glaze over most likely) and they will become frustrated while not being able to follow the discussion.

Issues with setting up a controller for the appropriate Low Voltage Disconnect (LVD) and other topics will be discussed in this section, and it's mostly for technicians who like to set up systems for others or build custom solar systems, from common parts. (see more details)

Purchase Summary:

1) Do your homework here and decide first how much CPU power to you really need in a computer. Most likely not much. Paratext and Word Processors do not tax small modern computer systems purchased in 2016.

2) Purchase pretty much any notebook computer that uses the "Bay Trail" technology to manufacture the CPU inside the computer. Linux users will want to carefully note the processor model for now.

3) Determine the average wattage of the machine in normal use. For an 8 hr workday, and while working in rainy and overcast weather, multiply this value in watts by 5, and determine the minimum size solar panel you require. For example, for a 6 watt notebook, you would require a $6 \times 5 = 30$ watt solar panel. For some older (circa 2014) laptop computers running at 15 watts of power, plan on purchasing a $15 \times 5 = 75$ watt solar panel. It makes a huge difference what the notebook/laptop computer you have to start with. **If your present laptop runs at 25 watts, you want to decommission that computer.**

4) If you are planning for 4 hrs of work time at nights, each and every workday, because the user works gardens in the day, or has some other job, then consider the size of battery you need. Energy capacity is measured in Wh, so to run a 5 watt computer for 4 hrs at night, you want to purchase a battery pack at $4 \text{ hrs} \times 5 \text{ watts} = 20 \text{ Wh}$. Due to "depth of discharge" issues (see section on this) you want twice that size larger in your LFP battery, so consider 40Wh minimum. Note that the GTIS Half-Pint solar system (as an example- see section) is 72 Wh !! Very nice. You want the extra margin, believe us, for other reasons in the village. Purchase this part.

5) Consider avoiding Lead-Acid type batteries, particularly car automotive type batteries. The above formula **does not work for them** and you need a **much larger capacity battery** to do the same work. Plus the lead-acid battery does not have the lifetime cycles of an LFP chemistry battery. You will pay more for the necessary larger battery size, and the battery will expire in around two years anyway, at least under solar applications. Each day is a heavy discharge, and you don't necessarily top up the next day. For a deeper discussion of this see the [Battery sub-section](#), if you have time.

On the Threshold of a Dream

We are on that threshold where appropriate and robust technology may launch us into a new era of involvement by third-world national coworkers that would not otherwise be able to participate in the work of vernacular Language Development. The dream is to provide the tools (and training) necessary to encourage native speakers of a given vernacular, to take pride in their own language and culture; to begin to document their mother tongue for themselves and to consider the translation task as well. Given the harsh realities of our limited number of outside visitors to complete the task, it is time for the citizens of the third-world to enter into this exciting work as well, perserving their language and culture for future generations. By adopting new methods, it may be possible for national citizens and the local level community churches, to be encouraged to

join us in the work with their own equipment and resources.

About One Author



Brian Chapaitis originally studied electrical engineering at Cornell University, USA. He is comfortable with programming embedded micro-controller systems, and thus is a “hardware and software” man, although he considers “real programmers” to only work in assembly code (joke).

Together with his wife Helen (physician), they have served in a variety of positions in the SIL Papua New Guinea Branch for 30 years.

Brian presently works out of the Language Technology and Training office in the SIL Language Resources department building at Ukarumpa, in the Eastern Highlands Province, Papua New Guinea. Brian is also the Pacific Technology and Publications coordinator (PTP), when he works for the entire Pacific Region. In PNG, He can often be found far from home, ministering within the church in the local village context. He shares the growing vision of empowering national counterparts to do aspects of the Language Development task hitherto thought impossible, with more self-sufficiency, using the latest new appropriate technologies, both hardware and software. Appropriate coworker training is "front and center" in the effort. But developing less complex solar systems will lead to reduced training costs.

Photo: (click to zoom) In a hot and steamy, equatorial coastal setting, the user of this solar controller complained that their system was no longer working. The battery was not receiving a charge. Measuring the tiny solar panel current coming inside the house, it appeared that the solar panel was broken. Climbing on the thatched roof, I discovered a "totally black" front face to the rather expensive solar panel, carefully mounted absolutely flat horizontal. Years of evaporated rain water with organic matter from nearby palm fronds, had painted an opaque, light-impervious layer. When I asked the user: "How long since you last cleaned off that solar panel?" They responded: "Ahhh.... you mean to tell me that you **have to clean solar panels?**" What do they teach those students back in language school, I wonder. 

Additional References and Comments: