Power solutions in the field: Solar power for laptop computers
McGill and Salffner (2007)

Summary

The task of language documentation is increasingly tied to computers, for processing both text and audio. Working in the field can create problems that many of us do not experience in our home countries. Many language communities live in remote locations where mains electricity is non-existent or unreliable. One solution to this problem involves using solar panels to capture electricity, and a car battery to store it. This paper summarises the authors' experiences with powering laptops using solar panels and car batteries during our recent fieldtrips to Nigeria.

Overview of components

The main components can be diagrammed as in Figure 1.

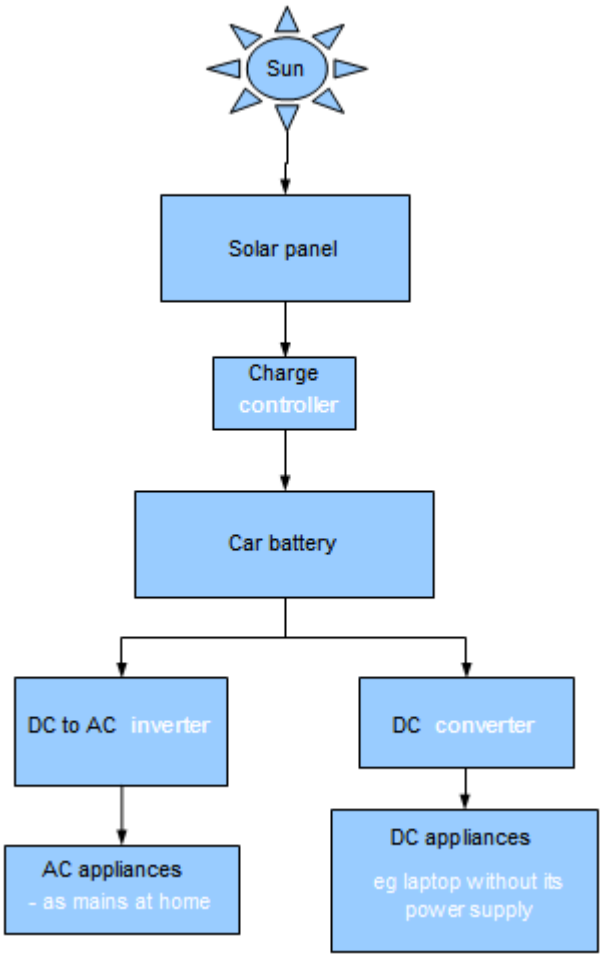

Figure 1 Main components

A solar panel converts solar energy to electrical energy, which then charges the battery via the charge controller. The function of the charge controller is twofold. Firstly it regulates the charge being supplied to the battery. On a sunny day the voltage supplied by the panel is likely to be higher than the maximum recommended voltage for the battery (approximately 14V). The charge controller will stop charging if the battery is 'full', preventing damage to the battery.

Secondly the charge controller contains a one-way diode which prevents electrical current flowing backwards from the battery to the panel (e.g. at night), which could damage the panel.

The battery stores the electrical energy. It is possible to run appliances from the panel without the battery, but not in low light conditions, such as dusk, night, or a cloudy day. To ensure a regular supply of electricity a battery is essential.

There are two methods of powering appliances from the battery. The simplest is by using an inverter, which changes the battery's DC output (direct current) to AC (alternating current), and also raises the voltage to a mains level (e.g. 100V or 240V. This means you can simply plug in appliances to the inverter's output.

More complex is a DC converter. You typically need an adaptor for each appliance you intend to use (e.g. laptop, video camera, mobile phone, AA battery charger etc). However, their advantage is that they lose less energy in the conversion process and are therefore more efficient.

See also http://www.hrelp.org/archive/advice/accumulators.html for details of batteries and inverters.

Solar panels

Solar panels are of two types: rigid or flexible. Some, such as the Global Solar 30W flexible panel shown in Figure 2 fold into a small pack (others can be rolled up). This roof was in the sun all day long, and the panel charged the battery from sunrise to sunset. The power is drawn via the cable that drops down and under the roof and then threads through into the window. It is wise to take plenty of such electrical cable, as it may be very difficult to get more on the field.

Figure 2 Solar panel on roof

It is advisable to physically check the panel from time to time. For example, dust settles on the panel, reducing sunlight and therefore power, so occasionally climb up and wash the panel with water.

This panel is shown held on the roof by bungee cords. The panel did not sit flat against the roof because the upper two bungee cords went over the roof capping. As a result, a night of strong winds gave the panel a tremendous buffeting, which it survived; however, we subsequently threaded the bungee cords underneath the capping, so as to make the panel flat sit flat on the roof.

Figure 3 Battery and inverter

At the bottom-right of Figure 3 you can see the DC to AC inverter. The lead on the left supplies power from the battery, and on the right a desk lamp is plugged in to the inverter's outlet. Although you can power several appliances at once using a multiple adaptor (depending on the capacity of the battery and inverter), this will drain the battery very quickly and you will have to be careful to avoid discharging the battery too much.

Figure 4 Inverter and desk lamp

Figure 5 shows various cables connected using gaffer tape. Gaffer tape is invaluable for joining and insulating cables, as well as holding cables (and various other items) in place.

For more details on setting up solar charging systems see Eva Lindström's excellent site at

http://www2.ling.su.se/staff/evali/solar.html

Figure 5 Gaffer tape connections

Types of solar panels

Solar panels can either be rigid and fixed, or portable/flexible. The main advantage of fixed panels is that they are cheaper, thus providing far more power for the same purchase cost (roughly four times as much). The disadvantage is that sourcing solar panels locally is difficult in many fieldwork destinations, and their size and weight make them difficult to transport. It will also be difficult to move them from site to site, and they are more difficult to mount than flexible panels (although in most places a local carpenter might be able to do this for you).

Flexible solar panels are light and fold down to a very small size (e.g. the 30W Global Solar panel is about the size of an A4 writing pad). Bungee cords (available from DIY or camping shops) can be used to hook them on to roofs, and they can easily be moved between field sites, or taken back home for other researchers to use when you finish. However flexible panels are much more expensive. For example, a 30W panel - which is the very minimum that a fieldworker should consider - currently (May 2007) costs around 500 pounds in the UK. Getting a fixed panel from a reliable source in the destination country, if it is possible, may be the better option.

Lead-acid batteries

Car batteries are lead-acid batteries and are totally different from laptop and dry cell batteries in their chemistry and their behaviour. Lead-acid batteries are designed to operate at full or nearly full voltage. Over-draining a lead-acid battery will damage it. In contrast, laptop batteries behave fairly constantly throughout their discharge cycle, and in fact manufacturers typically recommend occasionally draining the battery completely.

To prevent over-draining a lead-acid battery, most inverters shut off the power or sound an alarm when the voltage reaches a preset low value (usually 11.5 or 11 V). However, if you are not around to hear the alarm then this is no use.

Stuart learned these facts the hard way. He purchased a new, very high capacity battery (150 amp-hours Ah). Not knowing much about lead-acid batteries, he treated it like a laptop battery. Although he knew from multimeter readings that he was draining more power than the solar panel was generating, he decided to wait until the inverter sounded the alarm before partially recharging it.

With several such cycles, the battery drained faster and faster, and never recovered! Five months later, it would barely power a laptop for half an hour. This pattern of use, which would be acceptable with a laptop battery, was seemingly fatal with the lead-acid battery.

Sophie, on the other hand, was a bit luckier. She bought a high quality 85 Ah battery; however, being slightly worried about how reliably her electrical setup would work, she did not let the battery drain below 12V. In addition, because the battery's capacity was a manageable 85 Ah, it could occasionally receive a full charge on weekends. As a result of being able to regularly charge the battery fully, and not letting it drain too low, she was able to sustain three hours' laptop usage per day as well as regularly charge an iPod and mobile phone.

Caring for lead-acid batteries

Given the experiences described above, it is vital to monitor a battery's charge level and to keep it charged up. The battery's state of charge can monitored by measuring its open circuit voltage using a multimeter ('open circuit voltage' means the battery's voltage when it is not powering a device in a circuit, and is read by connecting the multimeter probes to each battery terminal). See Table 1.

Table 1 BCI standard for State of Charge estimation (source: The Battery University http://www.batteryuniversity.com/partone-13.htm)

Open circuit voltage (V)	State of charge (%)
12.65	100
12.45	75
12.24	50
12.06	25
11.89 or less	Discharged

If possible, test a battery by fully charging it before going to the field site, e.g. by charging it from the mains or fitting it into someone's car and driving around (during the daytime) for a few hours. A few hours after charging, measure the voltage, which should have stabilised at approximately 12.65V for a battery in good condition. Then, when you use the battery in the field, make sure that you regularly charge it so that it reaches this full voltage.

Note that charging (including using a solar panel) raises the battery voltage and that once charging stops the battery takes some time (up to several hours) to stabilise at a voltage that reflects its true state of charge. In a field situation using solar panels, this might mean measuring the battery voltage at dawn, before the sun comes up and resumes charging.

It is recommended to keep lead-acid batteries at least 80% charged, which corresponds to a stabilised voltage of approximately 12.5 V. It may take a week at the beginning of your field trip to work out how many, say, full laptop charges can be obtained from this 20% of battery charge, but doing this might save you from damaging the battery irreparably.

See Battery University units BU13 and BU22 (http://www.batteryuniversity.com/partone.htm) and Power solutions in the field: Using an accumulator (Castle and Nathan 2007) for further details.

Inverters

Inverters are used to convert a battery's DC output (direct current) to AC (alternating current), while also raising the voltage to a mains level (e.g. 110V or 240V. Inverters are not 100% efficient, so, whilst performing these conversions, they also consume power; power which is, from the user's point of view, wasted.

We used three different 240V inverters, one with a capacity of 300W (Nikkai Automotive 300W Power Inverter) and the others with 150W (GX-150AF Pro Power Inverter 150W, Nikkai Automotive 150W Power Inverter). The power rating refers to the maximum amount of power that can be consumed using the inverter. Given that most laptops do not use more than about 50-60W we expected the 150W inverter to be fine.

Neither of the smaller inverters performed well. In particular they tended to overheat and so the built-in fans would run constantly, leading to further power loss. Neither of us were able to actually use the laptop while charging it through a 150W inverter, since this drained too much power from the battery and resulted in the voltage dropping very quickly.

The Nikkai 300W inverter suffered neither of these problems. Although our experience does not amount to a scientific test, we would be wary about using a 150W inverter again.

Charging alternatives

Your solar setup may be effective, and you may not need to look elsewhere for an energy source. However solar panels are not the only way of obtaining electrical power in the field. Tom Castle and David Nathan's (2007) article Power solutions in the field: Using an accumulator suggests a different way of thinking about the problem: base the strategy around the "accumulator" (lead-acid car battery in our case), and then secondarily consider practical options for replenishing it.

Note also that in some cases you need to consider the quality as well as the quantity of power. For example, in some countries the power supply may be unstable, and could damage your equipment. Check with knowledgeable people, and carry a surge prevention device and a multimeter to safely measure the mains voltage.

Reducing electrical needs

Investigate alternatives to electricity, such as using kerosene lanterns for lighting if they are available locally. But for laptops, electrical power is essential. You need to work out strategies and working styles to deal with the fact that you will not have have power to run a your laptop as much as you'd want, and there will be times when you cannot use it at all.

Even if you can keep a lead-acid battery topped up, whether by solar power or other means, it is still worth taking steps to conserve power. It may not be possible to use the laptop while it is charging, since this can drain the lead-acid battery too quickly and therefore damage it. Or it may be difficult to work in the immediate vicinity of the lead-acid battery.

Of course, if you are having difficulties charging the lead-acid battery, conservation of laptop power becomes crucial. Therefore as well as the generation of electricity, it is important to consider how you use the available power and what you can do to use it most efficiently. Despite the advantages of having a computer in the field, you must ask whether it is really needed. Language documentation and linguistic research is possible without a laptop – until fairly recently the majority of such work was done in this way. Setting up and maintaining a field power supply is not cheap, straightforward, or reliable, and therefore it is worth considering your dependence on it. This section offers some advice on minimising the need for power.

You can reduce the amount of energy a laptop consumes in two different ways. First, you can reduce the amount of power the laptop uses as it runs. Secondly, you can reduce the amount of time it runs.

Laptop power consumption

Different computers have different power requirements. If you are buying a new laptop then consider its power consumption and battery life. Otherwise, reduce the energy consumption of your existing machine.

Most laptops provide allow power management options via their control panel or machine specific management software. Default manufacturers' settings for power management are rarely appropriate for fieldwork situations. For example, in the field you want the most efficient use of power regardless of whether you are running on the laptop battery or on mains power, if the mains power is supplied from an inverter.

Some other tips:

- the screen lamp is one of the biggest energy consumers – use the lowest brightness you can comfortably work with (most computers use a function key combination to adjust this)
- turn off the wireless LAN
- avoid CDs/DVDs; take disks out of the machine so that it does not try to read them. If you use certain files regularly, copy them on to the hard disk
- some USB devices drain power – don't leave them in longer than necessary
- turn off your anti-virus software's on-access scanning and reduce the frequency of disk scans. Do this if you are absolutely sure your computer is not at risk

Most importantly, plan your workload according to the amount of power you have available. For example reading a document using a simple plain text editor uses very little power; on the other hand processing audio or video can use much more.

Use the laptop less

Audio recording

Computers are not necessary - or even desirable - for recording audio. Some fieldworkers record audio directly to the computer, or via an external sound card, usually because it is cheaper than buying a good quality audio recorder. However, quality solid state recorders are a better alternative,

since they offer more appropriate and accessible controls, professional connectors and are both more portable and less distracting. In addition, they waste less power overhead, and most can be powered by AA batteries. Their capacity is approaching what you would want to store on a computer; memory cards currently store up to 4GB, so by taking a small number of cards, dozens of hours of recordings can be stored. Nevertheless, backup of this data is necessary, for which a computer may be required. This task can be allocated to a time/place where you have better access to power, such as a weekly or monthly visit to a town.

Audio playback

The most frequent type of data processing done in the field is transcription and annotation. It is often done by writing while listening to recorded audio, in collaboration with a language consultant. Some fieldworkers transcribe directly using a computer. Although this might save time overall, there are good reasons for using pen and paper. Typing in the transcriptions after formulating and checking them will take less computer time. You can postpone time-alignment until you have a more reliable power source. Quite apart from issues of power management, there may be other social and practical reasons for avoiding using computers in transcription sessions.

Audio recorders can be used to play back previously-recorded texts during transcription sessions. All have headphone outputs – either you take two sets of headphones and an audio splitter so that you can your consultant can both listen, or you can take some compact speakers); better still some such as the Marantz PMD 660/671 have built-in speakers.

Alternatively a small cassette recorder or an MP3 player can be used for audio playback during transcription sessions. Sophie used an ipod and found that with its power saving options such as turning off the backlight it provided between four and eight hours of playback. Standalone ipod solar chargers are available (cost: about £60), but in any case MP3 players draw much less power than laptops when charging. On a sunny day the output of the solar panel was sufficient to charge Sophie's ipod without draining the lead-acid battery at all.

Example budget

This article concludes with an indicative budget based on our equipment. Your budget will depend on your field circumstances and preferences. You may also need to budget for a technician to assemble wiring etc. (we were grateful to Bernard Howard, the technician at SOAS for his assistance with this). Note that these are (2009) UK prices; in many places you may be able to buy cheaper.

Table 2 Minimum budget outline for a field solar system

Item	Manufacturer	Cost	Comments
Solar panel	P3 Powerflex Solar Power Pack	£750	30W is a minimum, at least 55W is recommended. Fixed panels are much cheaper.
Charge controller	Kemo 5Amp Charge Controller	£15	This is just one of many charge controllers available
85 Amp-hour, good quality car battery	Typically bought in-country, so brand will vary	£60	The battery capacity should be matched to the panel output so that all the generated solar energy can actually be stored. The 85 Ah battery worked well with the 30W panel

300W inverter	Nikkai 300W Power Inverter	£35	A 300W inverter is heavy but seems to be worth the extra weight. Remember to take spare fuses!
Cables and connectors		£20	Purchase a variety, e.g. to connect from roof to interior, and between devices. Also crocodile clips for connecting cables to the car battery, other low voltage connectors, and insulation tape
Multimeter		£7	Digital, automatic polarity units are preferable. Note that some use non-standard internal batteries
TOTAL: £887			

References

Castle, Thomas & Nathan, David. 2007. Power solutions in the field: Using an accumulator. *ELAR advice document*, http://www.hrelp.org/archive/advice/accumulators.html.
McGill, Stuart & Salffner, Sophie. 2007. Power solutions in the field: Solar power for laptop computers. *ELAR advice document*, http://www.hrelp.org/archive/advice/solar.html.