AJ's technical tips: Small solar PV systems should have small batteries

Mr. Arne Jacobson

This article is the first of what *Solarnet* editor Moses Agumba and I hope will be a regular feature in this magazine. The idea is to create a column for discussing technical issues related to solar energy systems that will provide useful information for solar technicians, shopkeepers who sell solar equipment, and people who are interested in buying or operating a solar energy system. Because this column is meant as a discussion, I invite your technical questions (send them to "Technical Tips", Solarnet Magazine, P.O.Box 76406, Nairobi, Kenya; you can also send them to me using electronic mail at this address: "arne@socrates.berkeley.edu").

I am happy to answer questions that you have about the design or installation of solar or other renewable energy systems. I am especially interested to hear about any difficult problems that you face in your work. You can also offer suggestions or ask me questions about anything you do not understand about any of my articles. Please remember to include as many details as possible in your questions as this information will help me to give an accurate answer.

Before turning to the first technical topic, I will take a moment to introduce myself. I have been doing research on solar energy in Kenya for the last two years (you may have noticed articles that I have written in this magazine).

I started working in the solar energy field 10 years ago when I began my apprenticeship as an electrician in the Southwest of the United States. After working for several years as a solar technician, I later got a degree in engineering with a focus on the design of renewable energy systems. Now I am a solar energy researcher at the University of California at Berkeley in the USA.

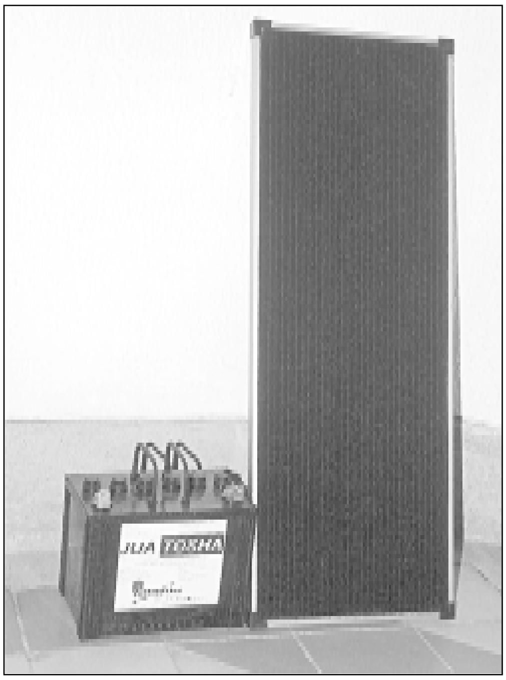
In addition to my current research work in Kenya over the past decade, I have worked with renewable energy systems in the USA, Central & South America, and India. I have particular experience working with solar electric (PV) systems, micro-hydroelectric systems, and solar water heating systems.

In writing this column, I will draw from my experiences working with these technologies as a technician, an engineer, and a researcher. I will do my best to answer your questions, and will turn to my many expert colleagues in Kenya and around the world when I get a question that I cannot answer myself. Of course, space in the magazine is limited so I may not be able to answer all of your questions right away, but I will answer as many as I can.

One of the things that I have noticed over the last two years of working in Kenya is that for small household solar PV systems, the battery is often larger than it needs to be. Here I am referring to systems that have a solar panel that is 20 watts or less (for systems with larger solar panels the battery size is usually OK). In most cases, these small systems work well with a solar battery that is 20 amp-hours to 40 amp-hours in size. However, a survey by 108 Kenyan solar technicians who had installed small solar PV systems recently showed that in 87% of cases the battery was larger than 40 amp-hours. In other words, for most of the systems the battery was larger (and more expensive) than it needed to be.

System users (that is, the family) often use too much electricity and the solar panel is not able to keep the battery charged. This problem is especially bad when the battery is too large since the battery will almost never get a full charge. This damages the battery quickly. With a smaller battery, the solar panel is more likely to give the battery a full charge from time to time (though it is still important for the family to be careful not to use too much electricity). This helps the battery last longer.

As an example, for a 12 watt solar panel in a system with a black



Matched 12 W amorphous panel with 20 amp-hours Jua Tosha battery

& white television, one 7 watt fluorescent tube lamp, and a small radio, I would recommend a solar battery that is between 20 and 30 amp-hours in size. In the Mount Kenya region, this system should provide enough electricity for each of the appliances for approximately 1.5 hours per day in cloudy months (May to August), and 2 or 2.5 hours per day during the rest of the year. Near Nakuru the same system would give 2 to 2.5 hours of electricity per day, depending on the time of year. The performance in other regions will vary a little bit, but my recommendation for the battery size will still be the same.

Many people may complain that small batteries do not give enough electricity. However, the correct way to increase the number of hours per day that the family can use its electric appliances is to get another solar panel (or a larger solar panel). Buying a larger battery will not help them to increase the amount of electricity they can use if they only have a small solar panel, though the larger battery will cost them more money. The 20 to 30 amp-hour solar battery that I recommend for this system will save the customer money (it costs less to buy than a larger battery) and it is the right size for use with a small solar panel. If the customer wants to spend extra money, I would recommend that they spend it on a larger solar panel instead of a larger battery.

I would like to return briefly to the 108 technicians who had installed the small panels with the big batteries. I should point out that it is usually unfair to blame the technician for the large size of the battery. For example, many times a customer will ask a technician to do the installation only after buying the equipment. In these cases it is the salesperson at the shop who has the opportunity to advise the customer about which equipment to buy. In other cases, the customer will ask the technician for advice about which things to buy before going to the shop. This points out the need for both solar technicians and salespeople to learn the basics of sizing solar electric systems. Of course, customers may still insist on buying the larger batteries, even if they are advised to buy the smaller ones.

To summarise the main message of this article, for household solar PV systems with a solar panel that is smaller than 20 watts, a solar battery that is between 20 amp-hours and 40 amp-hours in size is usually the best choice. At present, two solar batteries are available in Kenya in this size range. These are the 20 amp-hour and 30 amp-hour batteries made by Voltmaster in their “Jua Tosha” line of batteries. Although I do not know of small solar batteries that are made by other battery companies, I hope that they will choose to offer them soon. Note that you should always insist on using “solar” type batteries for use in a solar panel system. Do not accept lower quality “automotive” type batteries, as these do not last long.

In the next issue of *Solarnet*, I will provide details on how to make design calculations for small solar power systems. (This will be in addition to answering questions that I may receive from you, the reader). In addition, those readers who are interested in learning more about solar system design and maintaining

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Small solar PV systems should have small batteries

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solar PV systems should consider getting a copy of the book, *Solar Electric Systems for Africa*, by Mark Hankins. It costs Ksh.1950 and is available at the Energy Alternatives Africa office in Nairobi (Rose Ave. off Ngong Road). The book is also available at some solar shops in Kenya, including Solagen Ltd. (Nakuru and Nairobi) and Sollatek Ltd. (Nairobi shop).

Contact Information:

•*Arne Jacobson, or*

•*Mark Hankins, c/o Solar Book, P.O. Box 76406, Nairobi, Kenya; Tel: 254-2-714623; Fax: 254-2-720909*

Email: arne@socrates.berkeley.edu

Excellent RE reference material, *SolarNet* Magazine

I finished my studies on August 17, 2001 and am now trying to make ends meet. Once again I am grateful for the magazines that you gave me because they were of help in my project. God bless you. At the moment, I would like to express my interest in joining EAA or any other RE organisation if there is any opportunity.

John orutwa
jorutwa@avu.org

Support *SolarNet's* RE Public Education's Endeavour

Dear Editor,

I refer to your article in *Daily Nation* Newspaper for Tuesday 18 September 2001 - *What RE can do for the benefit of Kenya* and would like to know if you have a newsletter featuring new and current development in renewable energy. As a keen follower of this topic, I would like to sincerely congratulate *SolarNet* on the effort to highlight the potential of RE, its status, impediments and requisite way forward. That article, I believe, is worthwhile, timely and needs to be regularly updated and transmitted to the burgeoning readers in the region. While taking cognisance that to carry this out, non-profit making organisations like *SolarNet* need financial support to sustain this good cause, I would challenge all RE and environment donors, companies, organisations, governments, policy makers and individuals to emulate the good example of EAA, SCI, KENITAL, Chloride Exide and SOLARNET and support the organisation in this worthwhile endeavour.

Munaver Gulamali
meg@clubinternetk.com

Reply

Dear Munaver,

We are happy that that our writer in the Daily Nation had an impact - just as was intended. We are committed to educating the public, decision-makers and media in Kenya and beyond on the benefits derived from RE. We also publish the leading East Africa RE magazine, Solarnet, that has been referred to as informative and the only official RE magazine in the region. Your subscription is highly welcome if you wish to be a regular reader. Solarnet's membership and liaison officer, Mr. David Otieno (david@solarnet-ea.org) will get in touch with you with a membership application form. Please let us know if you are interested in the membership so that we can move to the next step.

Editor

The Great - *SolarNet* Newsletter

Sir, thanks a lot for coming up with *SolarNet* newsletter, it is informative and to the point. I would like to read all issues. I was lent a copy of issue - Vol. 3 No. 2 by a colleague and its content and simplicity of presentation of all topics covered was fantastic. Even people with little technical knowledge of the subjects covered would understand without straining. I will subscribe small business category in due course. Now among the articles covered, I was impressed by AJ's technical tips and the update on the performance of 14 watts phoenix Gold Solar Panels. Sure this particular brand of modules has done a lot of damage to the reputation of solar PV as a renewable source of energy. They don't work! Dealers who have scanty and misleading information on the same have not helped much either.

We hope that with *SolarNet's* intervention and with accurate and reliable data/information we will re-design the systems when confronted with customer complaints. Systems designs and sizing is one area giving field technicians a big headache. With a copy of "SOLAR electric systems for Africa by Mark Hankins" the problem will, hopefully, be overcome. I hope to get a copy as soon as possible.

As there are limited reading materials on solar renewable energy available, we shall continue looking to SolarNet for in-depth analysis and updates. We also ask manufacturers to provide manuals on their products.

Keep it up - *SolarNet*

Gitau G. Kinyua

Reply

We are pleased to read your comments on our newsletter. We are committed to making it the EA official RE journal. To realise our ambitious target - and we are almost there - we need all inputs from our wider readership.

Regarding the Solar schools project, the mentioned issue had a detailed set of requirements and criteria for schools participation. Kindly pass it on to your neighbouring schools for the formal application.

Editor

Need of RE information

I live in Kitui and have recently received one of your magazines on solar energy. My husband and I have recently bought some land and will be building a home there next year. We wish to learn more about solar / wind power so that we can install the necessary equipment as we build. This will probably be in phases due to financial constraints. Could you please send us any relevant information and details on how we may subscribe to your magazine.

Thank you.

Sue Nzyimi
(formerly Stott)
Kitui

We wish you well

We are a small three-year-old rural based organisation pursuing mainly four long-term thematic lines of work: Assistance, Poverty reduction, Relief and Capacity building.

The founders of this organisation are local secondary school teachers who charitably fund the organisation activities from their own resources.

Your mission of promoting renewable energy technologies in Kenya is something we highly appreciate. Energy is a crucial factor in realising the above objectives. We wish you well. You can always count on us in your endeavours to make renewable energy available especially in our rural areas.

Mutuku Muthiani
Hon. Secretary

Congratulations !

I would like to congratulate you and the other participants on the auspicious organisation of the sixth annual solar day event. Rural electrification will not take 400 years, but less than that. Through exhibitions and promotion, it will only take 20 years!

Please send me more information about solar and wind power on how to adjust, maintain types and choose the most efficient.

Andrew Omondi
Mombasa

Request for community demonstrative systems

I am a local electrician in a rural village in Njoro. I install panels for the local community. Before I take up any assignment, I have to demonstrate the working of solar panels using my 12-watt system, which has proved to be too small.

I therefore request you to offer me a bigger one plus an inverter to enhance clear understanding on how solar energy is generated and how it can be used in households. This will create a positive attitude towards solar energy.

There is no possibility of my area being connected to the national grid in the near future. Thus, this technology is the only solution to my community's energy needs.

Henry Kimani Mwangi
Njoro

Please, help me out

Attention: 'TECHNICAL TIPS' DESK

I would like to thank you very much for sending me both issues of your *SolarNet* magazine (Vol. 3 No1 and Vol. No2). I have keenly gone through them. I have found your publications very valuable and interesting to me as a technician.

However, I have some problems I face during installation of the solar systems and a few comments to make:

- I may finish my installation very well, but after fitting in the DC filament bulbs, the lights start going off one by one after about half an hour. The client will immediately start to complain that the work has been poorly done. When I try to twist the bulb in its holder, it lights up again. So I have learned that any small arching (loose connection) will definitely make a solar bulb not to light unlike AC bulbs, which will either work or just 'blink'.

- Using a diode in between the panel and the battery is always the advice I give to my clients although these diodes also fail sometimes. Even after fitting the diode properly using a meter, the battery does not work for more than three hours. This happens in spite of having charged the battery from the panel for, sometimes, a whole day. I would like to know if different types of batteries or sizes of panel need different sizes of diodes.

- In the rural areas (like Kitale where there are a lot of night thefts) it is risky to leave solar panels on the roof at night. There is a case in one of my past works where I was forced to improvise the framework of an angle line metal around a solar panel with a wire mesh on top and some bolts at the corners before mounting it on the roof and tying it with nuts from inside the ceiling. I found this to be safer and more secure as the owner could now lock it at night. So, other technicians and manufacturers could consider this.

Lastly, I would like to thank Mr. Arne Jacobson of *SolarNet*, technical tips desk for this very important technical article. I have found it very educative and useful for my studies in the solar field. So let us keep in touch. I will be very grateful to receive any other information and assistance.

Simon Nyukuri
Pen Electrical Services
Kitale (K)

This is great!

I am writing this letter in response to your *SolarNet* newsletter (Vol.3 No.1). The issues covered in it were of great value to me. I found them very informative and enlightening.

At a time when the country is still recovering from a recess in power supply, people want a reliable source of power; and your newsletter is guiding us in the right direction. For a country like Kenya, with the equator passing right across it, we should have harnessed all the vast potential renewable energy resources our country is endowed with and used it effectively to cater for all our ever increasing energy demands.

The only factor I can possibly see as a hindrance and barrier in this process, is public ignorance. The ordinary Kenyan is not aware of the extent to which they can utilise the potential energy resources around them.

I am wishing all of you a healthy, happy and a better working year 2002. Please send me more information. Your assistance is greatly appreciated.

Miltone Obote Manyala
Migori

ADVERTISERS' INDEX
(Sept/Dec 2001)

As part of the continuing improvements to the Solarnet website, www.solarnet-ea.org, you can now make enquiries to the companies advertising through an easy-to-use enquiry channel. Just drop a line on info@solarnet-ea.org

For information on advertising in future issues of the magazine, please contact David at Solarnet on Tel. 254-2-714529 or david@solarnet-ea.org

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management and implementation systems.

The project's baseline survey has been undertaken and the first 20 systems are to be installed before the end of the year to raise the morale of enthusiastic farmers who have expressed interest to have their systems in readiness for the Christmas festivity.

Kenya SACCOs movement is the strongest in the world. It houses the most financially stable farmers co-operatives in the region, a majority of which draws membership and savings from rural households in un-electrified parts of the country. The Michimikuru SHS Finance on successful implementation is poised to be an eye-opener in the sector that would undoubtedly be emulated by other SACCOs in Kenya that are currently too naïve to venture into SHS finance.

AJ's Technical Tips:

Designing a Small Solar PV System Part I: Calculating the Amount of Energy Used by the Electrical "Loads"

In rural areas, there is a high risk of solar panels being left on the roof of a house for a night

I want to start this article by thanking all of those who have sent letters. In particular, Simon Nyukuri of Kitale sent in a suggestion about security and solar panels. Simon writes:

In rural areas (like here in Kitale where there are night thefts) there is high risk of a solar panel being left on the roof of a house for a night. There was a case in one of my jobs where I was forced to improvise a framework of an angle line metal around a solar panel with a wire mesh on top with some bolts at the corners. I was able to mount this on the roof and I tied it with nuts from inside the ceiling. This made it safe and secure and he (the owner) was able to use a padlock. So mine is a suggestion to manufacturers to consider making frames that are more secure.

"Simon raises an important point about security for solar PV panels. In many areas around Kenya solar panel owners are concerned about theft. I agree that it would be good to have an easy-to-use and secure framework that people could buy for mounting their solar panels. And Simon's suggestion for setting up a framework that can be bolted to the roof with nuts from inside the house is very good. This is exactly what I would recommend. ***However, when installing the panel it is VERY important not to use wire mesh or other things that might block the sun from reaching the front of the solar panel***. Blocking the sun reduces the amount of electricity produced by the system – in some cases blocking even a little bit of the panel can cut the electricity produced in half! This means that security systems for protecting against theft should be designed so that they attach to the edges of the panel (that is, to the frame) without blocking the sun from hitting the panel. This makes securing panels a little more difficult, essential as it is."

Simon also asked a question about diode use with solar PV systems. I will save that question for a future article, but I will be sure to answer it! Thank you Simon for your good questions and enthusiasm. Thanks also go to Gitau Kinyua, also of Kitale, for his letter and compliments. And to the rest of you, send me a letter at "Technical Tips", So*larNet* Magazine, Box 76406, Nairobi, Kenya. Now, on to the main topic for this issue – design calculations for small solar PV systems.

Designing a Small Solar PV System

Designing small solar PV systems involves five main steps. These are (1) calculating the size of the electrical loads for the system, (2) choosing a battery, (3) choosing a solar panel, (4) selecting other parts that may be used, such as a charge controller, and (5) selecting wires and cables for the system. Over the next few articles I will describe the process of designing a small solar PV system, including some special tips on how to get the best design.

Calculating the size of the electrical loads

In this article I will begin with what should be the first step for designing any solar PV system: calculating the size of the electrical loads – or in other words, the amount of electrical energy that is needed to power the lights, television, radio, and other appliances that the customer may want to use.

In doing these "load" calculations I am going to keep things simple, so I will only talk about a system that uses 12-volt direct current (DC) electricity. This means that I will not talk about systems that use inverters or appliances that require 240-volt AC electricity. I will save these more advanced topics for a future issue of So*larNet*.

The first thing to remember about a solar PV system is that the amount of electricity that can be used by the customer is limited by the amount of electricity that is produced by the solar panel. This amount changes from day to day and from season to season because the amount of solar energy from the sun changes according to the weather. This means that customers must be aware that they cannot use as much electricity as they might want and also that they will have more electricity on sunny days and less when it is cloudy. As the designer of the solar PV system, it is your job to make sure that the customer understands these issues BEFORE he or she buys the system. Otherwise the customer may feel cheated when the system does not give them as much electricity as they thought it would.

The second thing to remember about making "load" calculations is that the amount of electrical energy that an "appliance" (that is, a light, a television, a radio, or anything that uses electricity) uses depends on two things. These are:

(1) the amount of power required by the appliance when it is turned on (in watts) and

(2) the amount of time that the appliance is on each day (in hours).

To calculate the energy use for the appliance multiply the power (in watts) by the hours of use each day to get watt-hours of energy (watt-hours are sometimes written as Whr or Wh in short).

Energy use (watt-hours) = Power (watts) X Time (hours)

For example, if a family has a 7 watt fluorescent lamp and they use it for 3 hours, then the energy use is 7 watts X 3 hours = 21 watt-hours. As another example, if they have a 13 watt black and white television and they turn it on for 2 hours, the energy use is 13 watts X 2 hours = 26 watt-hours.

Steps for Estimating Electrical Loads (that is, the energy used by appliances):

1) Find out what appliances the customer would like to use,

2) Find out how many watts each of the appliances uses when it is turned on,

3) Find out how many hours per day the customer would like to use each appliance,

4) Calculate the amount of energy the appliances will use each day,

5) Add up the daily energy use for all of the appliances to get the TOTAL energy that is needed from the whole solar PV system each day.

I have included a table for the calculations of the amount of energy used by the appliances (Table 1). Note that I have included calculations for the 7-watt fluorescent lamp and the 13-watt television that I mentioned above. I have also added a small radio (2 watts) that is used for 5 hours per day. Note also that all of the appliances are 12-volt appliances, since they will be used with a 12-volt battery and solar panel. Of course, it is possible to use a DC to DC converter if the radio voltage is less than 12 volts.

When I add up the daily energy use for all three appliances (the light, the television, and the radio) I get a total daily energy use of 57 watt-hours. This number is one of the important factors that I will use to decide how big the solar panel and the battery needed to be for this system. Suppose I calculate that a 20-watt solar panel and a 50 ampere-hour battery are the right size for these loads. In the next issue of So*larNet* I will show you how I did these last calculations for the size of the solar panel and the battery.

Table 1: Worksheet for Calculating Daily Energy Use for a Small Solar PV System

Electrical Appliance	Voltage (volts)	Power (watts)	Daily Use (hours)	Daily Energy Use (watt hours)
Fluorescent lamp	12 volts	7 watts	3 hours	21 watt-hours
Black and white television	12 volts	13 watts	2 hours	26 watt-hours
Radio	12 volts	2 watts	5 hours	10 watt-hours
			TOTAL:	**57 watt-hours**

Table 2: Daily Energy Use for Solar PV System – Higher Energy Use

Electrical Appliance	Voltage (volts)	Power (watts)	Daily Use (hours)	Daily Energy Use (watt hours)
Incandescent bulb	12 volts	*25 watts*	3 hours	*75 watt-hours*
Black and white television	12 volts	13 watts	*5 hours*	*65 watt-hours*
Incandescent bulb	12 volts	*25 watts*	*1 hours*	*25 watt-hours*
Radio	12 volts	2 watts	5 hours	10 watt-hours
			TOTAL:	***175 watt-hours***

What if customers want to use too much energy?

Of course most customers would like to use many appliances, and they would like to use each one for many hours each day. For example, the family in this example might want to use a 25-watt incandescent bulb instead of the 7-watt fluorescent tube, because the bulb is less expensive than the fluorescent tube. And they might also want to watch the television for 5 hours a day instead of just 2 hours. It is also possible that they might want another light (maybe a second 25-watt incandescent bulb) that they would use for 1 hour per day. This would change the amount of energy used by the system. I have done the calculations for this new and bigger system in Table 2. Note that I have indicated the changes in the table by writing them in *bold type*.

The changes (incandescent bulb instead of fluorescent, using the television for more hours each day, and adding a second incandescent bulb for one hour per day) have increased the energy use to more than three times what it was in the first table. To provide enough energy for these extra 'loads' the family would need to buy a bigger solar panel and a bigger battery than in the first case in Table 1. The panel would need to be 60 watts and the battery 150 ampere-hours. This would cost the customer a lot more money!

Most times the customer cannot afford the bigger panel or the bigger battery. In this case your job as the designer is to explain to the customer that they will destroy their battery if they try to use as much energy as they wish to. So they must cut back on the number of hours they use their appliances and maybe also use fewer appliances. Because customers often want too many appliances and also want to use them for many hours, I often have to design solar PV systems in several steps.

1. I find out the number of appliances they want and how many hours they want to use them.

2. I calculate the size of the panel and determine the battery they will need.

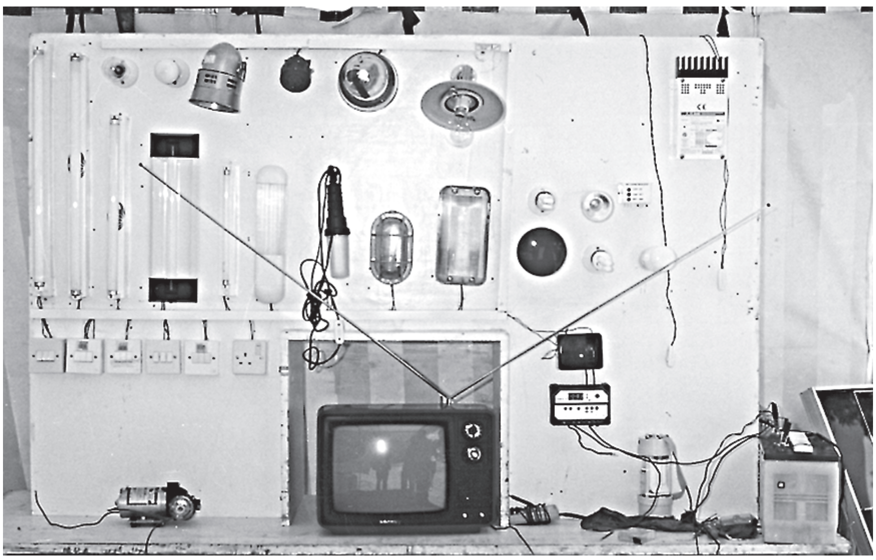
3. When they tell me that they cannot afford such a big and costly system, I show the customer the appliance load calculations (like the ones in table 2) and we talk about alternative appliances that use less power, and those that can be used for less time each day, and also those that can be left out altogether.

4. We make changes on the loads in the system until the system is affordable to the customer. This also means lowering the amount of energy required by the appliance.

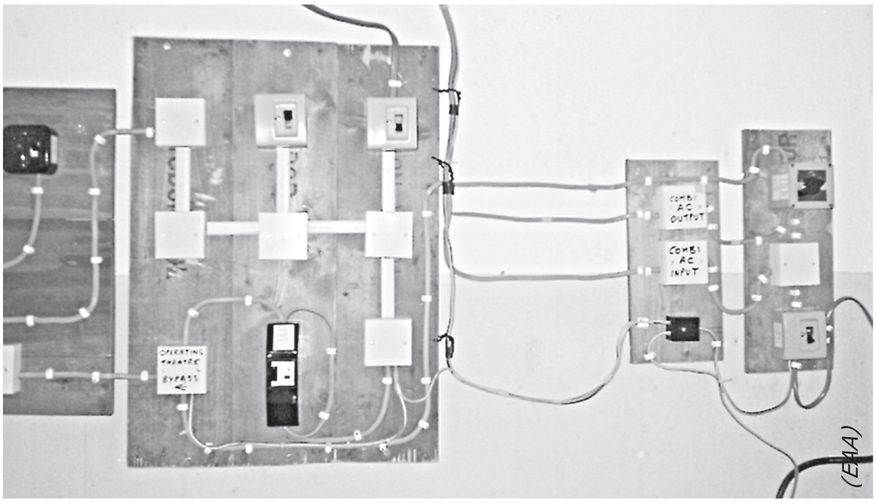
In this case I would suggest changing the 25-watt incandescent bulb for the 7-watt fluorescent tube. The energy used for that light will be reduced from 75 watt-hours to 21 watt-hours. A 7 watt fluorescent tube gives about the same amount of light as the 25 watt incandescent bulb, but it uses much less power (watts) when it is turned on. The fluorescent tube does cost more than the bulb, but the amount of energy saved means that the customer can buy a smaller solar panel and battery. The savings in money on buying the smaller panel and battery is much bigger than the higher cost of the fluorescent tube. So the customer saves money overall by opting for the fluorescent tube.

I also talk to the customer about reducing the number of hours per day that he or she plans to use each appliance. In this case I might recommend reducing the number of hours that the family has the television on from 5 hours to 2 hours. This reduces the energy use by the television from 65 watt-hours to 26 watt-hours per day.

A third possibility is to get rid of some of the appliances entirely. In this case I might suggest removing the second 25-watt bulb. This saves an addi-



Customers often want too many appliances to be used for many hours without the right size of the solar system



Calculating the size of the electrical loads is usually the first step for designing any solar PV system

tional 25 watt-hours per day, and we are now back to the system with the 20-watt panel and 50 ampere-hour battery in Table 1.

In summary, if the amount of energy that customers want to use is too high for the size of the solar system that they can afford to buy, then there are three ways to reduce the energy to an affordable level.

(1) You can switch appliances for ones that use less energy.

(2) You can help them decide to use the appliances for fewer hours each day.

(3) You can help them decide not to buy too many appliances.

All of these things can be done to ensure that the most suitable system is – and this allows them to use a smaller solar panel and a smaller battery. If the customers can afford the bigger solar PV system, then it is, of course, not necessary to make the reductions. It all depends on what they can afford.

I will come back to this topic of working with the customer to adjust the electrical loads to fit their budget for buying a solar PV system in the next issue of *SolarNet* when I write about sizing the solar panel and the battery.

How many watts does the appliance use?

As a final note, one of the most important things in making the calculations that I have talked about in this article is knowing how much electric power (that is, the number of watts) each appliance uses when it is turned on. There are several ways to get this information.

a) *Find the information (that is, the number of watts) written on the appliance*

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Take caution on batteries

Batteries are one of the most important and costly components of a renewable energy inverter system. Many people invest time and money to research on batteries and choose the most appropriate ones for their needs. Unfortunately, batteries are also the most dangerous part of a system. Most people are simply unaware of the dangers involved and are not well educated about battery safety and proper maintenance. To ensure safety around batteries, it is critical that you take some simple precautionary measures.

Batteries contain a sulfuric acid electrolyte, which is a highly corrosive and explosive poison. When being recharged or heavily discharged, the electrolyte will produce gases, which can explode if exposed to even the smallest spark.

Battery electrolytes should never be allowed to mix with salt water. This combination will produce a toxic chlorine gas that will prove to be lethal even in very small quantities. Batteries have the potential to be very harmful and even fatal if not handled properly.

When working with batteries, there are a few things you can do to ensure safety. Take the following precautions:

- Always exercise caution
- Be sure there is plenty of ventilation
- Don't smoke or use a flame around batteries
- Remove all jewelry, wear protective clothing and eyewear (safety glasses)
- Whenever possible, follow the manufacturer's instructions for testing, jumping, installing and charging the batteries.

As a reminder, ensure longer battery life by always using distilled water to refill your batteries. The minerals contained in tap water, well water, or bottled mineral water cause mineralisation of the batteries, which significantly reduces their life span.

Above all else, be careful when working with batteries. They can potentially harm you if mishandled and we should take all precautions to avoid that. Be sure to inform all of your customers of the dangers involved with batteries and educate them about the precautions that they can take.

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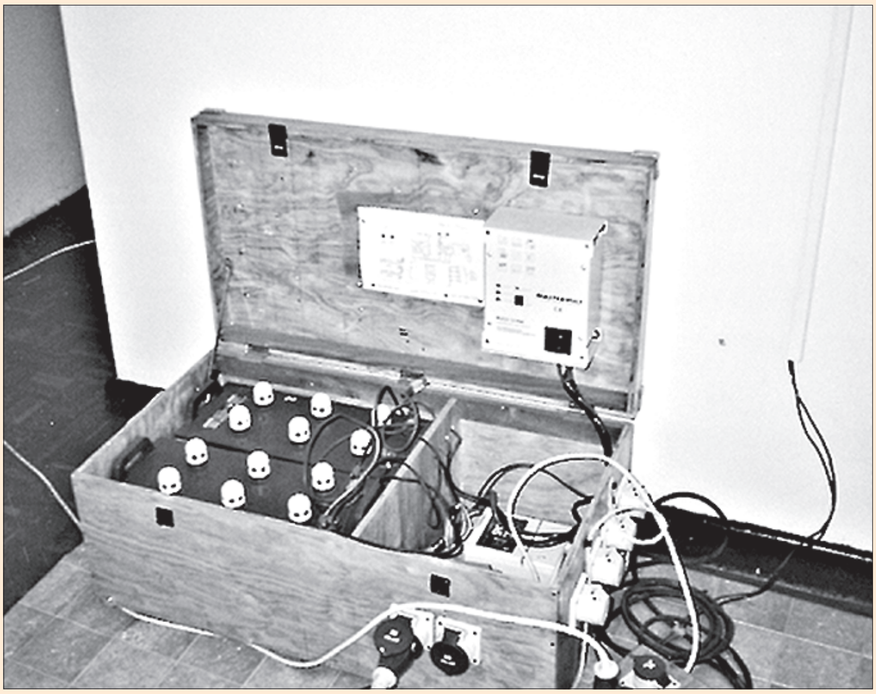

Batteries have the potential to be very harmful and even fatal if not handled properly

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For many appliances the number of watts that they use is written on the appliance. For lights the number of watts is often written on the tube or the bulb. For other appliances you can look to see if the number of watts is written down on a label somewhere on the appliance. For example, many televisions and radios have a place on the backside that says how many watts they use (though this sometimes is the maximum instead of the average power consumption, so the actual number of watts used may be a little lower than what is listed).

b) *Measure the power (in watts) used by the appliance when it is on.*

If the number of watts is not written anywhere on the appliance, it is possible to measure the amount of power (watts) if you have a multi-meter that measures electrical current (in amperes, or "amps"). Only try this if you know how to make the measurements properly (I will explain how to do this in a future issue of *SolarNet* if readers request it). Once you have measured the current (in amps) used by the appliance you should also measure the battery voltage when the appliance is on. Then you multiply the current times the voltage to get the power. For example, if you have a television that uses 1.1 amps and the voltage is 12.3 volts, then the power used is 13.5 watts (i.e. 1.1 amps X 12.3 volts = 13.5 watts).

c) *Look the information up in a table.*

Finally, if you cannot find the information about how many watts the appliance uses any other way, you might want to look up the information in a table that lists the power use for some appliances. I will include a list in the next issue of *SolarNet*. Mark Hankins also has a list in his book, "Solar Electric Systems for Africa".

Conclusion

In the next issue of *SolarNet* I will show you how to calculate the size of the solar panel and the battery based on the electric loads calculations that we made here as well as the amount of sun that is available in different places in Kenya. Until then – *kwaherini* to you all!