Continued from page 11

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.

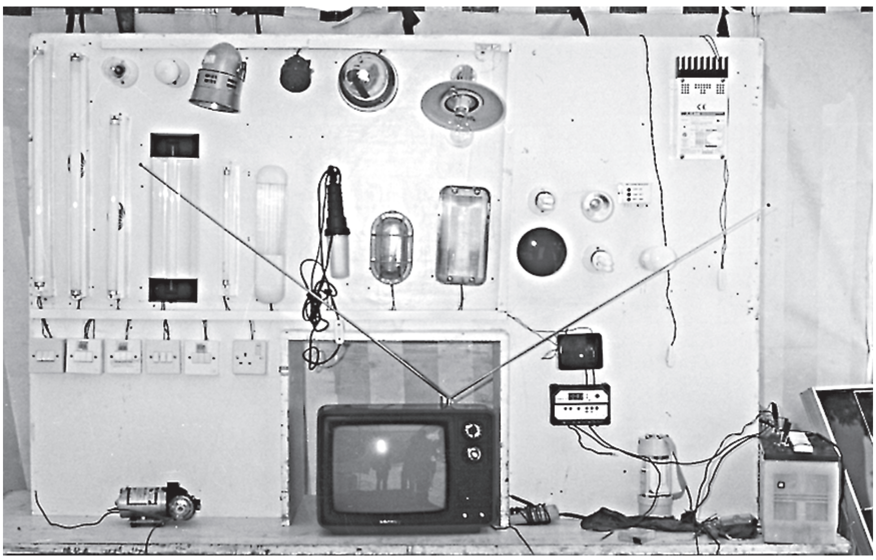
3. When they tell me that they cannot afford such a big and costly system, I show the customer the appliance load calculations (like the ones in table 2) and we talk about alternative appliances that use less power, and those that can be used for less time each day, and also those that can be left out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

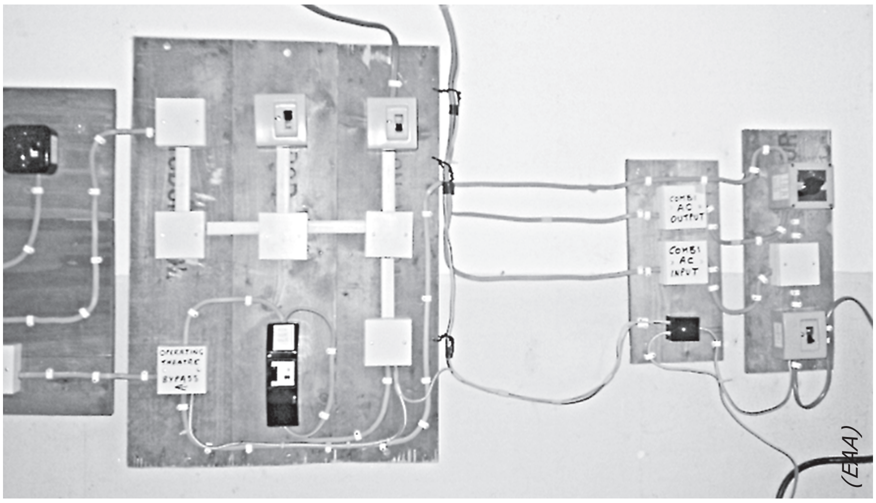
In this case I would suggest changing the 25-watt incandescent bulb for the 7-watt fluorescent tube. The energy used for that light will be reduced from 75 watt-hours to 21 watt-hours. A 7 watt fluorescent tube gives about the same amount of light as the 25 watt incandescent bulb, but it uses much less 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*

Continued on page 28

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.

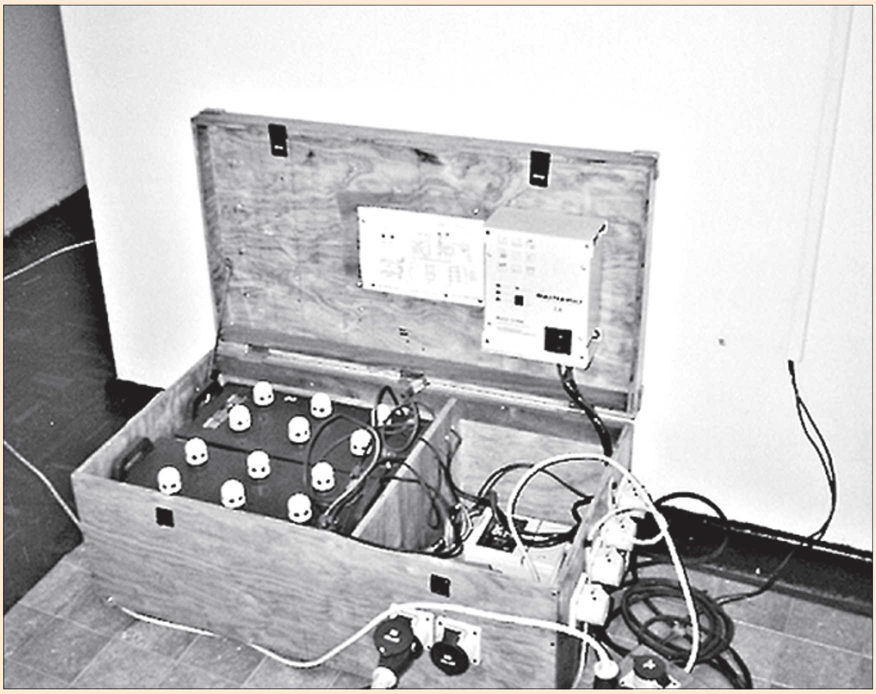
When working with batteries, there are a few things you can do to ensure safety. Take the following precautions:

- 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.

Visit Xantrex Africa online at www.traceengineering.com/xant**rexafrica**



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

Continued from page 27

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!