

Chapter 10

Cost Considerations

This chapter discusses how to compare the cost of solar electricity against alternatives. Simple cost comparisons of solar electric systems are presented for kerosene lighting systems, dry cell powered cassette players, and conventional generators. Practices and devices that reduce the cost of systems are introduced, including modular approaches to system planning, methods of collecting and storing more power, and improvements to energy management.

Deciding on Solar Electricity

Buying a solar electric system is like buying anything else. Often the difference between the thing you want and the thing that you can afford is quite a few shillings. Perhaps you want to buy a new motorcycle but, because of a tight budget, you can only afford a bicycle. Such *economic considerations* dictate what is practical.

In East Africa, economic considerations are crucial because solar electric systems are large investments. It is difficult for most rural people to save the money required to buy a solar electric system all at once. Although credit could help them buy systems, solar lighting systems are seldom available on a hire-purchase basis. It is therefore important that you carefully consider whether it will be economical to buy a solar electric system.

The demand for electric energy in rural areas is high, as electricity is the most efficient and safe way to power lamps, tools and amenities. Radios, televisions and other appliances must be run from electricity. In cases where the electric energy requirement per day is below one kilowatt hour (i.e. 1000 watt hours), solar electric systems have several economic advantages over other electricity sources:

- In many cases, the *initial cost* of a solar electric system is cheaper than a generator or grid electricity.

- Solar cells use no fuel. Because there are no recurring fuel expenses, solar electric systems are often cheaper than kerosene, dry cell, and centrally recharged lead-acid battery alternatives when costed over time.
- Solar electric systems are *modular*. This means that they can be built up a piece at a time if necessary. A school without enough money to install power throughout the compound can first install lights in one block of classrooms. When more money becomes available, the system can be expanded to other classrooms, laboratories, workshops and teachers' houses. Cash-starved farmers can also buy systems a piece at a time.

Comparing the Costs

You should decide whether it is economic to install a solar electric system for your purposes. Compare the costs and benefits of the practical alternatives. When making a simple economic comparison between a solar electric system and, for example, a generator, you should consider the following costs of each:

- *Initial cost of the device*: the money paid to install the device, including the price of the device and the money paid for labour and transport.
- *Annual recurrent costs*: the money that



Cost Considerations

Benefits and disadvantages of alternatives which cannot be listed in monetary terms should be considered when selecting power sources.

must be spent to operate, provide fuel, maintain and repair the device per year.

- *Investment costs:* the interest that must be repaid for any loans (i.e. if the device was bought by hire purchase or with a bank loan).

More detailed cost comparisons, such as life-cycle cost analysis, are beyond the scope of this book, but can be found in some of the references.

Benefits and disadvantages which cannot be listed in monetary terms should also be considered. For example, a diesel generator makes noise, a drawback (especially for school and homes) which cannot be considered in a strict cost comparison. Electric lights are much more convenient than kerosene lamps, and are preferred over paraffin lamps by most people. But the advantages of electric lamps (less smoke and maintenance, ease of operation) cannot be given a value in shillings.

Example 1:

Power for a 6 volt Cassette Player

Initial and annual costs are illustrated simply by comparing costs involved in powering a cassette player with solar electricity versus the cost of powering it with dry cell batteries (in this case, there is no investment cost because the equipment is bought with cash).

Table 10.1: The Cost of Powering a 6 Volt Cassette Player: Dry Cell Batteries vs. Solar Electricity

Energy Source	Dry cells	Solar electricity
Equipment Required	5 dry cell batteries per week	10 Wp solar module, 5 nicad batteries, mount and cables
First Cost*	None	Ksh. 3600: buying equipment
Annual Recurrent Costs	Ksh.1820 /year: 260 batteries per year	Ksh. 200 /year: replace nicads after 2 years

*1991 Kenya Shillings

Table 10.1 illustrates one of the most important points about the cost of solar electric systems relative to alternatives. The initial cost of the solar electric system is high, but the *recurrent costs* are low. Once the rechargeable nicad cells have been purchased, they will last for 2 or more years, and the module is likely to last as long as the cassette player. On the other hand, you will have to buy 5 dry cells per week if you power the player with dry cells. This does not seem to be a heavy cost, but it adds up until, at the end of the year, you find that you have bought 260 or more batteries. Within 2 years, the solar electric system will have paid for itself in battery savings.

The solar electric system has other advantages. When there are shortages of dry cells the solar electric system will continue to provide power for the cassette player. For cassette player operation, a 10 Wp module will provide more total energy over one year than 260 dry cell batteries in most East African sites (but during cloudy weather cassette player use may have to be reduced). Furthermore, the pollution caused by throwing away 260 dry cell batteries is an issue that must not be overlooked.

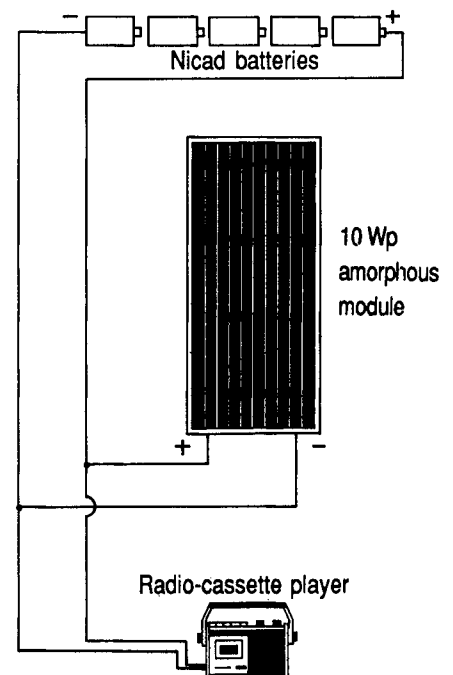


Figure 10.1

Six volt system for powering a radio cassette



Cost Considerations

Table 10.2: The Cost of Lighting a Single Room: Kerosine (Paraffin) vs. Solar Electricity

Energy Source	Kerosine	Solar electricity
Equipment Required	Pressure lamp, mantles & fuel	10 Wp module, lead acid battery, 13 watt lamp, mount, wiring & switches
First Cost*	Ksh. 600: Pressure lamp	Ksh. 4600 buying equipment
Annual Recurrent Costs	Ksh. 1400/year Fuel and mantle costs	Ksh. 500/year Battery/tube replacements

*1991 Kenya Shillings

Although it may take as long as four years for a solar electric lighting system to pay for itself when costed against a kerosene lamp, the solar system has attractive benefits.

Example 2: Power for Kiosk Lighting

The costs of lighting a kiosk with solar electric power and kerosene can also be compared. Table 10.2 shows typical costs associated with solar electric and kerosene pressure lamp lighting systems. Both systems provide two and a half hours of light for one room.

As the table shows, this comparison is not as favourable for solar electric power as the first example. It takes about 4 years for the solar electric system to save enough money on fuel costs to pay for itself. The obvious drawback to the solar electric system is the high initial cost.

However, the solar electric system has attractive benefits. First, it has a longer life than the pressure lamp. Secondly, in the event of kerosene price rises or shortages,

the solar electric system will not be affected. Thirdly, the fluorescent tube lamp does not produce soot, smoke, or glare, as does a pressure lamp. The electric lamp can be turned ON with the flick of a switch, instead of the more tedious process of lighting a pressure lamp. Finally, the electric energy which the solar electric system produces can be used for other purposes such as powering a radio.

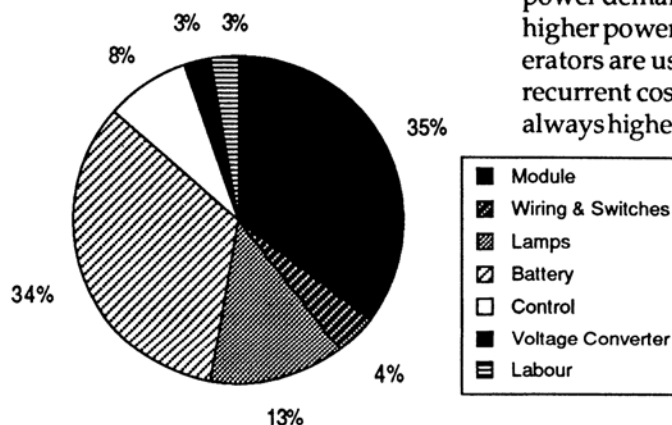
Example 3:

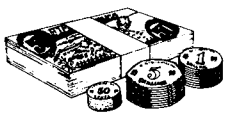
Solar Electricity versus Generator Power

Table 10.3 presents basic elements that must be considered when comparing the cost of powering a home or school with solar electricity versus a generator. It does not go into detail because space does not permit a comprehensive analysis, and conditions are different for each site.

There are benefits and drawbacks to diesel and solar powered systems. The *initial* solar electric system cost is often lower for power demand of up to one kilowatt. With higher power demands, *initial* costs of generators are usually less. However, annual recurrent costs (fuel and maintenance) are always higher with diesel systems, the exact amount depending on daily usage rate of the generator. Investment costs depend on the amount of money that must be borrowed to purchase the system, and thus increase with higher initial costs.

Figure 10.2
Cost breakdown of small solar lighting system





Cost Considerations

Table 10.4 presents a number of points that may help you choose between generators and solar electricity.

Note that it is possible to combine diesel and solar electric (or other renewable energy) systems when there is a high power demand. In such cases (these are called *hybrid systems*), solar modules or wind generators are used to charge batteries and supply daily power requirements. The generator is used to charge batteries when there is not enough sunshine, and to power occasional large loads. Hybrid systems are popular in remote locations with constant loads (for more information, see References).

Table 10.3: Electrifying a Home, Health Centre or School: Diesel Generator vs. Solar Electricity

Energy Source	Diesel	Solar electricity
Equipment Required	Diesel generator electrical equipment	Solar modules, batteries, controller, electrical equipment
First Cost	Equipment, labour, transport	Equipment, labour, transport
Annual Recurrent Costs	Fuel, transport, spare parts, maintenance	Spare parts, maintenance
Investment Costs	Loan/Hire purchase charges	Loan/Hire purchase charges

Table 10.4 Comparing Generators and Solar Electricity

Situations which favour generators	Situations which favour solar electricity
<p>Sites where:</p> <ul style="list-style-type: none"> • Power requirements are above 1-2 kW • Fuel supply is stable • The fuel depot is nearby • Fuel and maintenance costs are low • Cloudy weather is common • Low voltage lamps and appliances are not available • Deep discharge batteries not available • Lights and appliances are required for a short time only each day 	<p>Sites where:</p> <ul style="list-style-type: none"> • Power requirements are below 500 watts • There are frequent shortages of fuel • Fuel depots are far away • Fuel and maintenance costs are high • There is high solar radiation (5 or more peak sun hours throughout the year) • The equipment is expected to last a long time with little maintenance • Noise and exhaust must be avoided • Lights and appliances are in constant use

Practices and Devices that Reduce the Cost of Solar Electric Systems

To be economically practical, solar electric systems must be well-planned and managed. During planning, you may find that there is a shortfall between your equipment needs and the cash available to meet these needs. When modules are sized too small, or batteries are not up to standard, the system performs poorly.

However, with careful management even those on limited budgets can put together successful solar electric systems. The following sections present tactics for reducing high initial costs, for collecting and storing more energy, and for avoiding abuse of solar electric systems.

Methods of Reducing Initial System Costs

Use modular approaches to develop the system
Solar cell modules are available in sizes ranging from less than five peak watts to 60 Wp or higher. By choosing a module of the size you need, you can tailor a system to your own requirements. It is possible to meet one requirement at a time instead of trying to meet them all at once.

For example, in a rural home, a teacher on a fixed income may require electric energy to power a television, 4 lights, a radio and a sewing machine. Upon completing the calculations as described in Chapter 9, the teacher might decide that the cost of such a system is too expensive. Meanwhile, he or she might continue to buy paraffin for lamps and batteries for the radio, and to pay for occasional charging of the second-hand battery that powers the television. These costs add up.

However, the teacher could build a solar electric system *modularly* (i.e. a piece at a time). He or she could buy an amorphous 10 Wp module, and use it to charge the battery for the television and radio. Later on, the teacher could buy another module and several fluorescent lamps. The module would be wired in parallel with the first one to charge the battery; and at this stage, the system would power lamps, the television and the radio. When more



Cost Considerations

Any boarding school administrator is aware of the high cost of fuelling and maintaining several pressure lamps for evening studies.

money becomes available, the teacher could add another module, a control and a solar battery for more appliances.

Such a modular approach can also be used for lighting rural schools. Any boarding school administrator is aware of the high costs of keeping pressure lamps in operation for evening studies. However, he or she is probably discouraged by the high costs of buying, installing and maintaining a generator to light classrooms. Solar electricity may provide an effective method of avoiding high generator costs. A 100 Wp system could initially be installed to light several classrooms, and more modules could be added later to meet the lighting requirements of dormitories, dining halls, teachers' houses and other classrooms. There is already some success with this approach in rural Africa.

Decide which energy requirements are most important.

Modular planning of a system is only effective when you decide what energy requirements are most important. The question "What is desired, and what is required?" must be answered (i.e. Do you want to power the TV or the lights?). The priority energy need should be met first, and the others should wait until more energy is available.

For example, consider the case of a health clinic on a limited budget that requires power for a vaccine refrigerator, operating and examination room lighting, some small electrical appliances and a staff colour television. If the clinic cannot examine people at night because of lack of lighting, and it considers lighting a priority need, then it should install a solar lighting system first. When the lighting system is installed, however, the system manager should not power the television from the lighting system power sup-

ply unless the system has been designed to include it.

Know the prices of solar electric systems.

A major problem facing rural people who want to install solar electricity is that there is little information available about the prices of solar electric equipment. Because of this, it is easy for solar electric agents to overcharge customers, which discourages others from taking up the technology. It is always a good idea to visit as many companies as possible to get information on prices and equipment. Equipment prices often differ significantly among different companies.

How to Collect and Store More Power

Tracking: Getting the most energy from solar modules

Tracking is changing the position of the solar array to face the sun as it moves across the sky from morning to evening (see Chapter 2). This management practice helps to get the most power from the sun as it changes its path with different seasons. In East Africa, depending on the season, the sun may be in the northern sky (i.e. between April and August), directly overhead (March and September), or in the southern portion of the sky (between October and February).

Even small system users should consider tracking the sun, as simple manually-operated rotatable mounts (see page 15) cost much less than the price of a module and produce up to 25% more solar charge.

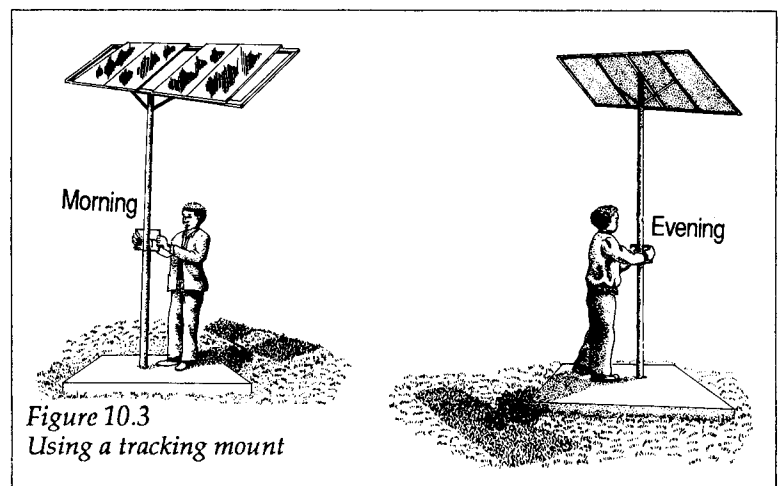
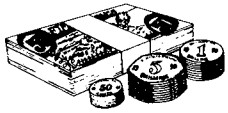


Figure 10.3
Using a tracking mount



Cost Considerations

A well educated system manager is far cheaper, and, in the long run, more effective than a control device.

Keep batteries charged and clean
Well-charged batteries have longer life spans, and do not have to be replaced as frequently. Batteries kept clean lose less energy due to self-discharge.

Keep modules clean
Dust-covered modules produce less electric charge. Regular cleaning of the module (i.e. every two weeks) in dusty locations will pay off in terms of extra energy collected. Always mount modules where they can be easily reached for cleaning.

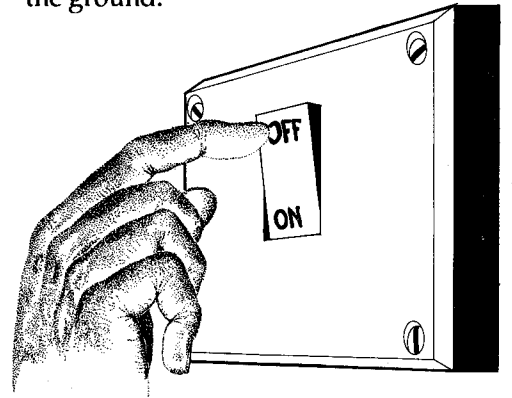
Ensure proper connections and cable choice
Choose correct cable sizes during planning to make sure power is not lost due to small sized wires. Make sure that connections are tight, especially at the control, module and battery terminals. Poor contacts can reduce the flow of electric power considerably.

How to Effectively Manage Collected Energy

Consider how much energy is collected and how much is being used.
Charge controllers with low voltage warnings and/or cut-outs are extremely useful for protecting the battery during cloudy weather. However, an educated system manager is far cheaper, and, in the long run, far more effective than any control device. If you know how much energy your module is collecting, and how much

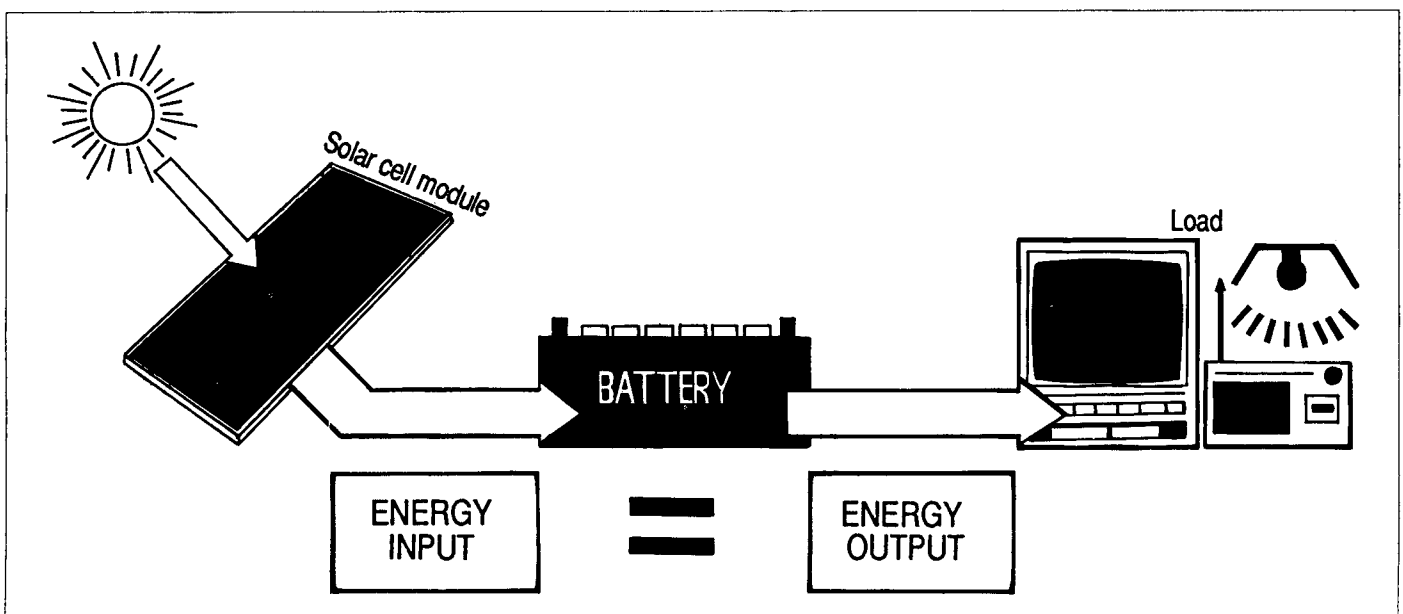
energy your equipment is using, then the task of balancing the input with the output is far easier. If you think that a 10 Wp module can power an electric cooker you are likely to ruin your battery very quickly!!!

Limit the use of loads
Turn OFF loads that are not in use. A 15W light bulb accidentally left ON overnight in a grid-connected house is not a problem. In a small solar electric system, on the other hand, one 15W bulb left ON accidentally for a few nights *can* be a major drain to the system. Leaving unused lights and appliances ON is like pouring paraffin on the ground.



Use efficient appliances and lamps.
Fluorescent tube lamps, though more expensive, are always preferable to globe type lamps. Where globe lamps are installed, try to limit their use to just a few minutes per day if possible, and choose the

Figure 10.4
Remember, the energy output to the loads must be balanced by the energy input from the module





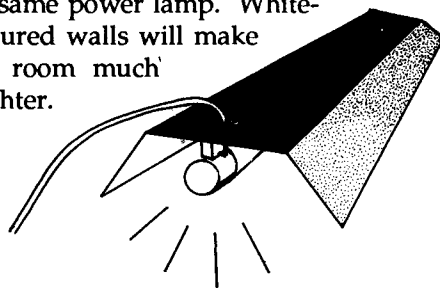
Cost Considerations

Reflectors direct light to the place it is needed most.

lowest power to do the job needed. When buying appliances such as radios, televisions or sewing machines, choose the one which uses the least amount of power but still meets your requirements.

Put reflectors on lamps, and paint walls with a light colour.

In schools, clinics or workshops where solar power is primarily used for lighting, place reflectors on work area lamps. With reflectors, 40% more light is easily provided to the desks or work benches with the same power lamp. White-coloured walls will make any room much brighter.



Use timer switches on lamps and/or loads if possible.

Timer switches turn lights ON and OFF automatically so that energy is not wasted by accidental or purposeful over use of lamps. There are two types of timer switches:

The first type is located in the control system, and it turns major circuits ON and OFF at times set by the system manager. This is particularly useful in schools or workshops where loads accidentally left ON overnight or over a weekend could drain the batteries. For example, in a school, study lights in Form I to IV can be set to turn ON at 6 PM and OFF at 9 PM. This prevents students from leaving the lights ON. Such a timer switch can be provided with a manual "override" so that, if desired, the system manager can occasionally leave lights or loads ON for a few extra hours.

The second type is simply a switch with a timing device inside it which automati-

cally turns the light OFF after a preset amount of time (i.e. 5 minutes). Such switches are commonly used in European bathrooms and hallways to save energy lost from lights carelessly left ON.

Switch to alternative power sources during cloudy weather.

During cloudy months the module output is likely to be reduced by one third or more. The load must therefore be reduced by the same amount to protect the batteries. Consider which loads need to be reduced. If the television is the most important load, then reduce use of the lights by switching to paraffin lamps until the weather turns sunny again. If the lights are the most important loads, then reduce, or cut out use of all other appliances.

Take batteries for charging when solar charge is not enough. It is much cheaper to charge them up when they are under stress than to replace ruined batteries with new ones.

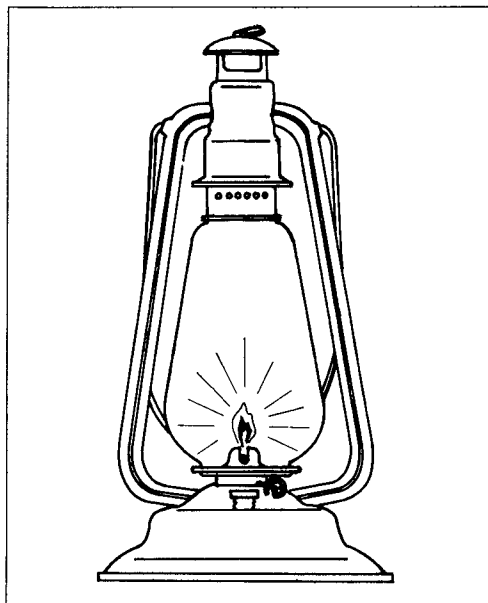


Figure 10.5

Remember, if there is not enough solar power, you can revert to paraffin lamps for a few weeks to protect your battery.