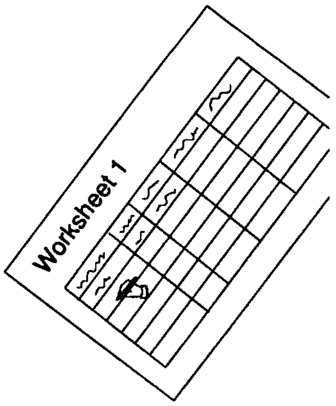


Chapter 7 Calculating the Daily System Energy Demand

This brief chapter explains how to estimate the total daily energy demand of the lamps and appliances in a system. A practical example shows exactly how this is done. The chapter explains the concepts of watt hours and amp hours, and how they are determined. System voltage, which depends on appliance voltage ratings, is also discussed. Once you know the energy demand of lamps and appliances in your system, you can then estimate the size of the battery and array required.

Before buying a solar electric system, you must determine how much energy will be required each day to power the *load* (i.e. your lamps and appliances). This quantity of energy is called the *total daily load energy demand,* and is measured in *watt hours.* It is calculated by totalling the energy that all the appliances and lamps use on an average day. This number, added to the extra energy needed to overcome system losses, is the *total daily system energy requirement* (see Chapter 9).

When calculating *total daily load energy demand,* the planner should consider all the appliances to be powered by the system, even those that will be purchased in the future. Tables 6.1 and 6.2 (see page 42 & 45) list the power requirements of a number of lamps and appliances, and can be used when making these calculations.

Column A Lamp or appliance (list below)	Column B Voltage (volts)	Column C Power (watts)	Column D Daily use (hours)	Column E Daily Energy Use (watt hours)

Total Daily Load Energy Demand — **Box F**

Table 7.1
Daily Load Energy Demand Calculation

Calculating Daily Energy Demand

How to Calculate the Total Daily Load Energy Demand

To calculate the total daily energy demand of the load, add up the energy in watt hours required by each lamp and appliance per day. Table 7.1 provides a step by step method of carrying out this calculation. It is identical to the table found in Worksheet 1, page 107. The instructions below explain how to fill in the table:

1. *Individual load description:* List all the lamps and appliances to be powered by the system in Column A.

2. *Individual lamp and appliance voltage:* List the voltage of each of the appliances and lamps in Column B.

3. *Individual lamp and appliance power:* List the power in watts of each appliance and lamp in Column C. Usually, the manufacturer indicates the power rating on the appliance itself. Radios and cassette players are rated according to their maximum power, but they normally operate at much less than half the indicated power (i.e. if a radio is rated at 30W, write down 15 watts in Column C).

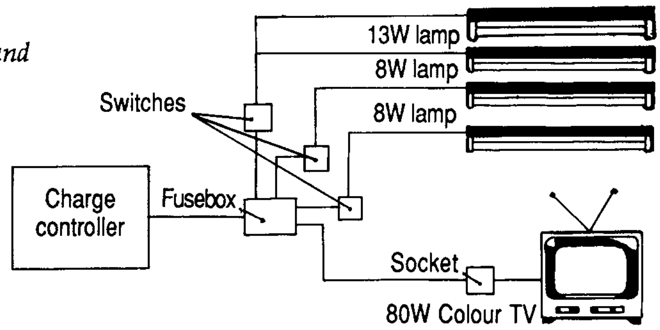
4. *Individual lamp and appliance use (in number of hours per day):* List the estimated amount of hours per day that each lamp and appliance will use in Column D. If the appliance is only to be used a few times per week (i.e. a sewing machine might only be used on weekends), estimate the number of hours it is used per week, divide by 7 and write the number of hours per day in Column D.

5. *Individual lamp and appliance energy use (in watt hours per day):* Multiply the power of each load (Column C) by the number of hours it is used per day (Column D). Write this figure in Column E. This is the energy use in watt hours per day of each appliance.

6. *Total daily energy demand of load:* Add all the numbers in Column E, and write the total in Box F. This is the total daily load energy demand in watt hours. At a later stage (see Chapter 9), this number will be used to calculate the total daily system energy requirement.

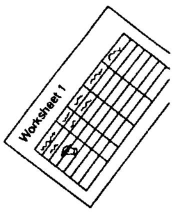
To calculate the total daily energy demand of the load, add up the energy in watt hours required by each lamp and appliance per day.

Figure 7.1
Total daily load energy demand calculation: example



Column A Lamp or appliance (list below)	**Column B** Voltage (volts)	**Column C** Power (watts)	**Column D** Daily use (hours)	**Column E** Daily Energy Use (watt hours)
Fluorescent lamp	12 V	13 W	3 hours	35 Wh
Fluorescent lamp	12 V	13 W	2 hours	26 Wh
Fluorescent lamp	12 V	8 W	2 hours	16 Wh
Fluorescent lamp	12 V	8 W	1 hour	8 Wh
14" Colour TV	12 V	80 W	2 hours	160 Wh

Total Daily Load Energy Demand — **Box F**: 149 Wh



Calculating Daily Energy Demand

System voltage is the voltage at which the appliances in the system operate.

Watt Hours and Amp Hours

For planning purposes, energy consumption is indicated in *watt hours* or *amp hours.* Watt hours (or kilowatt hours) is a common measure of electric energy. However, because battery capacity is generally measured in amp hours, solar electric system planners often use amp hours to indicate energy instead of watt hours (strictly speaking, though, amp hours are not a measure of energy, but a measure of total charge). A twelve volt, 100 amp hour battery contains approximately 1200 watt hours of energy.

To calculate amp hours, divide the energy in watt hours by the system voltage.

$$\text{Total charge (amp hours)} = \frac{\text{energy (watt hours)}}{\text{system voltage (volts)}}$$

Example:
A 12 volt system in a house with four lamps and an 80 watt television has an energy demand of 250 watt hours per day (see Figure 7.1). How many amp hours does the system consume per day?

Answer:

$$\text{Total charge (amp hours)} = \frac{250\text{ Wh}}{12\text{ V}}$$

$$= 20.8\text{ Ah per day}$$

Choosing the System Voltage

System voltage is the voltage at which the appliances in the system operate. It is normally the voltage of the largest load in the system. This book is written mainly for those using 12 or 24 volt (or smaller) dc systems. Small home systems can operate at 12 volts quite reliably, and 12 volt appliances are available in East Africa (including televisions, sewing machines, electric drills, radios and lamps). If appliances of different voltages than the system voltage are to be used in the system, then *voltage converters* (Figure 7.2) or *power conditioning units* will be required (see page 44).

For systems that use nicad cells to power radios or cassette players *only*, the system voltage can be set at the voltage of the radio. If, for example, a radio operates at 6 V, then five 1.3 volt nicad batteries could be placed inside the radio and charged with a small solar cell module at a system voltage of 6 volts (see Figure 10.1, page 73).

In systems where there are long cable runs, system voltage is often set at 24 volts or higher because the higher voltage reduces energy loss caused by voltage drop in the cables (see page 53). School systems are often 24 volts because of the long runs between classrooms and buildings. However, finding appliances that operate at 24 volts may be a problem in some areas. If more power is required in a 24 volt system, batteries and modules must be added *two at a time* (the 12 volt batteries and modules are in parallel and cannot be added one at a time).

System voltage above 24 volts is beyond the scope of this book. It is quite possible to design systems that operate at 36 volts, 48 volts or more, but these systems become increasingly complex. Otherwise, large systems can be designed to include a power conditioning unit (PCU, or inverter) which converts low voltage dc to 240 V ac. A properly sized PCU can operate 240 V ac appliances such as videos and refrigerators (see page 44). However, the price of an inverter may be more than that of the colour television. Systems that include PCU's should be designed by qualified solar electricians.

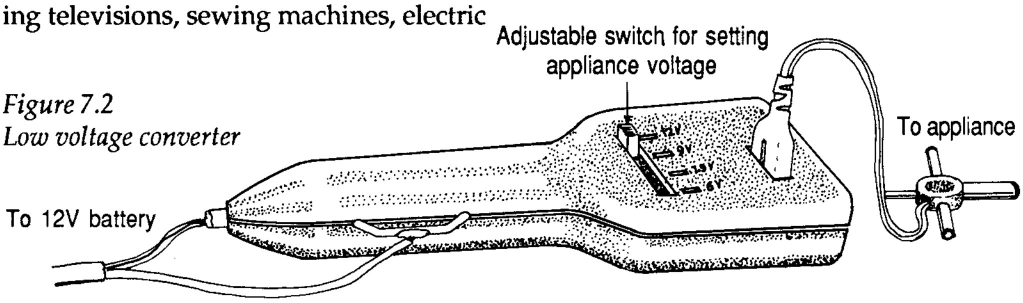


Figure 7.2
Low voltage converter