Solar Energy

16/04/2019

Reviewed: 15/05/2019

Version 1

Description: Calculating energy use

Howard Kirkman

Summary

Solar energy is a no-brainer for most parts of rural Zambia. It is of course expensive to setup but once this is done you get free energy for years to come.

There is a big snag though. It is very easy to destroy a setup if there are no rules in place to keep it well maintained.

So what are the rules and how do we keep a system safe?

Rule 1 Know how much energy you have.

Before adding anything to your energy source you must know exactly how much energy you have available. This involves knowing two things. Firstly how much solar energy you are getting and Secondly how much energy you have when there is no sun.

The common measurement of electrical energy is Watt hours, that is, 1 watt continuously working for 1 hour. Often written as 1 Wh or Watt h

Since the energy you have comes from the sun via your solar panels you need to know the capacity of those panels and how much sun you can reliably expect.

We aim to install 2 x 320Watt solar panels so when the sun is bright we will get 2 x 320 = 640 Watts of energy from both panels combined. If the sun is bright all day say 5 hours because in the twilight we don’t get so much energy, we will harvest

640 x 5 = 3200 Watt·Hrs or 3.2 kWh (kiloWatthours)

A PC consuming 100 Watts and operating for 5 hours uses 500 Watts hrs or half a kilowatt hour (kWh) of energy.

A Raspberry Pi computer consuming 3 watts operating for 24 hours continuously uses 72 watt hour.

A 1 metre LED light strip consuming 5 watts on for 24 hours uses 120 watts

Note: In terms of human power, a healthy adult male manual labourer will perform work equal to about half a kilowatt hour over an eight-hour day.

From this we can see running a PC and Pi with a 1 metre LED strip ONLY would not be a problem during the day. At night no sun so nothing would work.

This brings us to the second part of the setup, the battery.

Note:Before thinking about the battery it is important to understand that **a battery does NOT bring any power into the system**. It simply acts as a store for any excess power we generate during the day. This power can be used when the sun doesn’t shine.

Remember any power taken from the battery overnight must be replaced during the day.
So now we can think about the capacity of the batteries. Battery power is usually given in Amp Hrs.

A typical car battery might be 80 Ah or even 100Ah. Car batteries are designed to supply energy in short bursts, when you start the car! The rest of the time the car charges the battery via the alternator. Solar batteries are different to car batteries.
Solar batteries are deep cycle batteries they are designed to discharge over a long period of time. They MUST NOT be drained below half of their capacity.

We install 2 x 220 Ah (Amp Hrs) batteries. Battery capacity is usually measured in amp hours, that is, the current (Amps) it supplies for however many hours. This is a nuisance because as we saw above we want to measure power in Watts. Fortunately physics can come to our rescue in the form of an equation

W=V.I — or power in watts(W) is equal to voltage in volts(V) multiplied by current in amps(I).

Most batteries are 12 volt so the power in Watts of a 220Ah 12 volt battery is

12 x 220 = 2640 Watt.Hrs or 2.6 kWh

This almost matches the daily power generation of the Solar panels

Note: Although we have 2 batteries we only count the capacity of 1. This is because we don't want the capacity of the battery set to go below half

It is important to start with the batteries fully charged. Batteries supplied by a good dealer will always be supplied close to fully charged. In any event it is good practice to let the batteries charge before you use them. The solar controller in the system will not let the batteries over-charge.

So let's do some calculating

Let's suppose we want to run 2 laptops, a projector, The Raspberry Pi with the RACHEL resources installed and a router. We also want to provide 4 x 1 metre LED strip lighting.

How much power will all this require for 1 days use?

A laptop consumes 40 Watts per hour so in a 5 hour day that would be 40 x 5 = 200 Wh
2 Laptops bring the power consumption to 400 Wh

A projector consumes something like 80 Watts so if it is on for 5 hours that is 80 x 5 = 400 Wh

the Raspberry Pi consumes 3 watts so if that is left on all the time that's 3 x 24 = 72 Wh

Finally we have the lighting. A 1 metre strip consuming 5 watts on for 8 hours 5 x 8 = 40 Wh
4 strips therefore consume 160 Wh

Thus the total energy used by our equipment is 200+400+72+160 = 832 Wh

We can use this equipment and know that on a bright day we will still charge the batteries.
Solar energy in - energy used = Stored energy
3200Wh – 832Wh = 2368Wh

If we have very cloudy days we can use the system for 3 days without having to turn things off.

Now you can do your calculations and see if your setup is realistic.

I would be very grateful if you could send me your work so I can see if we are hitting the right spot

Your Energy Calculations

Device	**Energy (Watts)** **E**	**Time (Hrs)** **T**	**Power (Wh)** **ExT**	**Notes**

Battery size (Ah) A	Voltage (volts) V	Storage capacity (Watts) AxV

Solar Panels

Panel power (watts) W	Hours of bright sun T	Power supplied WxT

Charging potential = Power supplied by panels - Power used by devices = Watts

Days equipment can be used = storage capacity / Power used by devices = Days

The table overleaf gives the power consumption of some domestic appliances.

Appliance Consumption Table in Watts

Appliance, Consumption

100W light bulb (Incandescent),100W

5"colour TV,150W

3" belt sander,1000W

32 Inch LED TV,20W-60W

46 Inch LED TV,60W-70W

60W light bulb (Incandescent),60W

9" disc sander,1200W

American-style Fridge Freezer,50W

Ceiling Fan,70W

Clock radio,12W

Clothes Dryer,4000W

Coffee Maker,800-1400W

Cordless Drill Charger,70-150W

Curling Iron,35W

Desktop Computer,100-450W

Dishwasher,1500W

Domestic Water Pump,200-300W

DVD Player,26-60W

Electric Kettle,1200-3000W

Electric Mower,1500-1500W

Electric Shaver,15-20W

Electric Stove,800-1000W

Extractor Fan,12W

Food Blender,300-400W

Freezer,50W

Fridge / Freezer,400W

Fryer,1000W

Game Console,120-250W

Gaming PC,300-600W

Guitar Amplifier,20-30W

Hair Blow Dryer,1800-2500W

Home Air Conditioner,1000-4000W

Home Internet Router,5W

Home Sound System,95

Hot Water Dispenser,1200-1300W

Hot Water Immersion Heater,3000W

Inkjet Printer,30W

Iron,1000W

Laptop Computer,50-100W

Lawnmower,1400W

LED Light Bulb,7-10W

LED strip light 10W per metre

Microwave,600-1700W

Night Light,1W

Oven,2150W

Paper Shredder,200W

Pedestal Fan,60W

Phone Charger,4-7W

Pressure Cooker,700W

Projector,60W-270W