Solar power on 11 pages

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Introduction – why should we learn about solar power?

Here in Kopan, we live in a country (Nepal) where we only get about 10 hours of electricity every day. The rest of the time, we run a generator to produce electricity.
Whenever we use Kerosene or Diesel or any form of fuel made from oil, we are using a limited resource.

Some countries have more stable power, but the problem is the same all around the world:
we are using the last remaining resources of oil, coal and wood and other fossile fules very fast.
It took millions of years to save all this energy inside our earth – and we are using it in just a few hundred years.
And, already now, the fight for resources is leading to wars and conflicts all over the world.

We do not feel it, but this is what we are involved in whenever we have light and machines working for us.

The best alternative to fossile fuel is sustainable energy – energy that comes to us naturally and can be used without being exhausted:

- Solar Energy
- Wind energy
- Water (Hydro) Energy

Nepal is blessed with a lot of all three – so, we can contribute to people's benefit by learning about them.

When we learn about solar energy, we can maybe in the future help maintaining our own energy supply, and also go out and help other people, for example in remote and poor regions.

Saving energy

All good use of energy starts with one thing:

learning how to use energy wisely, learning how to use as little as possible.

In our modern times, many tasks need a computer – but it is up to us to decide, whether we want to use

big power hungry computers,

or clever small computers, that can do the same work.

Electricity – Voltage, Current and Power

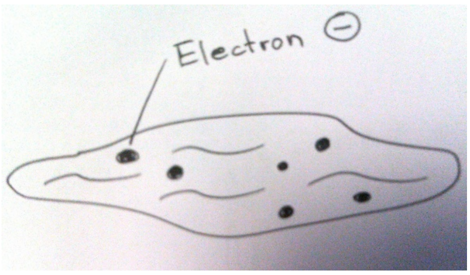
Inside all things, we find small particles called electrons.
These electrons have energy - we say, electrons carry an electric charge.

The electrons are a part of the atom. We can imagine they circle around the core of the atom like the planets around the sun. The core is made of neutrons and protons.
Protons carry a positive electric charge. Electrons carry a negative electric charge. In an atom, we find as many protons as we find electrons. So the total charge is zero or neutral.
The opposite charges - positive and negative – attract each other. That is what holds atoms (and all matter) together.

But electrons can be moved from their home atom – they can move around as free electrons.

We can use the picture of water to understand electricity.

Much like many small drops of water make a pool of water,
many of these electrons can make a powerful charge.



The flow of electrons makes a current,
much like drops of water make up a river,
or water from a bucket makes a shower.

Generating electric power is like pumping water up into a tank -

we collect the electric charge and the power stored in it,
until we need it and we allow it to discharge.

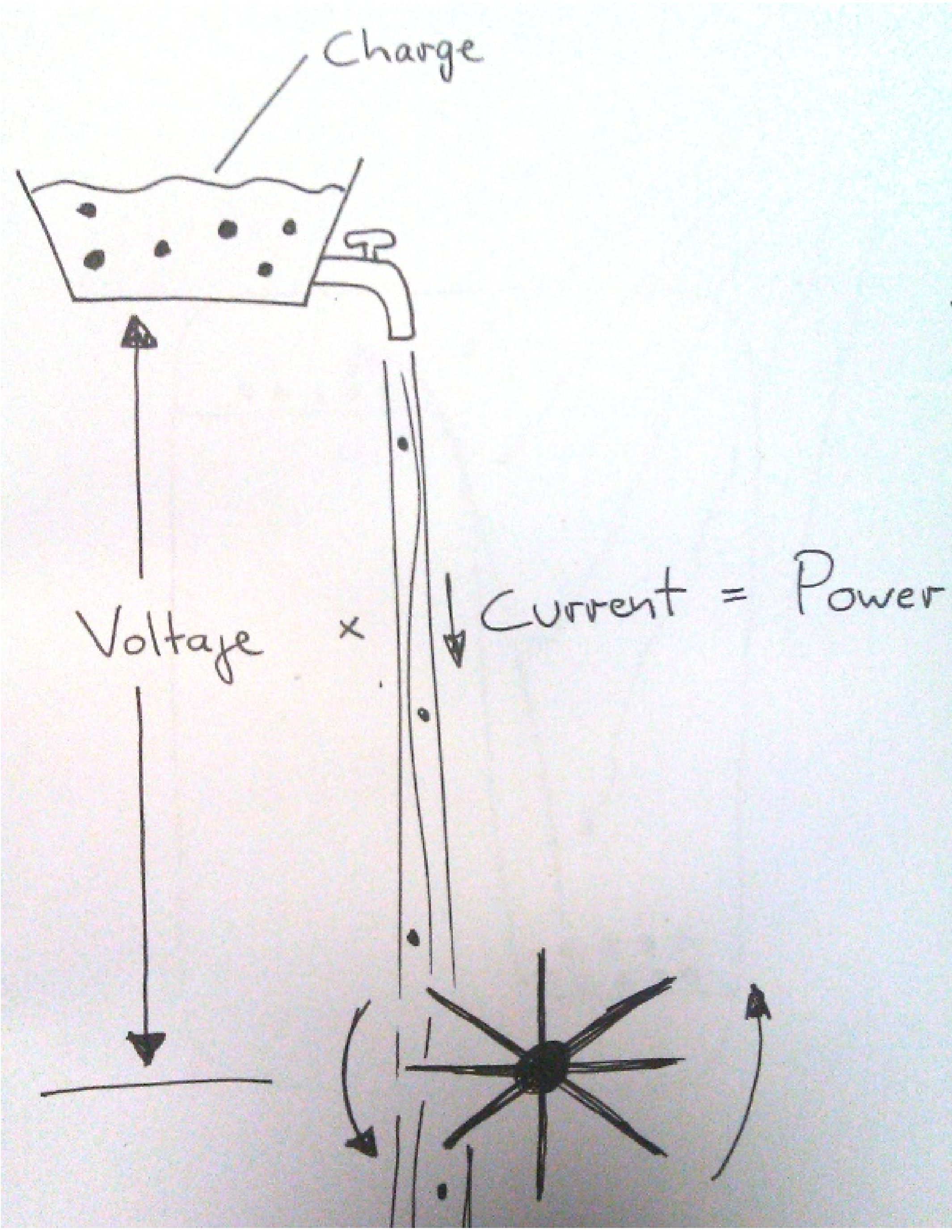
Using the stored power is like emptying a tank to take a shower,
or to use the water flow to turn a mill and grind corn.

Electric charge is a measure for how much water we have pumped up.
Electric voltage is a measure for how high we have pumped up the water.
Electric current is a measure for the stream of water running down.

The voltage multiplied with the current gives electric power.
It is a measure of strength.

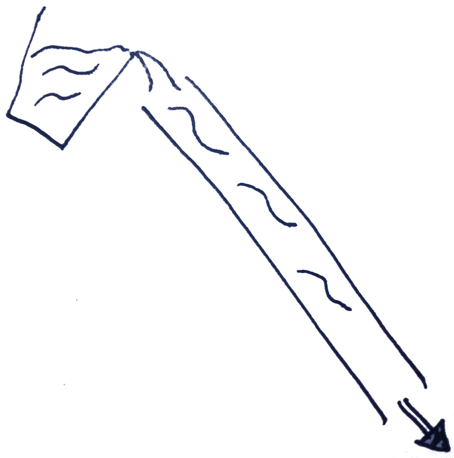
Let us write this down as formulas:
Power P, measured in Watt [W]
Current I, measured in Ampere [A]
Voltage U, measured in Volt [V]

P = U *x* I
I = P / U
U = P / I



Resistance

If we send water through a pipe, there is only space for so much water.
The pipe has a resistance.



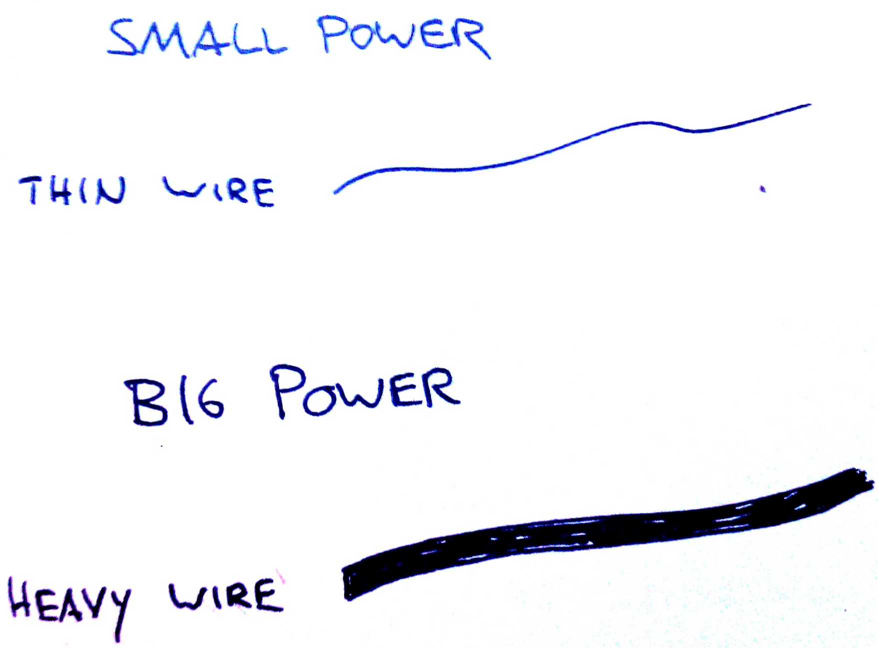
Like we use the pipe to transport water, we use metal wires to transport current.
In a wire there is only space for so many electrons.

It has a resistance too:

Resistance R = Voltage / Current

$R = U / I$

The bigger the resistance, the smaller the current we can move through the wire. If we want to move a lot of power through it, it has to be a strong wire.



What is a solar panel?

You can use the energy of the sun in many ways – for example, you can let it heat water.
Look up to the roofs of the buildings in Kopan, and you will see the warm water systems.

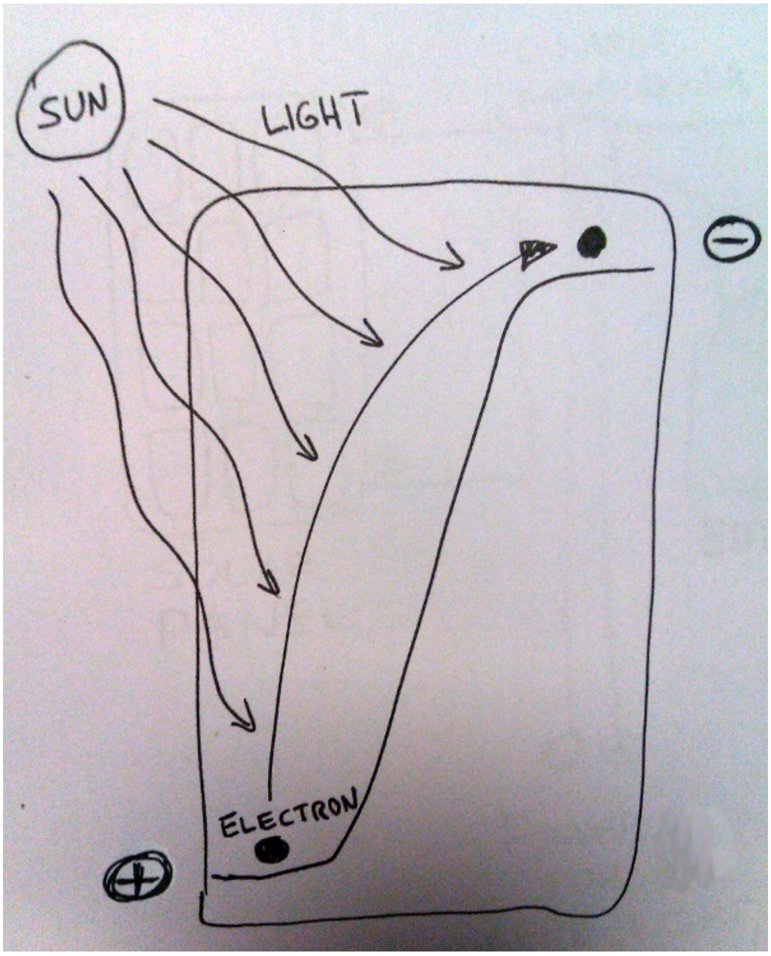
You can also create electricity out of the sun's energy – we call such a system a **photovoltaic system.** Its most important part is the solar panel.

The solar panel turns light into electricity.

In a solar panel, the power of the light makes the electrons hop up to a higher energy level, and moves them over to one side of a barrier they can not cross.

It is a bit like pumping water up to a tank.

The electrons build up a negative voltage between the two contacts of the solar panel.
The two contacts are two cables which can be connected to where the power is needed.



The most important things we need to know about a solar panel are:

- The voltage it produces. Most panels make 12 Volts.
- The power it can produce. You can find panels from a few milliWatts (up to hundreds of Watts.

Parts of a solar power system

In a photovoltaic system,

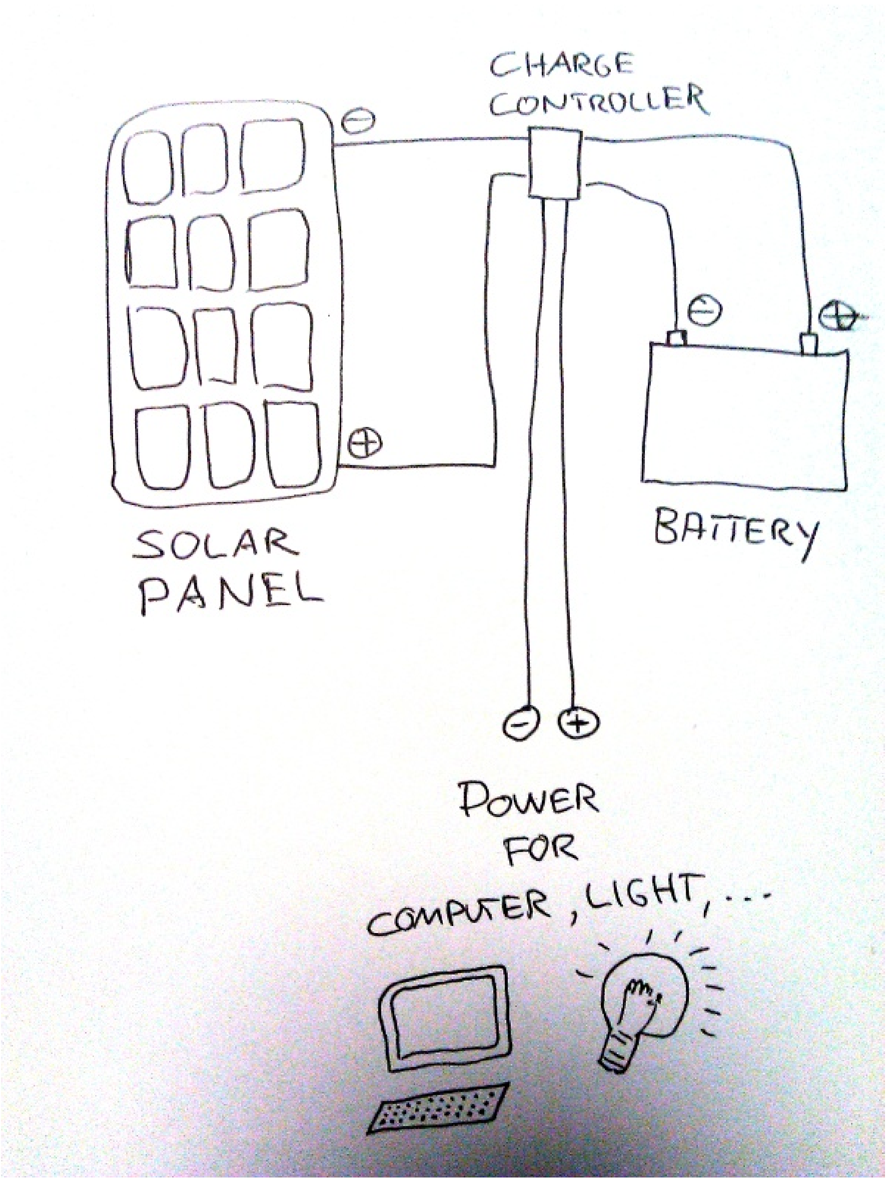
The solar panel creates the electric voltage.
It brings up electrons and pumps them out on its one side.

We store this power, the charge, in a battery.

Somebody needs to control the flow of current.
This is the charge controller.
It makes sure we only charge the battery when there is enough light.
It makes sure we only use the power when there is enough of it.

We also need small things:

Cables strong enough to carry the current.
Clamps to fit the cables to the battery.



How much can it do?

Now we need to do some mathematics:

We learned that

Power = Current x Voltage
$P = I / U$

Therefore, we can calculate

Current = Power / Voltage
$I = P / U$

One of our panels can make

a power of 100 Watt and a voltage of 12 Volts.

So, the current ist

$I = P / U = 100$ Watt / 12 Volts = 8.33 Ampere.

So our panel makes a current of 8.33 Ampere.

One of our batteries can store 100 Ah, that means 100 Ampere x Hours.
We call this the capacity of the battery.
From this battery, you can have a current of 1 Ampere for 100 hours, or 2 Ampere for 50 hours, or 10 Ampere for 10 hours, and so on.

If we charge it with the solar panel in full sun for 12 ½ hours with 8.33 Ampere, it will be full.

We now have energy for 100 hours of 1 Ampere current stored in the battery.

There is a special thing to remember:
Batteries are funny – you should never empty them completely. Always leave them half full.
They are like a water bowl that wants to be at least half filled at all times.

So for a Battery with 100 Ah capacity, we should only use 50 Ah before we recharge the battery.

What can you do with it?

If we know how much power we use, we can calculate for how long our battery will last.

Time = Voltage x Capacity / Power we use

$t = U \times C / P_{used}$

$t = 12$ Volt x 50 Ah / P_{used}

(Remember we will only use half of the battery capacity! Therefore, we write 50 and not 100 Ah!)

- Computer: Our little computer system needs about 20 Watt. This means, it needs a bit less than 2 Ampere (1.66 Ampere). Remember, Power = Current x Voltage!

  If we have 50 Ah to use, we can keep it running for about 30 hours.

  Time = 12V x 50 Ah / 20 Watt = 30 hours

- Lights: If we connect a little LED light which needs 3 Watt, we can have light for

  12 V x 50 Ah / 3 Watt = 200 hours.

- Heat - needs a lot of power!

  A 500 Watt heater will only run for
  12 V x 50 Ah / 500 = 1 hour and some minutes.

Dimensioning a photovoltaic system

Dimensioning means: choosing in the right way how much solar panel power and how much battery capacity to install.

This can be quite difficult, as you need to know exactly

- how much sun energy you are receiving at your place
- how and when you will comsume your power
- and a lot of other factors.

But here is an **easy guideline:**

1) Calculate how much power you are consuming. This will tell you how much current you will be using. Remember: I = P / U
2) Calculate how long you want to use power without recharging, that means: without sun.
3) The current multiplicated with the hours gives us the capacity for the batteries.
4) Decide how long it should take to recharge your battery, once the sun is shining. This will tell you, how much solar panel power you need.

Example:

A mini computer with monitor uses about 20 Watts. At 12 Volts, this means a current of 1.66 Ampere.
To be on the safe side, we will assume 2 Amperes.

We would like to use this computer for 3 days, 5 hours each day: 15 hours total.

This means, we need a capacity of 2 A x 15 hours = 30 Amperehours = 30 Ah.

Remember, we should never use more than half of our battery – so our battery needs to have a capacity of 60 Ah.

We would like to recharge the half empty battery in 5 hours of sunshine. This means we will need

30/5 = 6 Ampere.

P = U x I = 12 Volt x 6 Ampere = 72 Watt.

It is always a good idea to add a little bit to all our results, so that we can be sure the system is strong enough.

So our photovoltaic system could consist of

a Solar Panel of 80 -100 Watt,

and a Battery with a capacity of 60 – 80 Ah.

Such a system would be enough for lights and some small electric things in a household.

AC and DC

There are two kinds of electrical current:

Direct current, DC: The current always flows in the same direction. Minus and Plus stay on the same side all the time.

Example: A solar panel gives Direct Current.

Alternative Current, AC: The current changes its direction back and forth all the time.
Example: Our wall plugs give 220 Volts AC, with a frequency of about 50-60 Hz. This means, the direction changes 50 to 60 times per second.

We use inverters and converters to change DC to AC, and back.

But, whenever we do that, we loose some power. A typical inverter or converter loses about 50% of the power. So we try to avoid having to many conversions.

AC can travel long distances in a wire much better than DC – that is one reason why we use AC for our buildings, for most lights and computers.

Inside, most computers, monitors and so on use DC. So, they convert the current in their power supply.

Being careful

Electricity - like all power - can be dangerous!

AC is especially dangerous, because the quickly changing direction causes damage to our heart and our whole body, even at low power.

DC is not quite so bad, but high power and current can also make DC dangerous to us.

If we let all the power out of the battery in one short moment, it is very strong.

If you put a metal plate with food on the battery contacts, it will throw the food up to the ceiling.

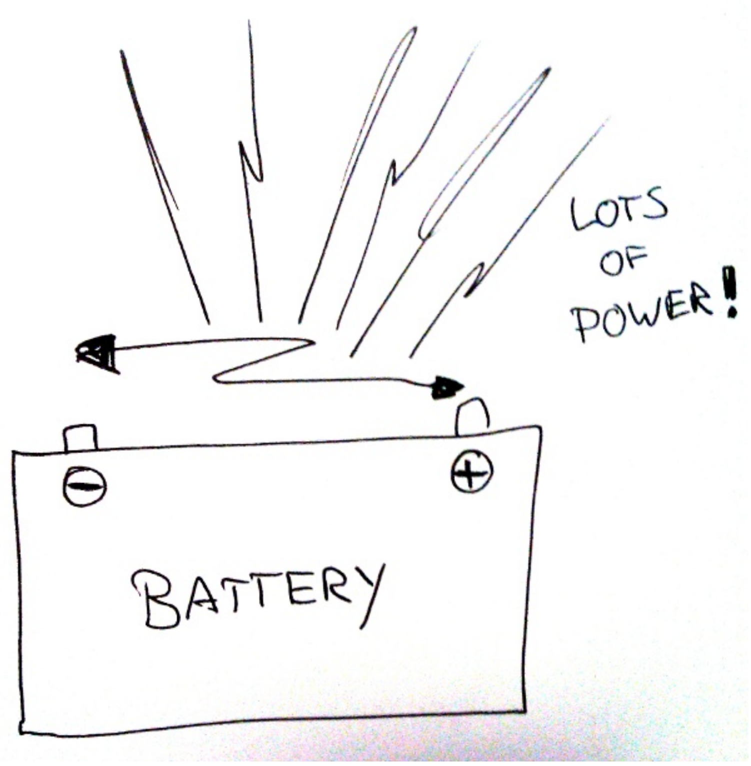
If you lay a knife on the battery connectors, it can destroy the knife.

If you touch both battery connectors with your hands, you can get an electric shock!

You can burn your hands, too!

Always be careful!

Also be very careful when installing solar panels, climbing on roofs or trees, and working with tools.



If you like to learn more

There is a lot more you can learn about solar energy,
and a lot of things you need to know if you like to build solar power systems yourself.

These were the most important ones.

If you like to know more, you can:

- ask your teachers
- read about it in books
- use the internet, for example the wikipedia
- or send an email to the author of these pages:

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