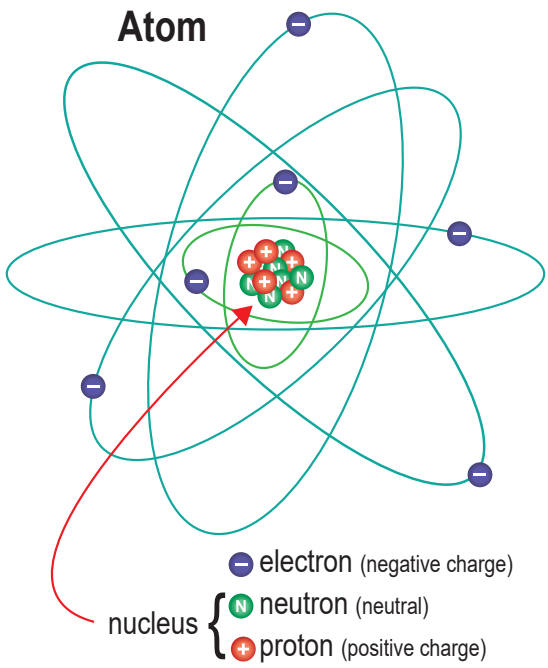
FACT SHEET: Understanding Electricity

(General)

Understanding the basics can make working with electricity much easier.

How Electricity Works

- All matter is composed of Atoms.
- Atoms are made up of a nucleus in the center surrounded by one or more electrons.
- An electron is a particle of energy with a negative charge that revolves around the nucleus as a satellite does around the Earth.
- The nucleus is made up of protons with a positive charge and neutrons which have no charge.



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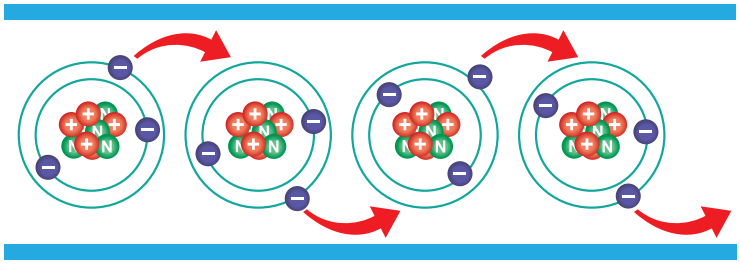
- What we call “electricity” is just a flow of electrons from one atom to the next.
  - Electrons do not move along a wire like cars on a highway. If you put a new electron in a wire, it will join an atom, and then that atom will deliver an electron to the next atom, and so on. The electrons jump from one atom to the next in a domino effect which is what we call electric current.



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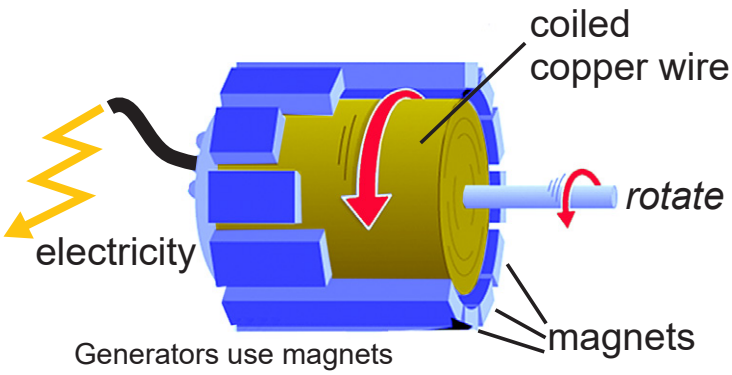
- Conductors - materials, like metals, that have electrons that are easy to detach from their atoms so they can move around freely. Electricity can move through these free electrons easily.
- Insulators - materials, like wood, glass and plastic, where the electrons are held tightly by the atoms. Since they don’t share electrons very well, these types of materials can’t conduct electricity well.

How Electricity Gets Moving

- Electricity can move through a conductor but to do so it also needs something to make it flow from one point to another. Some force must be applied to get the first electron moving.

Batteries

- A battery converts chemical energy into electrical energy.
- The chemicals inside the battery slowly go through a chemical reaction so electrons are pulled off atoms, sending them to the negative terminal
- The electrons then flow through the wires, powering whatever the battery is connected to and continue on to the positive terminal.
- This process continues until the chemical is completely changed. The electrons stop flowing and the battery is dead.



Generators use magnets and motion to make electricity

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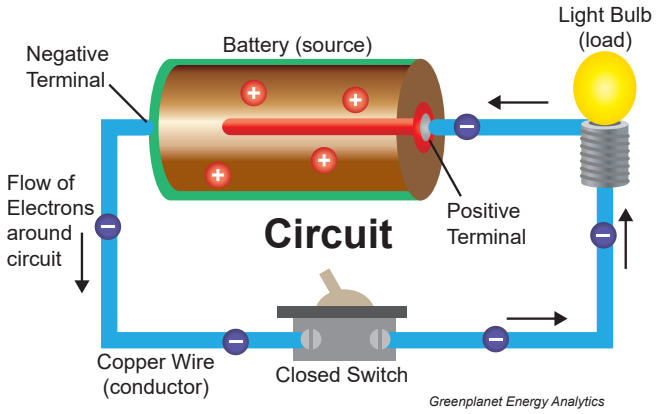
Generators

- Generators use magnets to make electricity.
- If you wave a magnet over a wire made of a metal such as copper, you create a movement of electrons in that wire.
- A generator has a central core wrapped with wires, spinning inside a layer of magnets. This creates an electromagnetic field which makes electricity flow through the wires.
- Interesting Note: Motors are basically the opposite of generators. Motors use electricity to make motion and generators use motion to make electricity.

Circuits

- In order for electricity to flow, you have to form a “circle” or closed loop to keep the electrons moving.
- This circular path is called a circuit. If the path is interrupted, the circuit is “broken” and the electricity stops flowing. (This is how switches work.)
- An electrical circuit always has 3 parts:
  - An electrical source
  - A load (the device or appliance being powered up)
  - A set of two wires to carry the electricity between the source and the load
- Within an electrical circuit, no matter what the source of electricity is (generator, battery, solar cell, etc), three things are always the same:
  1. The source must have two terminals: a positive and a negative.
  2. The source will push the electrons out of the negative terminal at a certain voltage (like water pressure)
  3. The electrons will flow from the negative terminal to the positive terminal through a conductor (like copper wire).
- Any sort of load can be attached in the middle of a circuit and the source will power it with electricity.
- Electrical systems and devices have safety features:
  - The electrical parts are covered with insulators – materials that do not conduct electricity
  - The Earth, (the soil and ground water) is a good electrical conductor. If the insulator fails and electricity is released from a wire or a device, a ground wire, ground rod transfers it directly to the earth. The ground protects people from being electrocuted.



A typical ground rod (left of gray pipe), consisting of conductive steel rod driven into the ground. Below is a ground plate which does the same thing but is easier to install.

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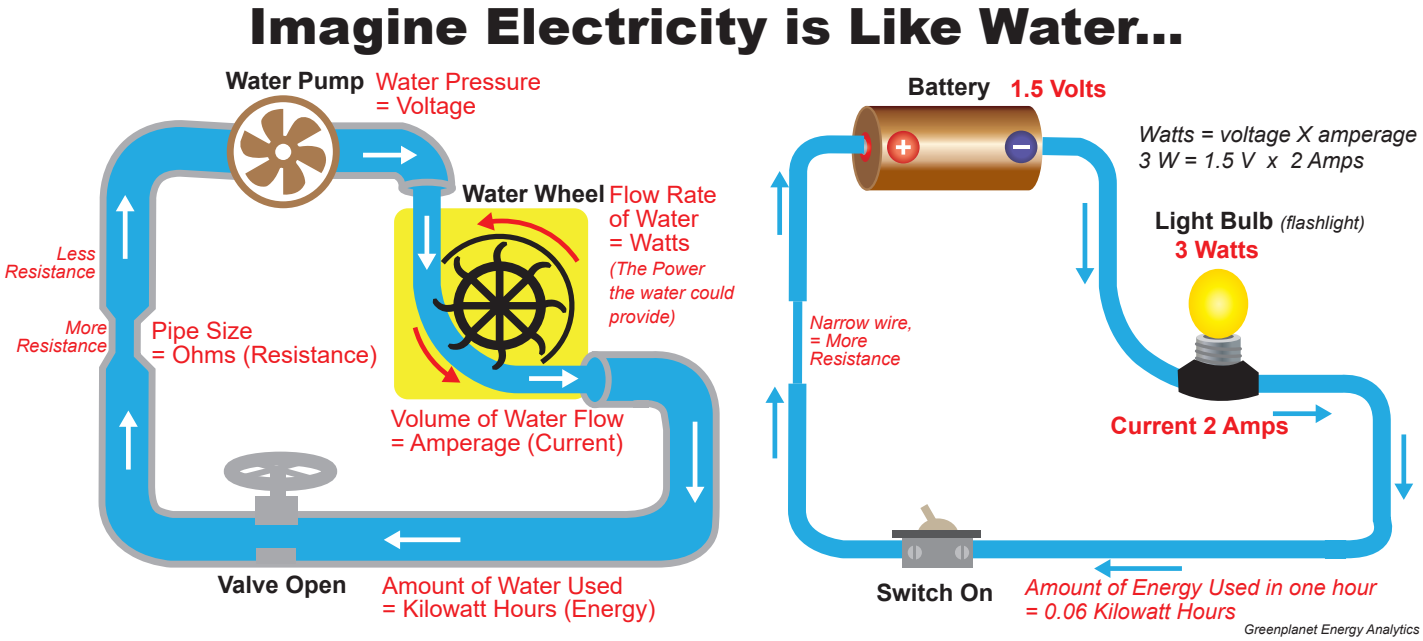
Understanding Electricity

Imagine electricity is like water.

- A generator is like a pump pushing water. Just like a pump pushes water molecules through a pipe, a generator pushes electrons through a wire.
- Both the generator and the pump move a certain amount electrons or water and apply a certain amount of pressure to push each of them through.
- The volume of water moving through a pipe is called flow rate. The amount of electrons moving through a wire is called current or amperage and is measured in **Amps**.
- The amount of pressure pushing the water through a pipe is like the amount of pressure pushing the electrons through a wire which is measured in **Volts (V)**.
- The size of the water pipe is like Resistance in the electrical system. Increasing the size of the pipe will allow more water to flow through. Similarly, increasing



the thickness of the conductor wire will increase the amount of electricity that can travel along it. Resistance is measured in **Ohms**.

- Electricity is measured in units of power called **Watts (W)**
  - Power is a measure of the rate at which energy flows. Watts are basically the speed measurement of the electrical world--they tell you how fast the water is speeding down the pipe
  - In an electrical system power (Watts) is equal to the voltage (V) multiplied by the current (Amps).
  - It's like pointing a hose at a waterwheel. You can increase the power (Watts) in two ways:
    1. Increase the pressure of the water coming out of the hose (Volts), it hits with more force and the wheel turns faster, generating more power.
    2. Increase the flow rate (Amps), the waterwheel turns faster because of the weight of the extra water hitting it.

Summary: The voltage is equivalent to the water pressure, the current (amps) is equivalent to the amount of water flowing, resistance (ohms) is like the pipe size and watts would be the speed of the water.

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How to Measure Energy

- Electric utility companies use a measurement called **Kilowatt hours** (kWh) to bill customers for the amount of electricity they use.
- While a watt is a measure of power, a kWh is a measure of energy. Energy is defined as the capacity to do work, such as creating heat, light, or motion.
- If you run a 60-watt lightbulb for one hour, you've used 60 watt-hours (or 0.06 kilowatt-hours, since a kWh is 1,000 watt-hours). In other words, 0.06 kWh is the amount of energy you need to run a lightbulb for an hour.
- A kWh is a unit of energy equivalent to 1 kilowatt (1 kW) of power being used for 1 hour of time.

Example Calculation of kWh:

A 60" TV that Uses 170 watts per hour

Step One: Calculate Watts per Day

170 watts x 5 hours used per day

= 850 watt-hours per day

Step Two: Convert Watt-hours to Kilowatt hours

850 watt-hours per day/1000

= 0.850 kWh per day

Step Three: Calculate use per month

0.850 kWh per day x 30 days

= 25.5 kWh per month

Step Four: Calculate cost of device per month:

Assume the price per kWh is 10 cents.

25.5kWh x 0.10

= $2.55 per month of TV use

Direct Current Versus Alternating Current

Electricity is provided in two different ways.

- Direct current (DC).
  - Current always flows in the same direction
  - DC is very simple - easy to make, easy to use and can be carried around
  - Used in batteries, fuel cells and solar cells
- Alternating current (AC)
  - The direction of the current reverses, or alternates, 60 times per second
  - The big advantage of AC is that it is relatively easy to change the voltage of the power, using a device called a transformer.
  - Power companies save money this way because they can use much smaller wires to transmit the high voltages over long distances to where the power is needed.
  - The power that comes out of a power plant is AC (about 245,000 volts)
  - The power is stepped down so that a standard wall socket is 15 amp, 110-volt, 60-cycle AC power.

REVIEW

- Electricity = the flow of electrons through a conductor
- Electric current (I) = the rate of flow of electricity; measured in Amps (A)
- Voltage = the electrical pressure – the push that makes the current flow; measured in Volts (V)
- Power = how much energy is released (supply) or used (demand) per second – measured in Watts (W)
- FORMULAS
  - Power (Watts) = Volts (V) x Amps (A)
  - Energy Consumption (Kilowatt Hours) = Power (W/1000)) x Time (hours)

More Information

How Electricity Works - howstuffworks (Basic)
https://science.howstuffworks.com/electricity2.htm

VIDEO: How ELECTRICITY works - The Engineering Mindset (Advanced)
https://www.youtube.com/watch?v=mc979OhitAg

VIDEO: Bill Nye the Science Guy - S01E18 Electricity (Basic)
https://www.youtube.com/watch?v=SYacUaukaxg&feature=youtu.be