



Chapter 18 Magnetism

Physical Science




Magnets

More than 3,000 years ago Greeks discovered deposits of a mineral that was a natural magnet.

The mineral is now called magnetite.

Ex: lodestone


☐ These magnets were used by the ancient peoples as compasses to guide sailing vessels.

Magnets

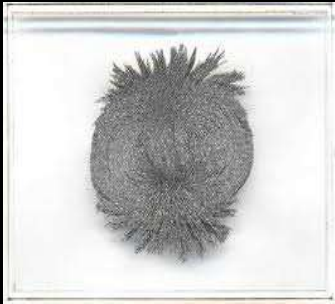
Magnet – any material that attracts iron and materials that contain iron

- ☉ **Magnetism** – the attraction or repulsion of magnetic materials
- ☉ Magnets attract or repel other magnets.




- Today, the word **magnetism** refers to the properties and interactions of magnets.

Common metals affected by magnetism are iron, nickel, and cobalt






IRON



NICKEL

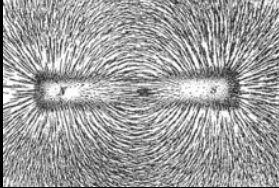
Magnets

- **Nonmagnetic materials**, such as plastic, glass and wood, have electrons that flow in different directions.

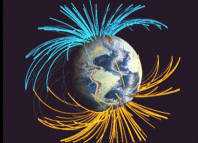




Magnets

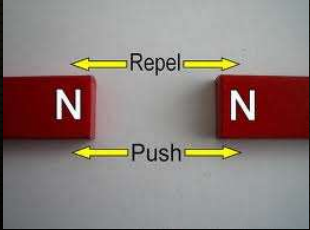
- All magnets have a north pole and a south pole.
- Every magnet has two poles
 - north (N) pole
 - south (S) pole
- magnetic force – the attraction or repulsion between magnetic poles

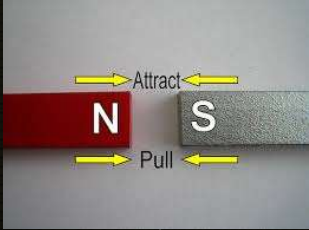


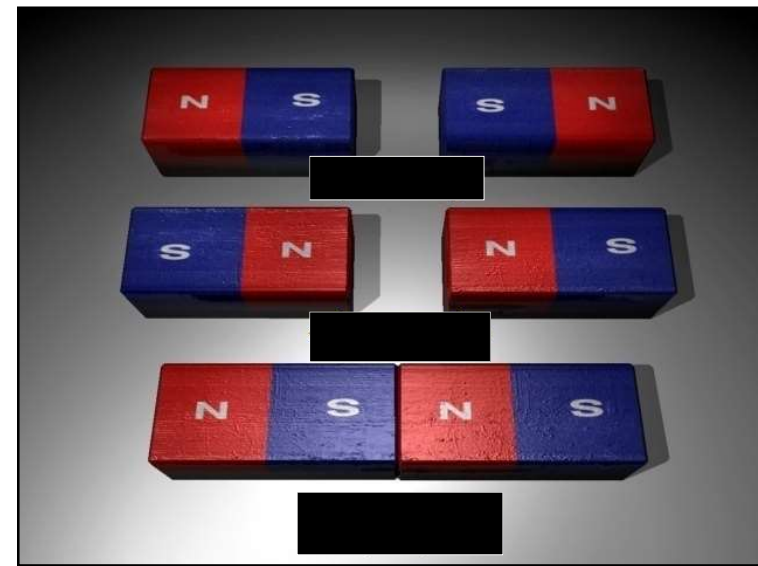
Magnetic Poles



- Magnetic poles that are **alike** **repel** each other.
- Magnetic poles that are **unlike** **attract** each other.



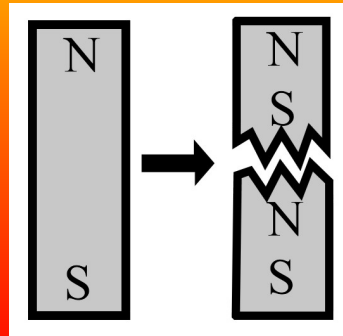




Magnetic Poles

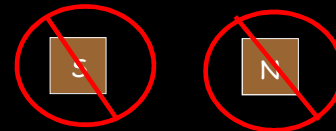
Poles- two ends of a magnet

- Even if you break a magnet in half, each half will have a north pole and a south pole

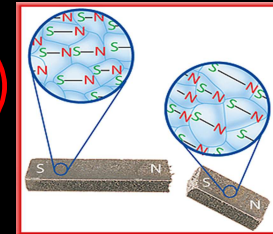


No Monopoles Allowed

It is not possible to end up with a single North pole or a single South pole, which is a monopole ("mono" means one or single, thus one pole).



- Recall that even individual atoms of magnetic materials act as tiny magnets.

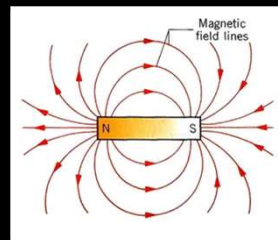


Magnetic Fields



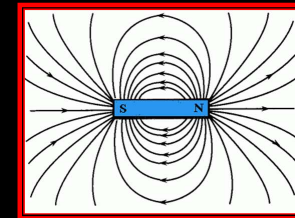
Michael Faraday realized that ...

A magnet has a 'magnetic field' distributed throughout the surrounding space




Magnetic Fields

- A magnet is surrounded by a magnetic field.
- A magnetic field exerts a force on other magnets and objects made of magnetic materials.
- The magnetic field is strongest close to the magnet and weaker far away.

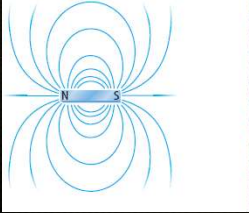
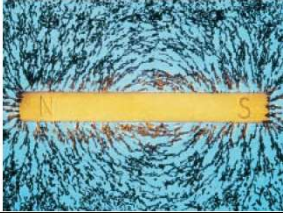


A magnetic field also has a direction & illustrated by arrows.

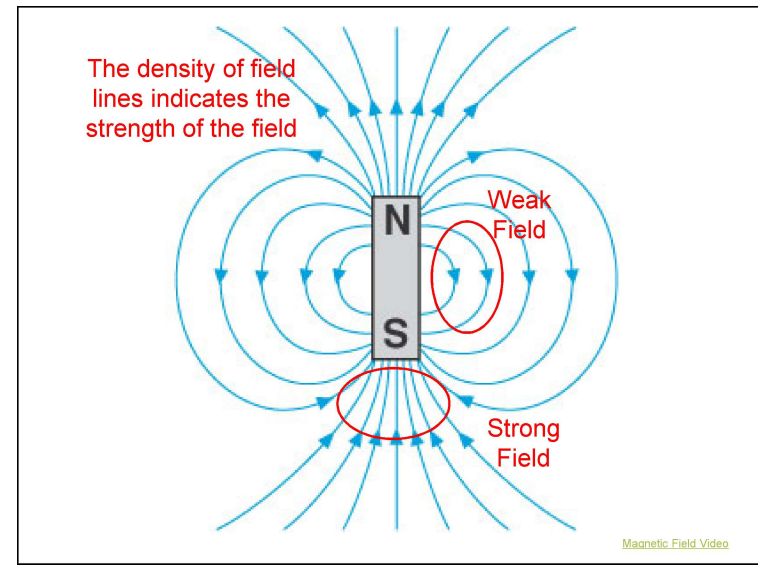
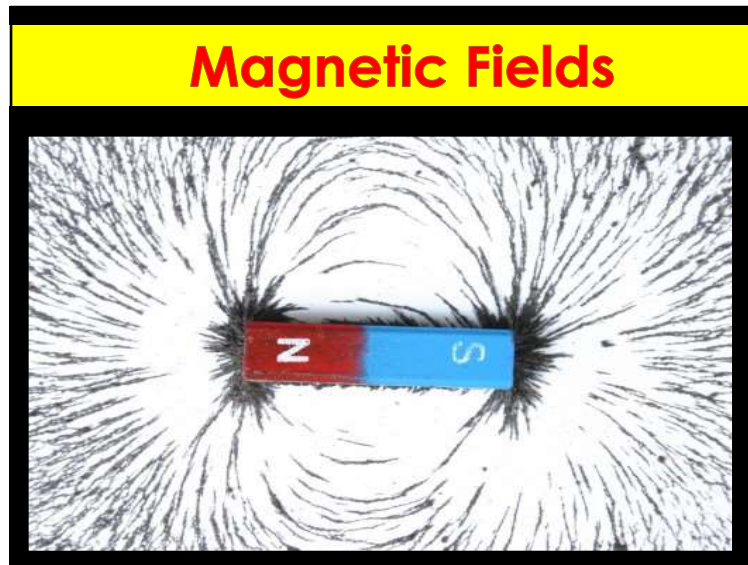
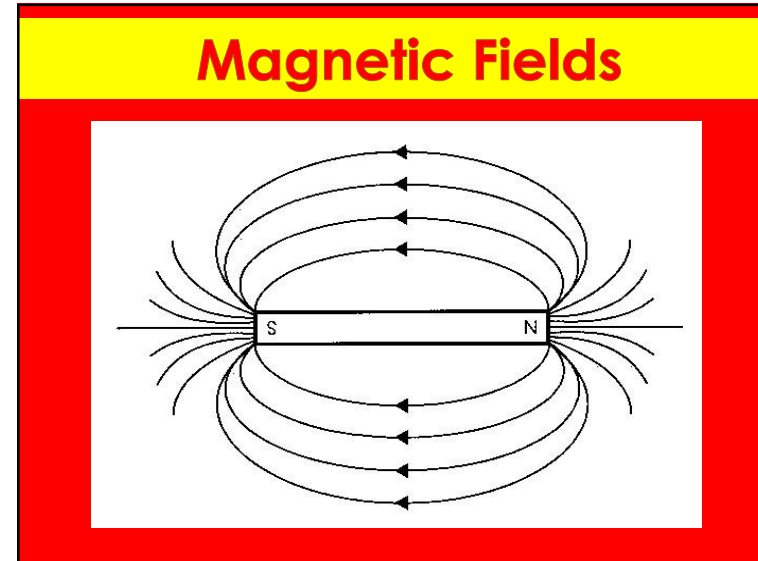
Magnetic Fields



- **magnetic field lines** – the lines that map out the magnetic field around a magnet

Magnetic field lines spread out from one pole, curve around the magnet, and return to the other pole forming a **closed loop**.



Field Lines Around Magnets

Bar

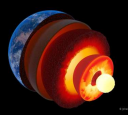
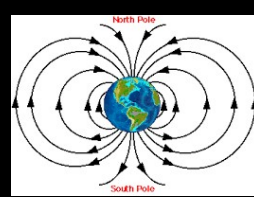
Sphere

Repelling

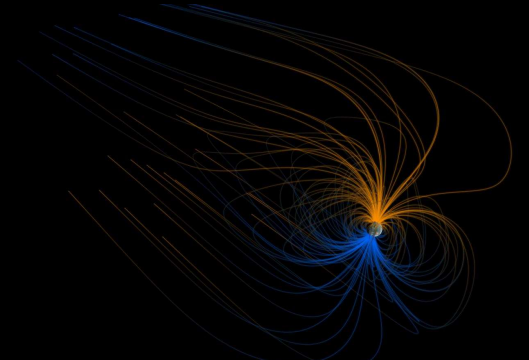
Attracting

Earth as a Magnet

- Earth has north and south poles like a bar magnet
- Our planet's rotation causes molten iron-nickel in its outer core to circulate
 - creating electrical currents and a magnetic field.

The Earth's Magnetic Field



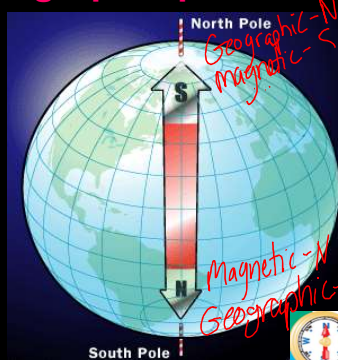
© greg shirah / tom bridgman, nasa/goddard space flight center

The Earth is surrounded by a magnetic field which extends far into space. Called the magnetosphere

Earth as a Magnet

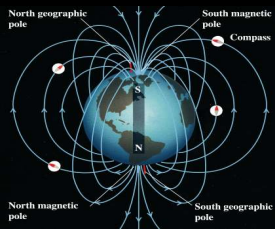
➤ **Magnetic poles of the Earth are different from the geographic poles of the Earth**

- the North Magnetic Pole is located near the geographic South Pole
- the South Magnetic Pole is located near the geographic North Pole

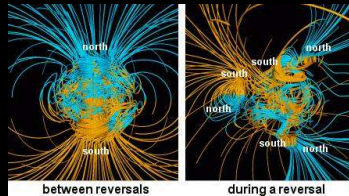


Earth's Magnetic Poles

- Earth's magnetic poles move slowly with time.
- Sometimes Earth's magnetic poles switch places so that Earth's south magnetic pole is the southern hemisphere near the geographic south pole.



North geographic pole, South magnetic pole, Compass, North magnetic pole, South geographic pole



north, south, south, north, north, south, south, north

between reversals, during a reversal

Their model offers the first coherent explanation of magnetic field reversal.


[Video](#)

Compasses

- Compasses are used to determine direction
- Compass needles are magnetized and respond to the magnetic field of the Earth
- We use the Earth's magnetic field to find direction.
 - Migration of birds


The needle of a compass always points toward the magnetic south pole.

The compass needle points toward the geographic "North"




Magnetic Effects

- ✦ The most visible effect of the earth's magnetic field is a colorful light display, called an aurora
- ✦ Collisions between the charged particles and other particles in the upper atmosphere create glowing lights



Electromagnetism


- In 1820, Han Christian Oersted, a Danish physics teacher, found that electricity and magnetism are related.
- When a compass was brought near electric current, the compass needle no longer pointed north



• Oersted hypothesized:

- Electric current must produce a magnetic field around the wire, and the direction of the field changes with the direction of the current.

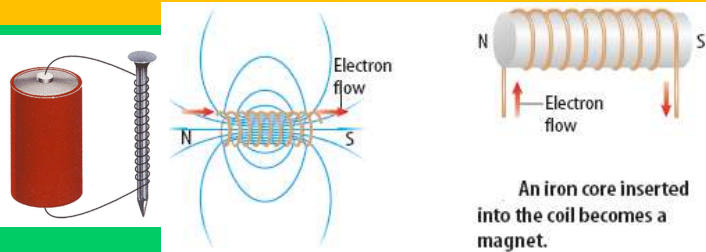
• Electromagnetism – relationship between electricity and magnetism



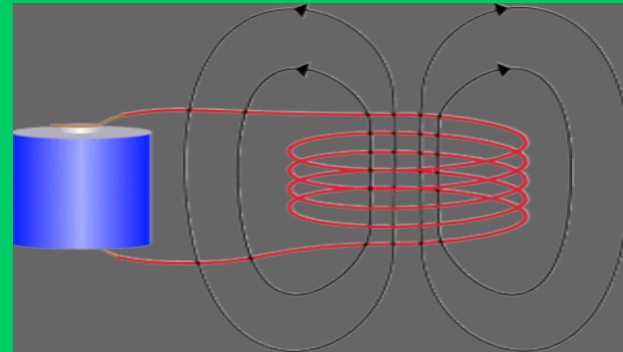
Electromagnetism

When an electric current is passed through a coil of wire wrapped around a metal core, a very strong magnetic field is produced. This is called an electromagnet.

The strength depends on the number of turns in the coil, the amount of current, and the size of the iron core.



Electromagnetism



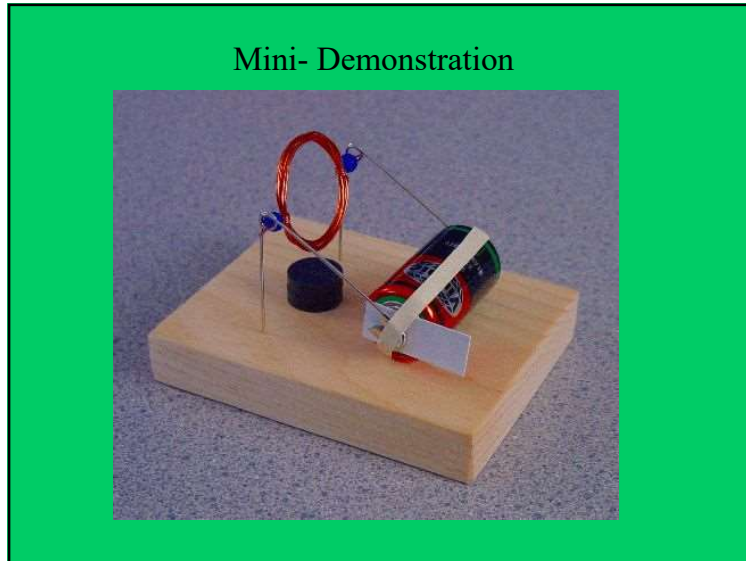
YOU CAN MAKE AN ELECTROMAGNET



Electromagnets can be turned on and off
 You can make an electromagnet by wrapping a wire around a piece of iron and sending a current through the wire with a battery.

Classroom electromagnet vs. commercial electromagnet





Electromagnetism

- A single wire wrapped into a cylindrical wire coil is called a solenoid.
- A type of electromagnet

- The solenoid's magnetic field magnetizes the iron core.

Electromagnetism

- The magnetic field inside the solenoid with the iron core can be more than 1,000 times greater than the field inside the solenoid without the iron core.

Electromagnetism

Properties of Electromagnets

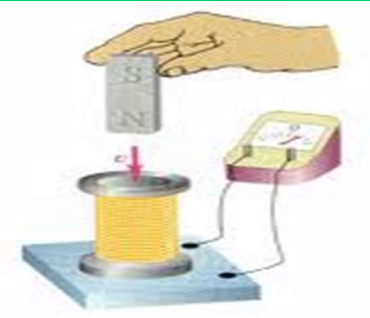
- Electromagnets are temporary magnets because the magnetic field is present only when current is flowing in the solenoid.

- The strength of the magnetic field increases:
 - by adding more turns of wire to the solenoid
 - by increasing the current passing through the wire.

Properties of Electromagnets

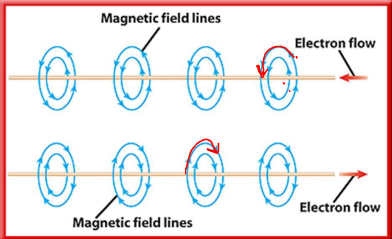
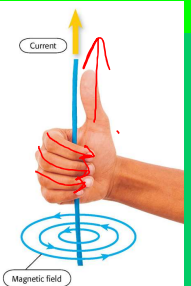
- Electromagnet has a north pole and a south pole.

- An electromagnet also will attract magnetic materials and be attracted or repelled by other magnets.



Electromagnetism

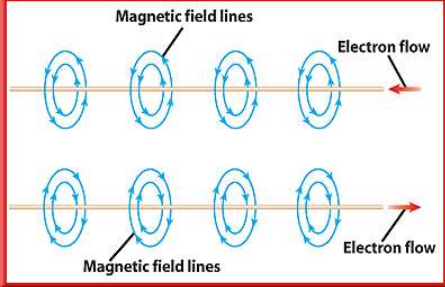
- When an electric current passes through a wire a magnetic field is formed.
- The magnetic field depends on the direction of the current in the wire.

Electromagnetism

- The direction of the magnetic field around the wire reverses when the direction of the current in the wire reverses.

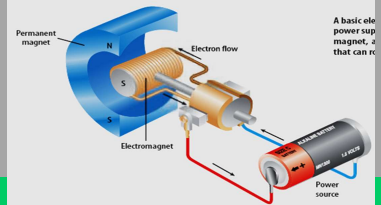
- As the current in the wire increases the strength of the magnetic field increases.



Electromagnetic Devices

Electric Motors

- **Electric Motor** – device that changes electrical energy into mechanical energy
- An electric motor is made up of an electromagnet and a permanent magnet



A basic electric motor consists of a permanent magnet, an electromagnet, and a power source that can be connected to the circuit.

Electric Motors

- A fan uses an electric motor
- The motor in a fan turns the fan blades, moving air past your skin to make you feel cooler.

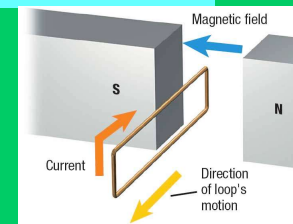
- Almost every appliance in which something moves contains an electric motor.



Electromagnetic Induction

The process of inducing a current by moving a magnetic field through a wire coil without touching it.

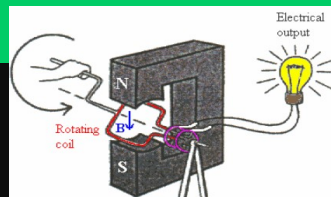
Causes charges to move within the wire.



Electromagnetic Induction

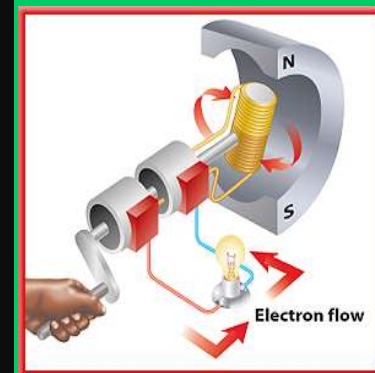
Generators

- electric generator – a device that converts mechanical energy into electrical energy
- A generator uses motion in a magnetic field to produce an electric current



How a Generator Works

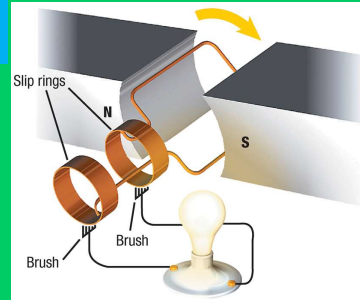
- a current can be induced in a loop of wire by spinning the loop inside a magnetic field
- due to the changing direction of the wire, an alternating current is produced



Electromagnetic Induction

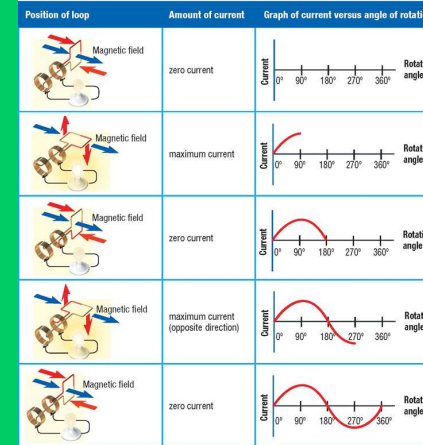
Using Electric Generators

- The type of generator in a car, is called an alternator.



- The alternator provides electrical energy to operate lights and other accessories.

Induced current in a Generator



Electromagnetic Induction

- Electrical energy comes from a power plant with huge generators.
- Produces the electrical energy that you use in your home.

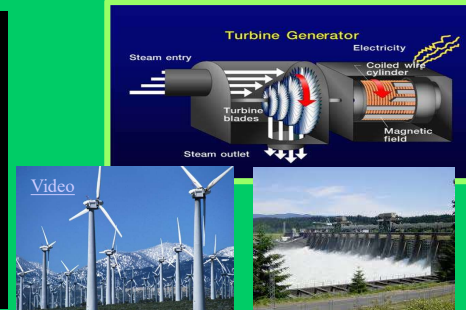


- The coils in these generators have many coils of wire wrapped around huge iron cores.

Electromagnetic Induction

- The rotating magnets are connected to a turbine (TUR bine)—a large wheel that rotates when pushed by water, wind, or steam.

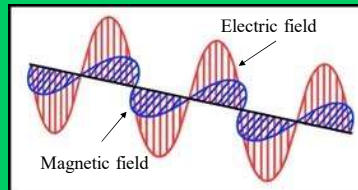
- Thermal energy is then converted to mechanical energy as the steam pushes the turbine blades.



Electromagnetic Force

- Electromagnetic force: Electricity and magnetism are two aspects of a single force.
- Electromagnetic energy results
 - Light is an example of electromagnetic energy.

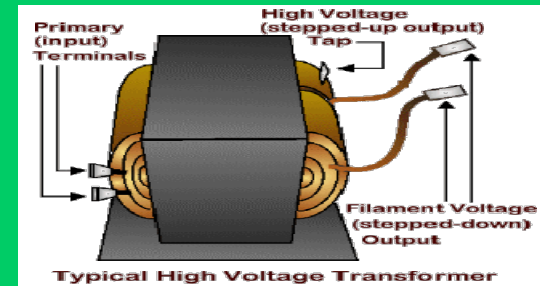
EM Waves are made of both electric and magnetic fields.



Transformers



- A transformer is a device that increases or decreases voltage alternating current.



Transformers

- This figure shows how step-up and step-down transformers are used in transmitting electrical energy from power plants to your home.

